City of Mukilteo Comprehensive Surface Water Management Plan

April 2001

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City of Mukilteo
Comprehensive Surface Water Management Plan

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EXECUTIVE SUMMARY

The City of Mukilteo undertook a comprehensive analysis of the city's watersheds in order to better understand the impacts of urbanization on the city's drainage system. Urbanization in a watershed can have adverse effects on streams and receiving waters; these include increases in flooding, streambank erosion, and pollutant transport. The rooftops, roads, parking lots, sidewalks, and driveways associated with development make much of the watershed impervious to rainfall. Unable to percolate into the soil, rainfall is almost completely converted into runoff, which quickly overwhelms the natural drainage system. Drainage improvements, such as culverts, curbs, gutters, open channels, or storm sewers, must be constructed to direct and convey the runoff through the watershed.

At the receiving end of the stormwater conveyance network, the stream channel must adapt to the new hydrologic conditions. The primary adjustment is through channel widening, which occurs through streambank erosion. Streambanks become undercut and slump into the channel. Trees that were providing bank stability are exposed at the roots and are more likely to fall, triggering landslides. Large quantities of sediment eroded from the streambanks remain in the channel as shifting deposits of mud and sand or are carried downstream to be deposited in flat reaches of the streambed. This can have a dramatic impact on the habitats of fish and aquatic insects.

Other changes accompanying urbanization, such as changes in water temperature, oxygen levels, and pollutants carried in the runoff, can also adversely affect the fish and insect communities. In the natural system, pollutants in the runoff are removed from the water as it soaks into the ground or flows through the organic litter at the soil surface. With urbanization, these areas are replaced with pavement and buildings, and deposited pollutants are washed directly into stream channels. Increased water temperature due to reduced vegetation cover and pollutants, such as fertilizers, oil and grease, and trace metals, affect not only the receiving stream, but also downstream wetlands, lakes, and Puget Sound. The most effective method for mitigating the effect of nonpoint pollution is to implement a rigorous non-structural program including elements such as public education, regulation, and maintenance.

The analysis for this study began with complete aerial photography of the city; from these digital topography was developed. These were used to identify and delineate the watershed boundaries, effectively dividing the city into drainage basins. Drainage problems known throughout the city were cataloged, and general solutions for these problems were summarized.

An analysis of each basin within the city was performed to assess the hydraulic capacity of the existing stormwater system assuming full buildout. This required an inventory of the major drainage system components and simulation of the 25-year and 100-year rainfall events. Except for Edgewater Creek, whose basin is almost wholly outside the city limits, every basin was modeled. In summary, the results of the modeling and drainage problem identification are:

Japanese Gulch—There was no predicted flooding in the gulch. There were reported problems with hillside erosion.

Brewery Creek—There was predicted flooding at the creek outfall due to a long, shallow-sloped culvert. There were reported problems of erosion, localized runoff, and water quality.

State Park Tidegate—There was no predicted flooding in the stormwater drainage system. There were reported problems of localized ponding.

Goat Trail Ravine—There was predicted flooding downstream of the elementary school and at a shallow culvert connected to roadside ditch. There were reported problems of erosion, a failing catchbasin and inlet, and malfunctioning detention ponds.

Unnamed Ravine—There was no predicted flooding in the stormwater drainage system. There were reported problems with lack of a formal drainage system, streambed scour, failing catchbasins and control structure, hillside erosion, and localized ponding and runoff.

Naketa Beach—There was predicted flooding downstream of a system of detention pipes and at an undersized culvert that reportedly has been repaired. There were reported problems with localized ponding and flooding, an insufficient number of catchbasins, a malfunctioning detention pond, and a failing manhole.

Smuggler's Gulch—There was predicted flooding in the subcatchment receiving runoff from Paine Field. There were reported problems with unmaintained ponds, hillside erosion, fish passage, localized ponding, and undersized culverts.

Big Gulch—There was no predicted flooding in the stormwater drainage system. There were reported problems with ditch erosion, hillslope failure, ravine scour, failing culverts, and localized runoff.

Chennault Beach—There was no predicted flooding in the stormwater drainage system. There were reported problems of groundwater seepage, sidewalk settlement, localized flooding, and substandard roadside ditches, catchbasins, and culverts.

Upper and Lower Chennault Creeks and Hulk Creek—There was no predicted flooding in the stormwater drainage system. No problems were reported.

Picnic Point Creek—There was no predicted flooding in the stormwater drainage system. There were reported problems of hillside erosion, fish passage, water quality, and sedimentation.

In order to prioritize the drainage problems, evaluation criteria were established. These included criteria for flood hazard reduction, environmental consideration, and community consideration. A weighting system was established and each problem was rated to determine ranking. This resulted in a listing of the problems by order of priority. The top nine problems in order were found to be:

1. At 126th Street SW cul-de-sac there is erosion in the ravine below the street from the outfall. Water from outfall flows along the road into creek. The road is eroding, causing siltation in Picnic Point Creek.

2. At 53rd Avenue W at the north end of the street past 80th Street SW, the area floods due to lack of a formal drainage system. (Unnamed Ravine basin)

3. West of Cyrus Way, at the upper end of the creek, there is vehicular traffic across the creek bed. (Picnic Point Creek basin)

4. At the intersection of First Street and the Mukilteo Speedway, storm water flowing off the ferry holding area in front of Ivars is a problem. No water quality control or oil/water separator is present. The Type 2 catchbasin on First Street has inadequate capacity and results in the street and parking on First Street up to Buzz Inn flooding. (Brewery Creek basin)

5. There is no tide gate on the Park Street outfall. Water backs up 1.5 feet deep to First Street during high tide. (Brewery Creek basin)

6. Either a pipe beneath the road is collapsing or groundwater is transporting away the pipe bedding material. This results in a low spot on 59th Avenue W and ponding during storms. (Chennault Beach basin)

7. There is no outfall on a local drainage system. It dead ends into private property. (Goat Trail Ravine basin)

8. There is inadequate capacity in the local drainage system due to small and low-slope pipes. (Smugglers Gulch basin)

9. Sheet flow occurs over all of the properties west of 63rd Place W. (Big Gulch basin)

A planning level assessment of the size of the project required to repair each problem was determined. These sizes were associated with a conceptual cost, resulting in an estimated total expenditure of $13.5 million to address all of the identified problems. For planning purposes, the projects were distributed over a 6-, 10-, and 20-year implementation schedule according to their established priority. The 6-year plan accomplishes an average of 13 projects a year, the 10-year plan addresses an average of 8, and the 20-year plan completes 4 per year on average.

A financial analysis was performed to determine the required stormwater utility rate(s) to support the various stormwater capital improvement and operational programs. The programs considered were the three capital improvement programs, a plan to respond to new problems solicited from the citizens, and three programs of additional maintenance operations: increased frequency of catchbasin maintenance, assumption of all detention pond maintenance, and establishment of a ditch enclosure program throughout the City.

The analysis found that the current stormwater utility rate of $5.40 is adequate for the next six years of expected growth if no additional stormwater capital programs or operations are undertaken. A 'menu' of incremental rate increases for each of the elements discussed in the capital improvement program and maintenance programs was determined. The rate increases are an additional $1 to $12 per residence per year for the capital programs and $.50 to $10 per residence annually for the operational programs. Some examples of the resulting rates are:

- For the most aggressive program of maintenance (all three) and capital improvement (6-year), the increased cost would be $30.80 for a total stormwater utility rate of $36.20 per residence per year.

- Both 10-year capital programs (Citizen Response and drainage problems identified in this plan) and no additional maintenance would be an additional $9.10 for a total of $14.50 per residence per year.

- The 20-year capital program and only additional detention pond maintenance would cost an additional $5.65 or a total of $11.05 per residence annually. Annual catchbasin cleaning would be an additional $.50 per year.

An evaluation of the City's compliance with the Puget Sound Water Quality Management Plan was also performed, comparing the Department of Ecology requirements with the ordinances and policies implemented by the City. Four major elements are required for the city to attain full compliance. These are:

1. Adopt a set of stormwater management ordinances.

2. Develop and adopt a stormwater technical design manual.

3. Develop an operations and maintenance manual.

4. Enhance the public education program.

Finally, a program of non-structural measures for stormwater management has been provided. This describes actions for administration, financial incentives, maintenance and operations, program monitoring, regulation and enforcement, waste control, and public education.

CHAPTER 1.
INTRODUCTION

The City of Mukilteo is committed to managing its surface water in ways that support beneficial uses, reduce damage to property, and prevent threats to human health and safety. In addition, it is desirable to conserve and, where practical, to enhance the surface water quality in the City through preservation or modification of drainage features. A comprehensive surface water management plan provides the City with a blueprint for managing surface water well into the future. Such a plan provides information and tools the City can use in making decisions regarding the protection of the public's health, safety, and property from flooding hazards caused by stormwater runoff.

The City of Mukilteo authorized TetraTech/KCM, Inc., to prepare a comprehensive surface water management plan for the City's drainage basins. The following tasks describe the work undertaken to prepare the plan:

- Determined the basic physical and meteorological characteristics of the City and its drainage basins, including delineating each basin and calculating statistical rainfall amounts. Obtained rainfall, land use, soils, and vegetation data to describe the relationship between rainfall and runoff.

- Reviewed past reports and interviewed City staff to assemble list of drainage problems throughout the City.

- Collected a "plan-view" database of the existing storm drainage system that includes approximate location of all drainage culverts, roadside ditches, catchbasins, and manholes. Field surveys and document researches were conducted; maps and data to define the existing drainage system were collected.

- Developed numerical models to evaluate the capacity of the existing collection system, analyze existing conditions, and determine the impact of development up to the maximum density allowable under current zoning (full buildout).

- Identified problem areas within the city limits, rated them against flooding, environmental, and community criteria, and prioritized them for implementation.

- Created several Capital Improvement Programs based on a 6-year, 10-year, and 20-year planning timeline for the identified problems.

- Evaluated funding options and determined the rate changes necessary for following the 6-, 10-, and 20-year planning timelines as well as increasing frequency on selected maintenance activities.

- Performed a programmatic evaluation for compliance with Department of Ecology surface water management regulations and recommended actions to complete program.

- Identified and outlined components of a non-structural program for improving water quality in the City. These include measures in administration, resource protection, maintenance operations, monitoring, enforcement, waste control, and public education.

In addition to chapters describing each of these tasks, a separate chapter is provided for each drainage basin or watershed within the city. These basins are each named by a letter designation, plus the local name if one exists. For example, Basin B is Japanese Gulch. These chapters describe specific basin characteristics, the significant subbasins within each watershed, and the modeling results. In the chapters, peak flow, capacity, and flooding results are documented; complete model output was provided in a separate volume.

CHAPTER 2.
PHYSICAL CHARACTERISTICS

This chapter provides an overview of the city and its drainage basins. A discussion of the climate, geology, soils, wetlands, creeks and land use follows. Understanding the physical characteristics provides a basis from which to discuss the effects and management of drainage problems in Mukilteo.

VICINITY, HISTORY AND POPULATION

The City of Mukilteo is in western Snohomish County on the eastern shore of Puget Sound between Seattle and Everett (see Figure 2-1). Mukilteo is a waterfront city about 25 miles north of Seattle. It is just over 6 square miles in area.

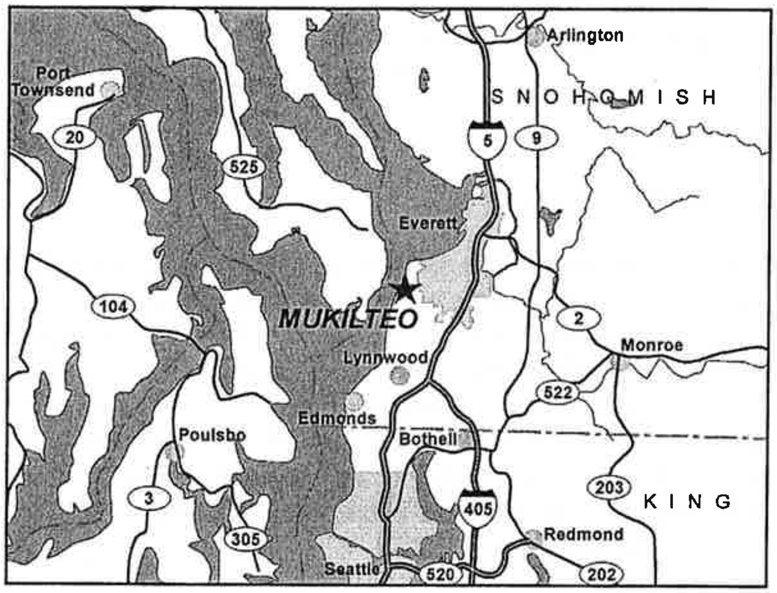


Figure 2-1. Mukilteo Vicinity

Mukilteo is a Native American name meaning "good camping ground," and the northern beach and point of Mukilteo, now called Elliott Point, were well-known places for American Indian councils and potlatches (ceremonial feasts). In 1855, Mukilteo was the site of the signing of a peace treaty between the governor of Washington and representatives of 22 Native American tribes. The first settlement in Snohomish County was established on the northern point of Mukilteo in 1858, and Mukilteo was designated the county seat in 1861 (the seat was later moved to the City of Everett). Pioneers to Mukilteo established a trading post, lumber mill, cannery, and a port of entry for trading ships. In 1906, the Mukilteo lighthouse began service.

In 1905, the estimated population was 350. The City was incorporated in 1947 with a population of 775. Current population is approximately 16,800.

DRAINAGE BASINS IN THE CITY

The City's drainage basins are:

- Basin A—Edgewater Creek
- Basin B—Japanese Gulch
- Basin C—Brewery Creek and State Park Tidegate
- Basin D—Goat Trail Ravine
- Basin E—Unnamed Ravine
- Basin F—Naketa Beach
- Basin G—Smuggler's Gulch
- Basin H—Big Gulch
- Basin I—Chennault Beach
- Basin J—Upper Chennault Creek
- Basin K—Lower Chennault Creek
- Basin L—Hulk Creek
- Basin M—Picnic Point Creek

Figure 2-2 shows the boundaries of the basins, all of which drain west and north to Puget Sound. Basins D, E, F, G, I, J, and K lie entirely within the city limits. Basins A, B, C, and H include area in Everett, upstream of Mukilteo, that drains through the City before entering Puget Sound. Flows from Basins L and M flow out of the City into Snohomish County before entering Puget Sound. Deep ravines at the creeks and steep slopes on the northern and western edges bordering Puget Sound characterize every basin. The storm drainage conveyance systems include open channels and piped networks. Table 2-1 briefly describes each basin. Appendix A contains a list of all the known culvert outfalls along the Puget Sound shoreline in Mukilteo.

TOPOGRAPHY

The shape of the land defines where runoff goes and how fast it gets there. Mukilteo's hilly topography slopes west and north toward Puget Sound, with many wooded gulches and streams. The Harbour Pointe and Paine Field area to the east is a broad upland plateau. Many hills terminate in bluffs and steep slopes overlooking the Sound. Mukilteo has published a landslide hazard map (Ordinance 987, 6 March 2000) shows steep areas in three categories:

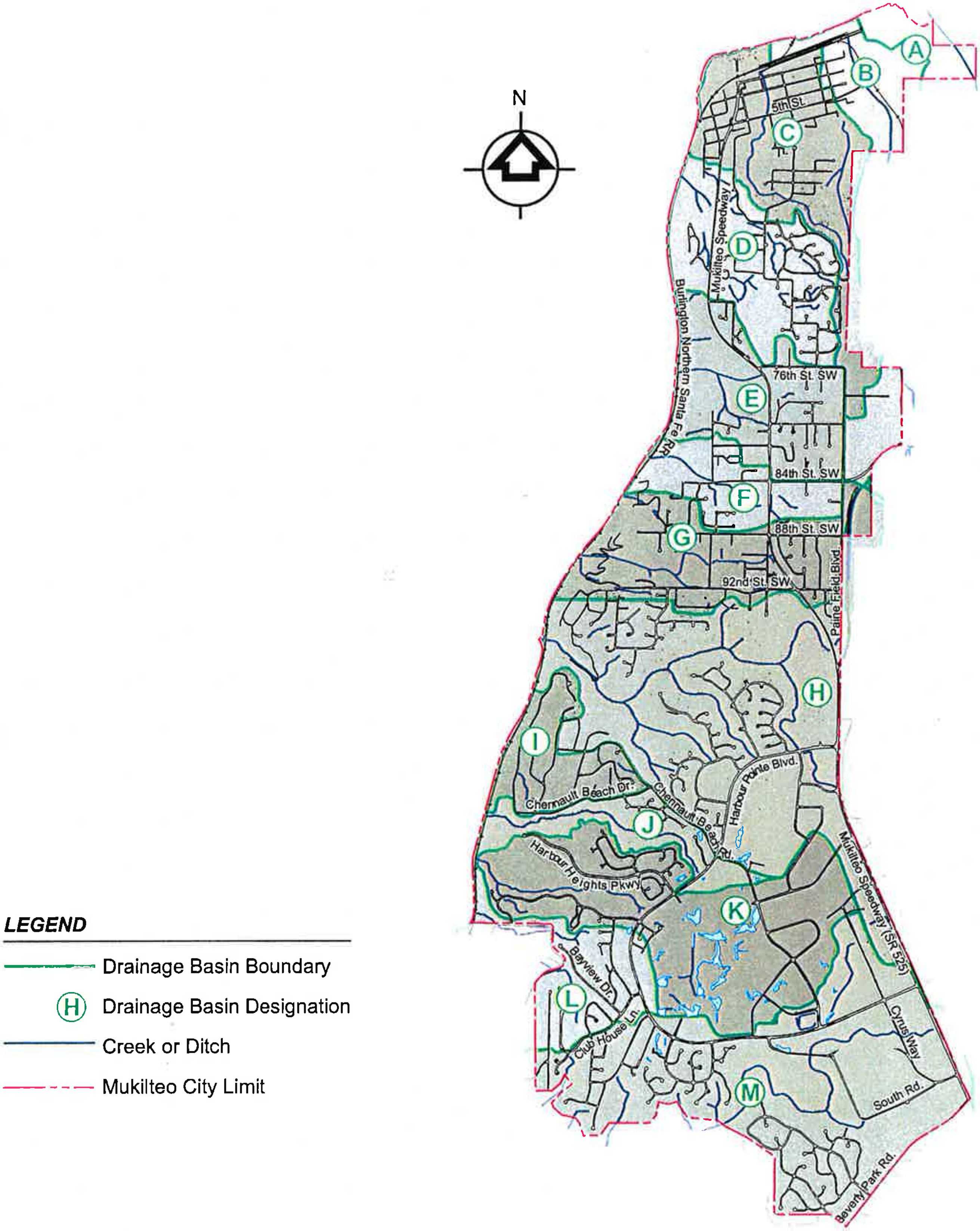
- moderate landslide hazard: areas with 15-40 percent slope underlain by sand, gravel bedrock or till
- high landslide hazard: areas with 15-40 percent slope underlain by silt and clay and any area with slope greater than 40 percent
- very high landslide hazard area: areas of known mapable landslide deposits

TABLE 2-1.
DRAINAGE BASIN SUMMARY

Basin	Area (acres)—Within City Limits/ Total	General Location	Land Use	Drainage System Components	Notes
A—Edgewater Creek	53/360	Northeast corner		None in City except pipe under railroad tracks	Basin almost entirely outside of city limits; runoff from Everett
B—Japanese Gulch	141/615	Northeast corner			Runoff from Boeing and Everett
C1—Brewery Creek	251/292	North end of City	Residential and light commercial	Brewery Creek is the main drainage system in the south changing to piped systems in the north	Most of basin is within city limits
C2—State Park Tide Gate	70/70	North end of City	State park area northwest of railroad tracks	Primarily piped systems that discharge to Puget Sound in multiple locations	
D—Goat Trail Ravine	274/274	Northwest corner	Almost entirely residential	Primarily piped systems in the upper basin changing to primarily open channel system in the lower reaches	Basin is entirely within city limits
E—Unnamed Ravine	262/262	Northwest corner	Almost entirely residential	Primarily piped systems in the upper basin changing to primarily open channel system in the lower reaches	Basin is entirely within city limits
F—Naketa Beach	164/164	Central west	Almost entirely residential	Scattered pipe systems in the upper basin with primarily open channel systems serving most of the basin	Basin is entirely within city limits

TABLE 2-1 (continued).
DRAINAGE BASIN SUMMARY

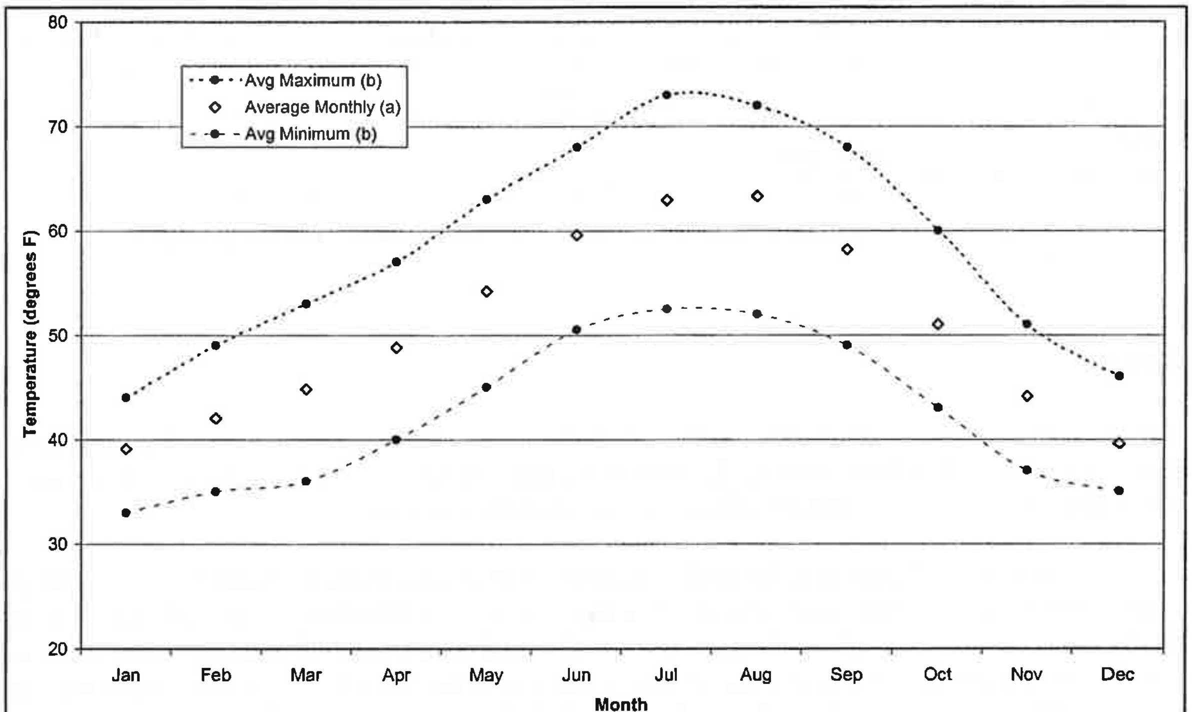
Basin	Area (acres)—Within City Limits/ Total	General Location	Land Use	Drainage System Components	Notes
G—Smuggler's Gulch	293/293	Central west	Lower half residential, upper half commercial and airport	Primarily piped systems in the upper basin (especially east of Mukilteo Blvd.) changing to primarily open channel system in the lower reaches	Upper half of basin at Boeing and airport
H—Big Gulch	806/1600	Central west	Lower half residential, upper half commercial and airport	Primarily piped systems in the upper basin changing to primarily open channel system in the lower reaches	Upper half of basin at Boeing and airport
I—Chennault Beach	125/125	Southwest corner	Entirely residential	Entirely piped systems (no open channel system)	Basin is entirely within city limits
J—Upper Chennault Creek	145/145	South end of City	Entirely residential	Primarily open channel system with piped systems serving the developed areas	Basin is entirely within city limits
K—Lower Chennault Creek	507/507	South end of City	Entirely residential	Primarily piped systems throughout basin with creek receiving all flows before discharging to Puget Sound	Basin is entirely within city limits
L—Hulk Creek	136/280	South end of City	Entirely residential	Primarily piped system that discharges out of City limits	Basin drains out of City to the west, about half of basin is within City limits
M—Picnic Point Creek	754/1455	Southern edge of City	Residential in lower (western) half, commercial in upper (eastern) half	Primarily piped systems serve the developed area with the creek the main conveyance method east to west	Upper basin located at airport, lower basin drains out of City to the south (Snohomish County).



Tetra Tech/ KCM, Inc. 1917 First Avenue Seattle, Washington 98101	City of Mukilteo COMPREHENSIVE SURFACE WATER MANAGEMENT PLAN	Figure 2-2. DRAINAGE BASIN BOUNDARIES

CLIMATE

Mukilteo has a temperate marine climate. It is greatly influenced by its proximity to Puget Sound and by prevailing westerly winds. Summers and winters are relatively mild and humid. Summer days are rarely hot, winters are cool and wet through spring; days of snow and freezing temperatures are infrequent. Temperatures are moderated by the Pacific Ocean and Puget Sound, which also provide a vast supply of moisture for storms that typically move from west to east. Rainy days are frequent throughout the year, except during late summer, when several weeks can pass without precipitation. Average annual precipitation is 36.51 inches according to the Climatological Data published by the National Oceanic and Atmospheric Administration (NOAA). Severe weather usually takes the form of strong and sometimes damaging wind, and in some years heavy rainfall causes serious flooding. Figures 2-3 and 2-4 show the estimated monthly precipitation, temperature, and evapotranspiration for Everett, the nearest weather station with a long-term record (Thomas, et al, 1997).



Sources
(a) 1997 NOAA Climatological Data Annual Summary, Everett, WA
(b) USGS Water Resources Investigations Report 96-4312

Figure 2-3. Historical Temperature Trends at Everett

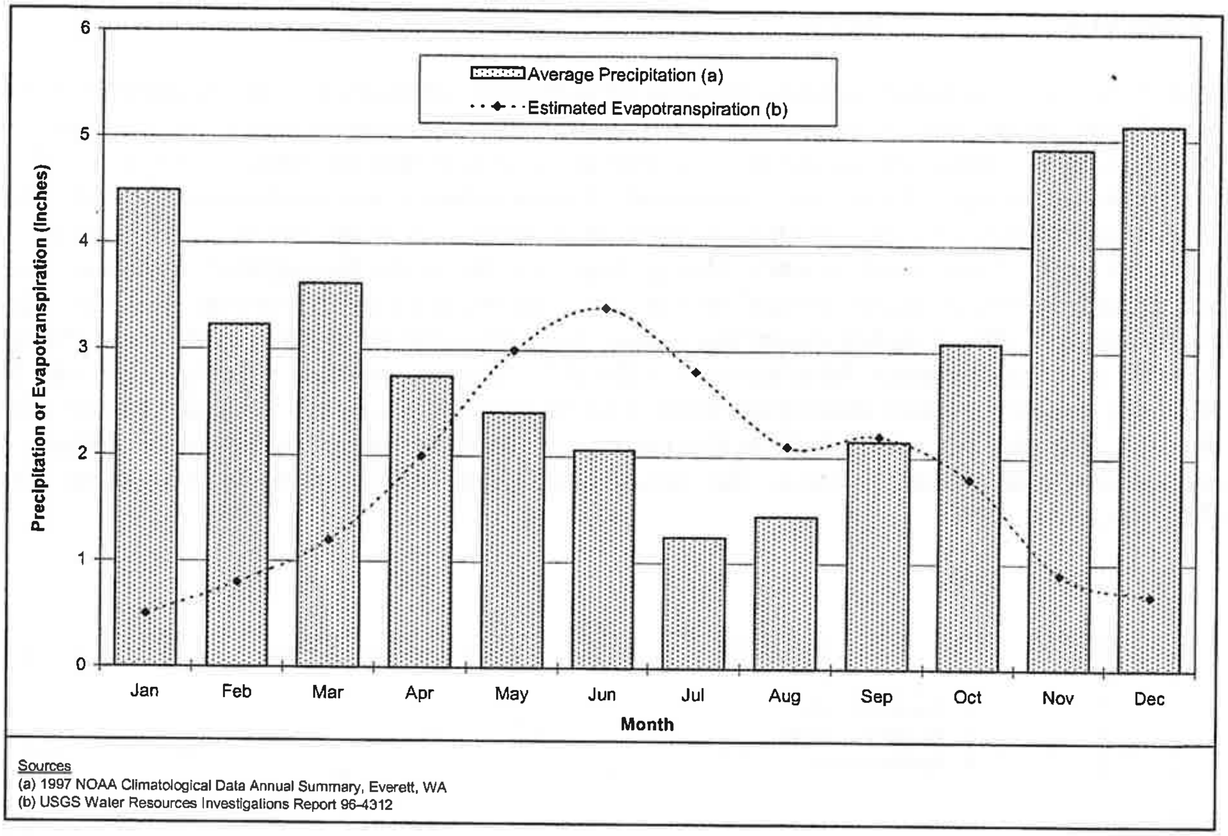


Figure 2-4. Historical Precipitation and Evapotranspiration Trends at Everett

GEOLOGY

Geologic and soil characteristics within a basin can affect the volume of runoff and the erosive potential of streambanks. A brief historical overview of Mukilteo geology provides perspective on the source and development of Mukilteo's soils.

Puget Sound regional topography and geologic formations were shaped by cycles of glacial ice encroachment and recession during the middle to late Pleistocene period, approximately 3 million years ago. The glacial deposits are derived from several regional glaciations; the most recent, called the Vashon glaciation, occurred from 15,000 to 13,500 years ago and at its maximum is estimated to have been 4,000 feet thick near Seattle. As the glacier advanced, valleys were deepened, forming the area known as the Puget Lowlands.

Each time the glacier advanced, a lake formed in the lowlands as the Strait of Juan de Fuca became blocked by ice. On the bottom of this glacial lake, finely ground remains of rocks pulverized by glacier action settled out. These deposits became the clays of the lowlands. As the glacier advanced, its weight compacted the underlying sediments and created a concrete-like material known as Vashon till (or, locally, hardpan) beneath it. As the glacier retreated, water from the melting ice deposited thick layers of sand and gravel called outwash. When the straight reopened, sea water flooded the deeper lowlands to form what is now Puget Sound. Post-glacial processes, including sedimentation, weathering, and erosion, are ongoing in the surface soils. Alterations and activities by man also influence the existing geologic processes.

The geology of the Mukilteo area consists of quaternary glacier and interglacial deposits, primarily Vashon Till laid over the sand and gravel deposits of the previous Fraser Glaciation. Vashon Till is a dense, partially cemented, nonsorted, nonstratified silty sand to sandy silt with gravel, cobbles, and boulders. Its percentage of silt typically varies from 10 to 30 percent. Vashon till mantles most of the City's upland areas. In some areas erosion or landslides have removed the till.

SOILS

Soil is the result of weathering of the geologic materials and incorporation of organics. The makeup of the soils determines the amount of infiltration and runoff that can occur in a storm. The permeability of soils derived from till deposits is moderately rapid in weathered zones and very slow through unweathered, hard glacial till. It is very common for water to infiltrate the surficial, weathered till, 'perch' on the underlying unweathered layers, flow laterally, and resurface as springs in hills or creek banks.

The primary surface soil type in the Mukilteo area, as shown in the U.S. Soil Conservation Service (SCS) Soil Survey for Snohomish County, is in the Alderwood series, derived from glacial till. Drainage is restricted by the underlying geology, the Vashon Till, so this soil is classified as generating moderately high runoff.

The Vashon Till hardpan drains poorly, resulting in swamps and ponds in the upland areas. Lack of soil permeability precludes the large-scale use of infiltration ponds to dispose of stormwater. Several landslide hazard areas are located along the steep hillsides bordering Puget Sound. Mukilteo has published a soil identification map (Ordinance 987, 6 March 2000) showing the surficial geologic materials. This ordinance breaks the soils into three types relative to construction suitability and slope stability:

- Type I: rated good for intended uses – Vashon Till.
- Type II: intermediate, generally suitable for development, but steeper sloped sites required geotechnical input – drift, recessional and advance outwash, and sandy clays located mostly in stream channels.
- Type III: poor soil types that require a minimum slope for development and geotechnical input – beach deposits, landslides, peat, and sand.

SURFACE WATER FEATURES

Several creeks have cut deep ravines and gullies through the underlying glacial deposits in the Mukilteo area: Naketa Creek, Upper and Lower Chennault Creeks, Picnic Point Creek, Hulk Creek and Big Gulch Creek. Some developments in the area include small constructed detention basins and water quality facilities to handle local drainage. Some of these are owned and maintained by homeowners; others have been taken over by the City. A centralized regional detention facility was built around the Harbour Pointe Golf Course. This regional facility is a collection of manmade ponds and wetlands joined by a network of creeks and swales. Small, interspersed wetlands are scattered throughout the Harbour Pointe area. No other regional facilities exist in the City. Appendix B contains a list of all the known detention facilities in the City.

CHAPTER 3.
DRAINAGE PROBLEMS

This chapter presents an overview of types and causes of typical drainage problems in an urban setting. An initial list of problems is presented, developed from reviews of past studies and interviews with city engineering and maintenance staff. The chapter concludes with a discussion of general structural measures to address stormwater problems and includes a list of costs associated with the elements of these approaches.

TYPES AND CAUSES OF DRAINAGE PROBLEMS

Understanding the sources of and conditions leading to stormwater flooding can improve the identification of problem areas and the alternatives appropriate to their solution. Drainage problems become a concern when they impose on existing and proposed development. Although some of the drainage problems in the City of Mukilteo are caused by the local geology (steep slopes, underlying hardpan), they can be exacerbated by development that increases impervious area, reduces vegetative cover, changes runoff routes, accelerates runoff rates, and affects water quality.

Rate and Volume of Stormwater Runoff Flows

The amount of runoff in a watershed is directly proportional to the amount of impervious area. Impervious area is the area covered by roofs, streets, sidewalks, etc., which prevent rainfall from infiltrating into the soil. As future development increases these areas, the amount of stormwater runoff will increase. Increased impervious area can also decrease groundwater recharge and base flow in streams. With a larger percentage of precipitation flowing as runoff, less is available to replenish soil moisture and groundwater storage.

Development can affect runoff by changing its natural flow pathways. Fill for driveways or homes often eliminates natural depressions. The flow of runoff from streets and roofs is faster than from treed and vegetated areas. The construction of artificial channels, such as storm sewers or ditches, also decreases the lag time between when rain falls and when it enters the flow of a receiving stream, thus increasing the peak runoff rate in the receiving stream, scouring streambeds and destabilizing slopes.

Vegetation loss that occurs with development can have several effects on stormwater runoff. Plants and trees not only improve soil permeability, they also provide a source of precipitation storage. Rain that had been evaporated from or absorbed by trees falls to the ground. When bare ground is exposed by construction, the sediment load in nearby streams and drainage channels can increase significantly. This sediment will eventually be deposited somewhere downstream, thereby decreasing the capacity to carry future storm runoff. Additionally, channels enlarged by increased peak flow rates and velocities are more likely to have unstable and unvegetated banks, which in turn increase scour and the sediment load in the stream.

The hydrology of a location changes in response to site clearing and grading, removal of organic soils, construction of impervious surfaces, and channeling of rainfall into the stream. The changes may include the following:

- Increased peak discharges (up to five times higher than predevelopment levels)
- Increased volume of storm runoff produced by each storm (a moderately developed watershed may produce 50 percent more runoff volume than a forested watershed during the same storm)
- Decreased time for runoff to reach the stream, reducing the natural infiltration of surface water into the soil
- Increased frequency and severity of flooding (a moderately developed watershed may flood as often as three or four times a year)
- Reduced stream flow during prolonged periods of dry weather, due to reduced base flows resulting from decreased infiltration
- Greater runoff velocity during storms, due to the combined effects of higher peak discharges, rapid time of concentration, and smoother hydraulic surfaces that occur as a result of development.

Water Quality

Urban stormwater quality is highly variable, depending on factors such as land use, the level of development, the age of the developed area, and the density of construction. The quality of stormwater runoff has historically been degraded by changes from natural to urbanized conditions.

The type and amount of pollutants depend on land uses in the drainage area, pollutant source controls, and drainage system maintenance programs. Primary contaminants in stormwater from developed areas are eroded sediment and debris from deteriorating roadways and buildings. Other pollutants associated with runoff are heavy metals, inorganic chemicals, nutrients (nitrogen and phosphorus), petroleum products, and fecal bacteria. Older, poorly maintained urban neighborhoods generally have higher levels of pollutants than newer developments, due to higher levels of traffic, accumulation of debris, and deteriorating housing stock. Developments under construction contribute a higher level of sediment to runoff because of the removal of vegetation during land clearing and resultant erosion.

In rural or undeveloped areas, stormwater pollutant loadings are low. The stormwater quality of forested areas is often used as a base condition for comparison to developed areas. Stormwater runoff in agricultural areas is generally characterized by high nutrient concentrations, virtually no petroleum products, and only naturally occurring metals.

Erosion and Sedimentation

Erosion and associated sedimentation are common problems in Mukilteo. Erosion of soils is a natural, ongoing process, caused by fast-flowing water through a stratum, frequently exposed earth that is incapable of withstanding the force of the water. When the stratum fails, it falls into the flowing water, becomes segregated by particle size, and settles out at downstream locations based on the particle size and water velocity. The rate of soil erosion can be accelerated by land clearing, grading, or construction, and may increase over the long term as a consequence of increased stormwater runoff resulting from development. Removal of vegetation, modification of topography, and poorly managed discharge of runoff commonly contribute to increased soil erosion rates.

The sensitivity of soils to erosion varies. Some soils are particularly susceptible to erosion because of their density or range of particle sizes. Noncohesive granular soils (sands) have higher erosion potential than more cohesive soils (silts). In general, soils on slopes have a higher potential for erosion than soils on flatter ground; the steeper the slope, the higher the erosion potential.

Unchecked erosion may have impacts ranging from a simple nuisance to major slope failures. Problems include loss of conveyance capacity, loss of stabilizing vegetation, smothering of fish spawning gravel, loss of property, creation of safety hazards, loss of riparian habitat, and many others. It is often a self-perpetuating problem that can be very difficult and expensive to correct once started. The ease of correcting erosion problems can vary greatly. The following procedure is provided as a general guideline:

- Once an erosion location has been identified, attempt to establish when the problem first occurred. Investigate whether the timing is associated with a recent change in the upstream drainage system (new development, recent land clearing, recent construction, roadway widening, malfunctioning detention facility, etc.).
- Determine whether the problem is recurring or associated with a unique upstream occurrence, such as rapid draining of a detention facility. The frequency of the problem may require a different solution.
- Establish and correct the cause of the problem if initiated by an upstream condition.
- Repair the problem area. The repair will depend upon many factors including the drainage conveyance type (open channel, pipe outfall, stream corridor, roadside ditch, etc.), flow velocity, water depth, accessibility, local, state and federal regulations, etc. Repairs may consist of armoring the channel with quarry spalls or riprap, reestablishing the channel slope with vegetation, or reinforcing the slope with geotextiles or webs. Bed stabilization approaches may also be required, including logs, log weirs and channel gravel. The final solution will depend upon the magnitude of the problem and its location.

Ponding

Ponding occurs when there is inadequate capacity in the existing drainage system, inadequate gradient for surface runoff to flow into the collection system, or inadequate infiltration due to compaction from construction, rising seasonal groundwater level, or blockage. Naturally occurring ponding in an undisturbed system is beneficial because it slows the rate of runoff, thus reducing the likelihood of conveyance and erosion problems downstream. However, if ponding occurs and poses a safety concern or property damage issue, then correction is required. The following procedure is provided as a general guideline:

- Determine the reason for ponding, such as blocked grate, inadequate pipe size, topographical sink, etc.
- If existing system is blocked, clear debris and consider installing a larger trash rack or increase maintenance frequency.
- If ponding is the result of a topographical depression, there could be considerable impact on the downstream drainage system if the depression is drained. A thorough hydraulic analysis of the downstream system must be performed to ensure that there are no adverse impacts on the system or habitat. The larger the ponded area to be drained, the greater the likely impact. Draining several small ponding areas can have a cumulative impact.
- If draining the depression will not create downstream problems, a gravity drainage system must be built connecting the depression's low point to the downstream system. To avoid plugging, extra grate area should be considered in the design.

Inaccessible Drainage Structures

Inaccessible drainage structures are structures on private property with no easements or in locations that are hard to reach, typically because of steep topography. Access to structures on private property requires an easement from the property owner. A property legal description should be obtained to determine if an easement for the drainage system exists. Structures in hard to reach locations need to be moved to a more easily accessible location or access must be improved through construction of an access road.

Easements

Municipalities may not need to make monetary payments for obtaining temporary or permanent easements, because improvements to the stormwater infrastructure can be a benefit to the landowner. The municipality typically pays the attorney fees for writing a new easement; however, the effort required for obtaining an easement depends greatly on the landowner. Some are eager to help or resolve the situation; others see it as an imposition and an opportunity to extract payment from the municipality. In some cases, buying the property outright may be preferable to obtaining a permanent easement, although land prices at $3-$15 a square foot may be prohibitive. Additionally, subdivision for purchase may not be possible as it may result in a sub-standard lot size.

Inadequate Drainage Structures

Drainage structures are considered inadequate when they were sized too small for actual flows, when land use changes upstream increase flows to levels beyond the system's capacity, or when a storm exceeds the facility's design storm. It is not economical to design systems with capacity for every possible storm, but systems that are inadequate for a reasonable design storm must be improved by performing a hydraulic analysis of the system and designing improvements that meet the City's design criteria.

Detention Pond Problems

Detention ponds must be maintained in order to function effectively. Otherwise, the pond will become choked with vegetation, storage volume will be reduced, and the outlet control structure will become plugged. The pond will then overflow, resulting in flooding and other drainage problems downstream (such as erosion).

Vegetation should be trimmed and removed as required, typically every other year. The outlet control structure should be inspected and repaired annually. All public facilities in the City should be located and referenced on a map and a maintenance log maintained.

Fish Passage Barrier

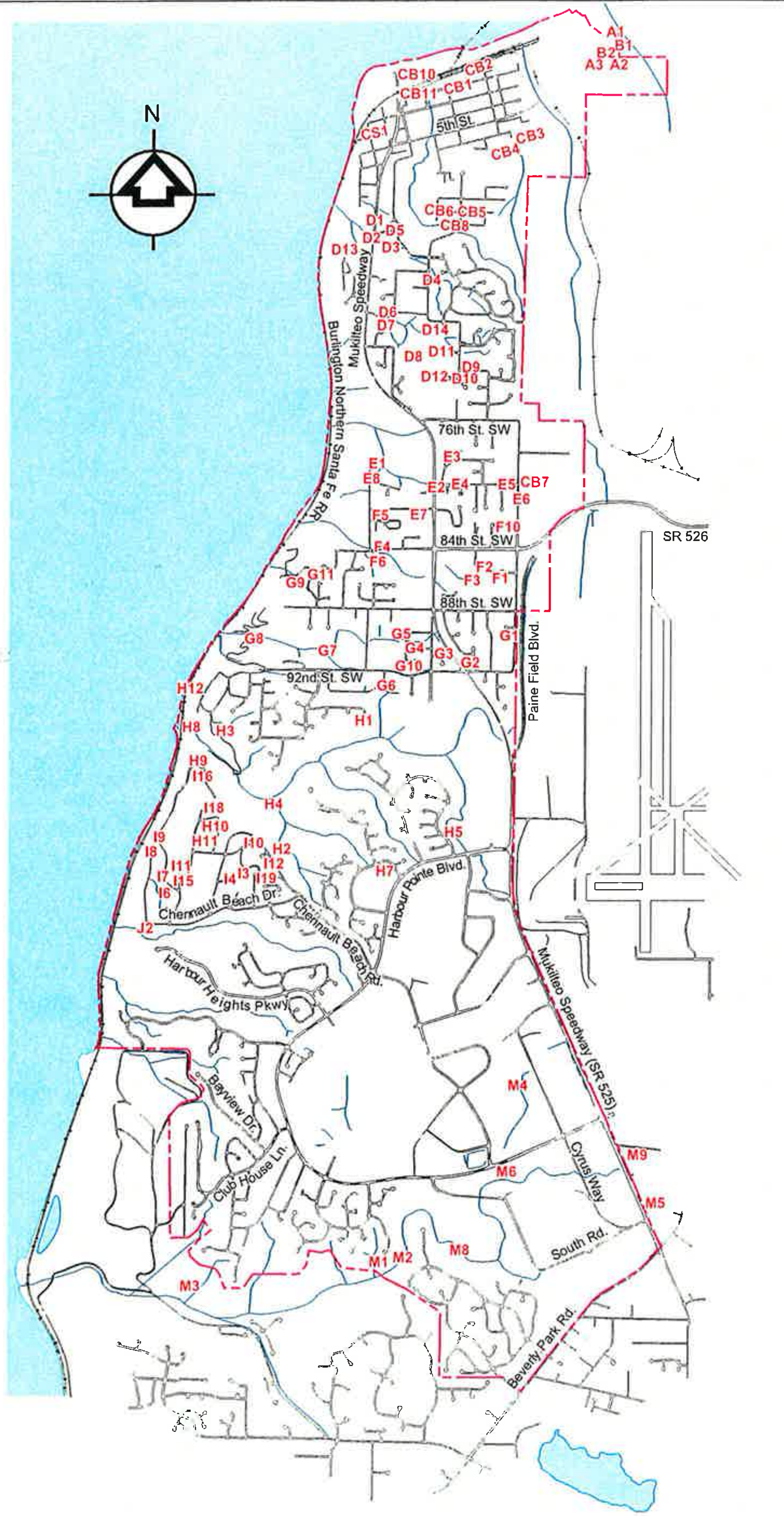
The Washington State Department of Fish and Wildlife has developed a design manual for culvert replacements to provide for fish passage. Any work in a stream system must adhere to this manual to receive a hydraulic project approval (HPA) from the state. Blockages other than culverts, such as head cuts within the channel, require stabilizing the cut with "fish-friendly" methods. These include log weirs that span the creek that provide about 8-inches of drop per log, bed stabilization logs that reduce bed erosion, and strategic log placements that provide for enhanced fish habitat.

SPECIFIC PROBLEMS

In order to develop a comprehensive list of stormwater problems throughout Mukilteo, various sources were gathered and the list shown in Table 3-1 assembled. This list served as a starting point for identifying drainage problems. Additional problems were cataloged through hydraulic modeling of the conveyance network in Mukilteo, described in detail in the following chapters, and through invitation of citizen comment. A copy of the letter and form sent to every resident of the city is located at the end of this chapter.

The information for Table 3-1 comes from the 1985 Storm Drainage Study (Brown and Caldwell, 1985), the 1993 Storm Drainage Technical Report (Hammond, et al., 1993), informal input from City staff, and an interview with the former drainage maintenance supervisor and technician (LaBell and Grilley, 1998) and the current maintenance staff (Accetturo and Arnett, 2000). Each problem has an identification number, in which the first letter indicates the drainage basin and the following number is assigned sequentially. The numbering indicates no priority. The problems are shown on Figure 3-1; for some, the location is approximate, based on the information available.

Several problems in the list have a symbol  over the identification number. This indicates that the City has addressed the problem in the time since it was identified in the various sources and can be removed from the list in the future.



LEGEND

M4 Identified Drainage Problem Area

Ditch or Stream

Mukilteo City Limit

Tetra Tech/ KCM, Inc. 1917 First Avenue Seattle, Washington 98101	City of Mukilteo COMPREHENSIVE SURFACE WATER MANAGEMENT PLAN	Figure 3-1. LOCATIONS OF IDENTIFIED DRAINAGE PROBLEMS

TABLE 3-1.
SPECIFIC DRAINAGE PROBLEMS

ID No.	Description	Location	Type	Source of Information[a]
Basin A—Edgewater Creek				
A1	Edgewater Creek is undermining City of Everett Bridge. Pick up pipe flows with a catchbasin, then pipe downhill.	Mukilteo Lane & Mukilteo Blvd. at bridge	Erosion, no drainage structures	Maintenance
A2	No drainage structures on Lamar Drive; Drainage runs off onto adjacent properties. Requires total road reconstruction. Very narrow and very steep.	Lamar Drive	No drainage system	1985 Study and Maintenance
A3	Ponding along Mukilteo Boulevard.	Mukilteo Blvd.	Inadequate drainage	1985 Study
Basin B—Japanese Gulch				
B1	Erosion problem. Running water on a steep slope was in a pipe, but hillside slippage is opening pipe.	Mukilteo Blvd. & Mukilteo Lane	Erosion damaging pipe	Maintenance
B2	Property slips into culverts. No slope in ditches. Could adjust hydraulic grade line.	South side of Mukilteo Blvd., SW of Lamar Dr.	Erosion, inadequate ditch grading	Maintenance
Basin C—Brewery Creek (CB problems) and State Park Tidegate (CS problem)				
CB1	Potential road bank sloughing over the existing culvert intake; poorly drained road shoulder on the uphill side of road crossing; lack of restraint for the culvert outfall; chronic channel erosion & sedimentation on the downhill side of the road crossing.	Uphill end of culvert west of Loveland Avenue; downhill end of culvert at former City wastewater treatment plant	Poor roadside drainage, embankment erosion, erosion and sedimentation in ditches ALREADY SOLVED	1985 Study
CB2	Pipe fills with sediment from upstream. Drainage backs up onto road. Mukilteo Lane Drainage Improvements Project addressed this.	South side of Mukilteo Lane from Park Avenue to east edge of basin boundary	Roadside ditch erosion; sedimentation in cross-culvert causes flooding ALREADY SOLVED	Maintenance

a. Information sources are identified as follows:
Maintenance: Interview with maintenance staff from the City of Mukilteo October 1998.
(2) indicates interview with maintenance staff June 2000.
1985 Study: 1985 Storm Drainage Study (Brown and Caldwell, 1985)
1993 Report: 1993 Storm Drainage Technical Report (Hammond, et al., 1993)

TABLE 3-1 (continued).
SPECIFIC DRAINAGE PROBLEMS

ID No.	Description	Location	Type	Source of Information[a]
CB3	Public stormwater going through private lot. 12-inch Corrugated metal pipe blew open.	7th & Randall, two blocks east of Campbell Avenue	Undersized pipe, no access to pipe	Maintenance
CB4	Hill slope slid into catchbasin; drainage OK otherwise.	South end of Campbell Avenue	Hillside erosion	Maintenance
CB5	Ditches on wrong side of street.	10th Street between Park Avenue and Campbell Avenue	Runoff not directed to ditches	Maintenance
CB6	Past problem. Slope problem	10th Street & Park Avenue cul-de-sac	Grade problem ALREADY SOLVED	Maintenance
CB7	New sidewalk has pipe underneath with no access to it (no catchbasins).	44th Avenue between 76th Street SW & 84th Street SW	No access to pipe	Maintenance
CB8	12-inch plastic pipe joined by bands; will separate soon because of ground movement. Steep area. Pipe staked to hillside on the surface out of catchbasin.	South end of Park Avenue	Unstable hillside	Maintenance
CB9	Upstream basin drains through a blocked private system between 3rd and 4th Streets with a lack of drainage facilities along 4th Street and small ditches subject to erosion and over-topping between 4th and 5th Streets.	3rd and 5th Streets between Loveland and Cornelia Avenues	Existing storm drainage system is under capacity ALREADY SOLVED	1985 Study
CB10	No tide gate on the Park Street outfall. Water depth of 1.5 feet at high tide and runoff. Water backs up to First Street during high tide events (only).	Intersection of Front Street and Park Street	No tide gate	Maintenance (2)
CB11	Storm water flow off ferry holding area in front of Ivars. Stormwater flows east down the middle of road to Park Ave. No water quality control or oil/water separator. Type 2 on First St. inadequate capacity, which all connects to State Park next to bulkhead on First St. Floods street and parking on First St. up to Buzz Inn.	Intersection of First Street and the Mukilteo Speedway	Inadequate drainage	Maintenance (2)

a. Information sources are identified as follows:
Maintenance: Interview with maintenance staff from the City of Mukilteo October 1998.
(2) indicates interview with maintenance staff June 2000.
1985 Study: 1985 Storm Drainage Study (Brown and Caldwell, 1985)
1993 Report: 1993 Storm Drainage Technical Report (Hammond, et al., 1993)

TABLE 3-1 (continued).
SPECIFIC DRAINAGE PROBLEMS

ID No.	Description	Location	Type	Source of Information[a]
CS1	Frequently swampy.	South end of Mukilteo State Park, 3rd Street & Church Avenue	Inadequate drainage	Maintenance
Basin D—Goat Trail Ravine				
D1	Open creek flows into round grate catchbasin. Catchbasin has riprap around it; may be a problem in the future.	Mukilteo Speedway, between 11th & 9th; east side of road	Catchbasin may plug and cause flooding	Maintenance
D2	Old brick catchbasin in gulch. No way to access for cleaning and erosion at outfall.	Mukilteo Speedway, where Washington Avenue curves into SR 525; west side of street	No access to outfall, old catchbasin possibly inadequate	Maintenance
D3	Inlet collecting Elliot Point stormwater needs a trash rack or protection—carries a significant amount of water.	SR 525 where Washington Avenue curves into SR 525; south side of intersection	Structure may plug and cause flooding; pipe undersized?	Maintenance
D4	Weir doesn't work properly; does not detain water or attenuate flows. Section of park could be used for storage.	Goat Trail Rd & 15th Place	Malfunctioning flow control structure	Maintenance
D5	Creek eroded fill under house.	11th Street & Mukilteo Speedway; southwest corner of intersection	Erosion problem	Maintenance
D6	Paved swale on steep grade. Water moves too fast. Picks up two drainage basins via CBs in backyards connected to school drainage. Plugs a lot.	Swales on north side of 19th Drive between fourth lot up hill and bottom of hill at SR 525	Inadequate drainage	Maintenance
D7	Property floods. Large subbasin drains to this spot (culvert under 19th). May be a part of D6.	Sixth lot up hill from SR 525 on south side of 19th Drive	Inadequate drainage	Maintenance

a. Information sources are identified as follows:
Maintenance: Interview with maintenance staff from the City of Mukilteo October 1998.
(2) indicates interview with maintenance staff June 2000.
1985 Study: 1985 Storm Drainage Study (Brown and Caldwell, 1985)
1993 Report: 1993 Storm Drainage Technical Report (Hammond, et al., 1993)

TABLE 3-1 (continued).
SPECIFIC DRAINAGE PROBLEMS

ID No.	Description	Location	Type	Source of Information[a]
D8	Pond does not work. Weir has pipe in it and does not work.	Corner of Clover Lane and Washington Avenue	Malfunctioning detention pond	Maintenance
D9	Open ditch carries a lot of water from higher ponds because of inadequate slope. Headwater for enclosed system is plugged with rocks and debris, garbage and leaves. School district retention/detention pond has not been maintained.	19th Street and 49th Avenue W	Grade problem; ditch under capacity?	Maintenance
D10	Cherry tree over manhole.	73rd Place SW & 48th Avenue W	Maintenance access restricted	Maintenance
D11	Inadequate capacity to convey drainage from development to the west and no easement available for improvements	East property line of Olympic View Middle School	Inadequate drainage from development, no easement	Maintenance
D12	Stormwater line plugged somewhere.	East property line of Olympic View Middle School	Maintenance, inadequate drainage capacity?	Maintenance
D13	There is no outfall on the system. It dead-ends at the Bell property.	Horizon Heights at the intersection of W. Horizon Dr. and E. Horizon Dr.	No outfall	Maintenance (2)
Basin E—Unnamed Ravine				
E1	Area floods due to lack of drainage. Put in a catchbasin and pipe into gulch.	53rd Avenue W, north end of street past 80th St. SW	No existing drainage	Maintenance
E2	Scour in gulch due to failed storm line.	West of Mukilteo Speedway at 80th Street SW	Erosion, storm line failed	Maintenance
E3	Structures plugged in past and caused problems	49th Place W, end of cul-de-sac & 78th Place SW	Maintenance issue or inadequate capacity?	Maintenance
E4	Always saturated but resident no longer complaining	NE of 80th Street SW & 49th Pl. SW	Inadequate drainage	Maintenance
E5	Control structure inside CB is broken	80th Street SW & 45th Avenue W	Maintenance issue	Maintenance

a. Information sources are identified as follows:
Maintenance: Interview with maintenance staff from the City of Mukilteo October 1998.
(2) indicates interview with maintenance staff June 2000.
1985 Study: 1985 Storm Drainage Study (Brown and Caldwell, 1985)
1993 Report: 1993 Storm Drainage Technical Report (Hammond, et al., 1993)

TABLE 3-1 (continued).
SPECIFIC DRAINAGE PROBLEMS

ID No.	Description	Location	Type	Source of Information[a]
E6	Driveways all flood. Unsafe sidewalk next to open ditch. Enclose ditch.	Suncrest Heights Point, Phase 1 on 44th Ave. W	Inadequate drainage	Maintenance (2)
E7	Flooding apartment lot	81st Place SW, west of SR 525	Inadequate drainage	Maintenance
E8	Possible erosion problem	South of Faraway Condo, west of 53rd Avenue W at 80th Street SW	Erosion	Maintenance
Basin F—Naketa Beach				
F1	Long run of stormwater pipe without catchbasins (Windsong Vista Div 3)	Between end of 85th Place SW & 46th Place W	No access to pipes	Maintenance
F2	Ponds on street. Springs and sheet flow contribute to flooding in the cul-de-sac.	South end of 46th Place W cul-de-sac	Inadequate drainage	Maintenance (2)
F3	Detention pond not functioning for system in F1 and F2	South of 46th Pl. W & 84th St. SW	Malfunctioning detention pond	Maintenance
F4	Private detention pond. Doesn't work. NE corner of intersection, next to roadway	53rd Avenue W & 84th Street SW	Malfunctioning detention pond	Maintenance
F5	No access to pipe. Pipe runs across private property (under a garage)	53rd Avenue W & 81st Place SW	No pipe access. No easement.	Maintenance
F6	Manhole—pipes aren't grouted into structure. Pipes are settling around manhole.	53rd Avenue W & 84th Street SW, SE corner	Unstable drainage structure, improperly constructed	Maintenance
F7	Deep ravine endangering road. Upper basin areas carry substantial water.	West of 53rd Avenue at 84th Street SW	Erosion ALREADY SOLVED	Maintenance
F8	Flooding at a condominium; improvement will require pumping flow uphill to City system	West of 53rd Avenue W	Private problem	Maintenance
F9	Upgrade pipe on north side of 84th Street SW & provide an adequate drainage path for drainage south of 84th Street SW	84th Street SW	Undersized pipes and inadequate drainage. ALREADY SOLVED	1985 Study

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Maintenance: Interview with maintenance staff from the City of Mukilteo October 1998.
(2) indicates interview with maintenance staff June 2000.
1985 Study: 1985 Storm Drainage Study (Brown and Caldwell, 1985)
1993 Report: 1993 Storm Drainage Technical Report (Hammond, et al., 1993)

TABLE 3-1 (continued).
SPECIFIC DRAINAGE PROBLEMS

ID No.	Description	Location	Type	Source of Information[a]
F10	Sheet flow (from property at 84th St. SW and 44th Ave. W to the 45th Pl. W cul-de-sac.)	North end of 45th Place West	Inadequate drainage	Maintenance (2)
Basin G—Smuggler's Gulch				
G1	Drainage from Paine Field. Small pipes have no capacity for local drainage. CH2M Hill is working on big problem.	Between 45th Pl. W & 89th Pl. SW and in cul-de-sac	Inadequate capacity	Maintenance (2)
G2	Detention pond not being maintained. (End of 45th Ave. W) City responsibility?	Highway 525 just north of 44th Avenue W	Maintenance	Maintenance
G3	Detention pipe for this development. Currently OK.	49th Ave W & 91st Ct (Village Lane)	Inadequate drainage?	Maintenance
G4	Water backs up from pond and makes swamp because not enough slope. Pond designed only for development, but gets water from Mukilteo Speedway and east of Speedway. No spillway, so pond overflows everywhere.	50th Place W and 91st Place SW	Detention pond over capacity (undersized)	Maintenance
G5	Creek needs to be cleaned out.	West of detention pond on 50th Pl. W & 90th Pl. SW	Maintenance; sedimentation problem?	Maintenance
G6	Not developed but water has no place to go. Plans exist for development?	93rd Place SW, east end of street	Inadequate drainage	Maintenance
G7	Slides from south of 53rd Avenue W to 61st Place W.	North of Sunset Lane	Erosion	Maintenance
G8	Culvert too small, frequently plugs. Spawning fish cannot pass, design for repair exists but there's no money. Possible solutions: upsize pipe, add headwall arch	61st Place W	No passage for spawning salmon. Pipe inadequately sized	Maintenance
G9	Always wet.	86th Place SW & 59th W	Inadequate drainage	Maintenance
G10	Ponding along 92nd St. SW because of a low spot with no outlet.	92nd Street SW at 50th Place W	Inadequate drainage	Maintenance (2)
G11	Inadequate capacity due to open ditch, shallow pipe, steep grade, and small pipes. Collect water on top of hill and hard-line down to the bottom.	56th Place W & Naketa	Inadequate drainage	Maintenance (2)

a. Information sources are identified as follows:
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(2) indicates interview with maintenance staff June 2000.
1985 Study: 1985 Storm Drainage Study (Brown and Caldwell, 1985)
1993 Report: 1993 Storm Drainage Technical Report (Hammond, et al., 1993)

TABLE 3-1 (continued).
SPECIFIC DRAINAGE PROBLEMS

ID No.	Description	Location	Type	Source of Information[a]
Basin H—Big Gulch				
H1	Pipe full of concrete slurry	53rd Avenue W (cul-de-sac)	Inadequate capacity.	Maintenance
H2	Gravel lined ditch eroding.	Central Drive	Erosion, possibly capacity problem.	Maintenance
H3	North bank failure.	Vicinity of access road, 95th Pl SW, Big Gulch ravine	Erosion	1993 Report
H4	South bank sloughing	South of 85th Place W. Big Gulch ravine	Erosion	1993 Report
H5	Scattered trash near outfall to Big Gulch	East of 102nd Pl SW & 48th Ave W	Maintenance	1993 Report
H6	Water freezes and pose hazard to traffic	102nd Pl SW & 48th Ave W	Maintenance COMBINED w/H5	1993 Report
H7	Drainage from Columbia Elementary School walkway flows into school's crawl space and yard.	5302 104th St SW	Inadequate drainage	1993 Report
H8	Eroding ravine near 54-inch outfall	Outfall	Erosion	1993 Report
H9	Bluff above Big Gulch sloughed in the past, but was stabilized with retaining wall. Bluff may slough more in future. Stormwater from home directed wrong way.	9804, 9806 Marine View Drive	Possible erosion problem, stormwater directed the wrong way	1993 Report
H10	Existing road drainage system discharges onto lawn of 6310 64th Place; water flows across yard to native growth protection area.	6310 64th Place	Existing road drainage outfalls onto lawn.	1993 Report
H11	Elephant pipe that has been temporarily repaired. Low spot flows over road and into pipe.	Webster Way and 63rd Place W	Damaged drainage structure	Maintenance
H12	Sheet flow over all properties west of 63rd Place W	West of 63rd Place W and south of 92nd Street SW	Inadequate drainage	Maintenance

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Maintenance: Interview with maintenance staff from the City of Mukilteo October 1998.
(2) indicates interview with maintenance staff June 2000.
1985 Study: 1985 Storm Drainage Study (Brown and Caldwell, 1985)
1993 Report: 1993 Storm Drainage Technical Report (Hammond, et al., 1993)

TABLE 3-1 (continued).
SPECIFIC DRAINAGE PROBLEMS

ID No.	Description	Location	Type	Source of Information[a]
Basin I—Chennault Beach				
I1	City detention pond has flooded in past.	59th Avenue between 106th Street & Kay Way	Malfunctioning detention pond. SOLVED	Maintenance
I2	Pipe from street right of way.	Central Drive and Chennault Beach Drive	ALREADY SOLVED	Maintenance
I3	Deep ditches are a safety issue	Canyon Drive	Safety issue	Maintenance (2)
I4	Driveway culvert made out of 5-gallon buckets with end cut out.	Canyon Drive east of 62nd Pl W, north side of street	Improper drainage structure	Maintenance
I5	Pipe abandoned in place.	Marine View Drive just south of 66th Place W.	Not a problem at present	Maintenance
I6	Backyard drainage problems, no easements. Problem throughout area.	West side of basin	Inadequate drainage on private lots. No easements	Maintenance
I7	Standing water in roadside ditch is seeping under road and undermining bluff on other side. Spring surfaces between lots 10413 and 10423. Basements flooding on west side of road, and bluff is sloughing 15 feet from top.	10413 & 10423 Marine View Drive	High water table, natural spring ALREADY REPAIRED	1993 Report
I8	12-inch storm outfall between 10324 & 10332 Marine View Drive causing erosion of bluff. Water from roadside ditch seeped under road and flooded lot 10324 basement.	Between 10324 & 10332 Marine View Drive	Stormwater from outfall eroding bluff ALREADY REPAIRED	1993 Report
I9	Possible ground water seepage and bluff erosion	10200 Marine View Drive	High water table, erosion of bluff ALREADY REPAIRED	1993 Report
I10	Groundwater seepage at 5919 Central Drive; water disappears in roadside ditch, flows through rockery and over bluff.	5919 Central Drive	Inadequate ditch, pipe needed to convey flow?	1993 Report

a. Information sources are identified as follows:
Maintenance: Interview with maintenance staff from the City of Mukilteo October 1998.
(2) indicates interview with maintenance staff June 2000.
1985 Study: 1985 Storm Drainage Study (Brown and Caldwell, 1985)
1993 Report: 1993 Storm Drainage Technical Report (Hammond, et al., 1993)

TABLE 3-1 (continued).
SPECIFIC DRAINAGE PROBLEMS

ID No.	Description	Location	Type	Source of Information[a]
I11	Ditch along north side of 66th Place Drive by lot 10505 badly eroded. Catchbasin by 10514 66th Place Drive is in wrong place, missing flow.	66th Place Drive by lots 10505 and 10514	Drainage structures not located correctly to catch runoff. Erosion problems.	1993 Report
I12	Sidewalk settlement due to incomplete roof drain connection to street storm drainage system at 10429 59th Avenue W.	10429 59th Avenue W	Inadequate roof drain connection to street	1993 Report
I13	Existing storm outfall pipe needs to be replaced.	10028 Marine View Drive	Malfunctioning outfall pipe ALREADY SOLVED	1993 Report
I14	Stormwater backs up at 12-inch pipe and overflows existing catchbasin along Marine View Drive, diverting water into yard of lot 10418. New outfall needed.	10418 Maine View DR.	Capacity problem. ALREADY SOLVED	1993 Report
I15	Inadequate wooden catchbasins by lot 10430 62nd Place W. No method of conveyance for drainage along west side of 62nd Place W.	10430 62nd Pl W	Inadequate conveyance, no drainage structures on west side of street.	1993 Report
I16	Groundwater seeps through sanitary sewer, surfacing on property.	9825 Marine View Drive	Groundwater seepage into sanitary sewer	1993 Report
I17	Runoff from uphill roof drains not connected to storm sewer system, floods property	59th Avenue W—10429 59th Avenue W	PRIVATE PROBLEM	1993 Report
I18	Cul-de-sac floods. No drainage system.	North end of 64th Place W	Inadequate drainage	Maintenance
I19	Pipe collapsing or groundwater transporting the pipe bedding material. Creating pond on 59th Ave. W.	Canyon Drive & 59th Avenue W	Damaged drainage pipe	Maintenance
Basin J—Upper Chennault Creek				
J1	Pipes under building – a note only	Not a problem	None	Maintenance

a. Information sources are identified as follows:
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1985 Study: 1985 Storm Drainage Study (Brown and Caldwell, 1985)
1993 Report: 1993 Storm Drainage Technical Report (Hammond, et al., 1993)

TABLE 3-1 (continued).
SPECIFIC DRAINAGE PROBLEMS

ID No.	Description	Location	Type	Source of Information[a]
(J2)	8-inch line through middle of yards backs up. Outlet over steep bank of Upper Chennault Creek badly eroding bank. Private System	West of Chennault Beach Drive and Marine View Drive	Inadequate drainage capacity, erosion problems	1993 Report
Basin M—Picnic Point				
M1	Erosion from outfall. Water from outfall flows along road into creek. Road is eroding causing siltation in creek.	126th Street SW cul-de-sac, in ravine below	Inadequate roadside ditch capacity causing erosion	1993 Report
M2	Several culverts make fish passage difficult.	126th Street SW and 49th Ave W	Inadequate fish passage through culverts	1993 Report
M3	Major landslide area.	South of Harbor Beach Drive and Harbour Pointe Blvd.	Erosion	1993 Report
M4	Vehicular traffic across creek bed.	West of Cyrus Way, upper end of creek	Water quality, erosion, stream degradation, and no culvert.	1993 Report
(M5)	Eroding retention pond outside city limits. Pond is silting in stream and walls of pond are eroding.	SR525 and south end east side of road	Malfunctioning detention pond outside city limits. Sedimentation in creek downstream.	1993 Report
M6	Silt deposition at outfall of 42-inch pipe into ravine	Harbor Beach Drive & Harbour Pointe Blvd.	Stream sedimentation, erosion upstream	1993 Report
(M7)	Water coming up from under sidewalk in front of property.	13131 42nd Avenue West	Private problem	1993 Report
(M8)	Water level high in two open space tracts in Possession Bay Highlands residential areas, caused water to sit in residence crawl spaces.	South of Harbor Heights Drive, east of 4th Pl W	High water table	1993 Report
M9	Brackish water from culvert under Mukilteo Speedway.	Mukilteo Speedway	Water quality issue, erosion upstream?	1993 Report

a. Information sources are identified as follows:
Maintenance: Interview with maintenance staff from the City of Mukilteo October 1998.
(2) indicates interview with maintenance staff June 2000.
1985 Study: 1985 Storm Drainage Study (Brown and Caldwell, 1985)
1993 Report: 1993 Storm Drainage Technical Report (Hammond, et al., 1993)

CITY OF MUKILTEO

4480 CHENNAULT BEACH ROAD • MUKILTEO, WASHINGTON 98275

October 12, 2000

Residents of the City of Mukilteo

Re: Comprehensive Surface Water Management Plan
Request for Information

Dear Resident:

Over the past three (3) years the City of Mukilteo has been examining our current storm drainage system in order to prepare a Comprehensive Surface Water Management Plan which will outline the future operation, maintenance, and improvements of the storm drainage system. We believe that through this process we have identified and compiled the majority of the existing storm drainage concerns within the City.

At this time we are requesting your help to identify all known drainage concerns within the City Right-of-way and/or private property. The information you provide will be included on our master list of possible future projects. Once we have a complete list, projects will be scheduled and completed according to a defined priority system. All projects on the list may not be resolved quickly or at all due to limited funding.

Please complete and return the enclosed survey by Friday, October 27th. We appreciate your effort in helping us with this long and arduous process.

Sincerely,

Thomas E. Hansen, P.E.
Public Works Director

pc: Project/Correspondence File

CITY OF MUKILTEO

4480 Chennault Beach Road, Mukilteo, WA 98275

City of Mukilteo, Washington

Storm Drainage Request

Contact Information

Name: ______________________________

Address: ______________________________

____

Daytime Phone: ______________________________

Storm Drainage Problem Information

Location: ______________________________

____

Brief Description (ex. Water Flowing onto Private Property from City Street, Standing Water, Nonfunctioning Storm Drainage, etc.): ______________________________

____

Occurrence (ex. After 2 Days of Heavy Rainfall, After Light Rainfall, Consistently, etc.):

____

____

Impacts (ex. Water Over Road or Sidewalk Impacting Vehicles or Pedestrians, Flooding of Yards or Homes, etc.): ______________________________

____

Is the safety of the public at risk? ☐Yes ☐No. If yes, please explain: ______________________________

____

____

**Please feel free to attach additional pages if needed.*

DEVELOPMENT OF ALTERNATIVE SOLUTIONS

With the identification of drainage problems comes the need to solve them. This section reviews a range of methods that may be used to address Mukilteo's surface water problems, examines potential beneficial and adverse effects, and provides some general component cost estimates.

Overview of Surface Water Management Techniques

Solutions to current and future flooding problems in Mukilteo will require a combination of nonstructural and structural approaches. Nonstructural solutions include regulations regarding development in sensitive areas, density restrictions, enforcement policies, and buffer zones to protect sensitive areas. These are summarized below and discussed in more detail in Chapter 19 on regulatory compliance and Chapter 20 on recommended non-structural measures. Structural solutions include construction of facilities, such as detention structures, relocation of existing structures, and improvement or enlargement of existing channels.

Structural Methods

Structural alternatives include projects such as improved conveyance systems and detention facilities. A conveyance system is made up of large and small channels, culverts, and storm drain pipelines; improvements include activities such as building overflow channels, adding additional capacity, or increasing system efficiency. These facilities, with a description of its purpose, how it functions and its impact, are listed below. Facilities for the improvement of water quality are also discussed. Table 3-2 summarizes the intended benefits of the structural stormwater control methods described in this section. Table 3-3 identifies the potential adverse impacts and environmental enhancements associated with the structural alternatives.

TABLE 3-2.
BENEFITS OF STRUCTURAL STORMWATER MANAGEMENT METHODS

	Intended Benefits					
Management Method	Reduce Peak Flows	Reduce Backwater Flooding	Increase Conveyance Capacity	Reduce Standing Water	Reduce Channel Erosion	Improve Water Quality
Increase Culvert Size		*primary*	*primary*	*secondary*		
Steep Slope Pipelines					*primary*	*secondary*
Storm Drainage Pipelines			*primary*	*primary*		
High Flow Bypass Pipelines			*secondary*		*primary*	
Stream Bank Stabilization					*primary*	*primary*
Stormwater Detention Site	*primary*					*secondary*
Pipeline Outfall Control					*primary*	*secondary*

TABLE 3-3.
IMPACT OF STRUCTURAL STORMWATER MANAGEMENT METHODS

Management Method	Potential Impact				
	Fish Resources	Wildlife Resources	Scenic, Aesthetic, Historic Resources	Water Quality	Hydrology Hydraulics
Increase Culvert Size	*3,7*	*7*	*0*	*3*	*1*
Steep Slope Pipelines	*0*	*0*	*5,7*	*3*	*2*
Storm Drainage Pipelines	*0*	*0*	*0*	*0*	*2*
High Flow Bypass Pipelines	*7*	*7*	*7*	*0*	*2*
Stream Bank Stabilization	*3,4,7*	*3,4,7*	*3*	*3,7*	*0*
Stormwater Detention Site	*3,4*	*3,4*	*5*	*3*	*0,7*
Pipeline Outfall Control	*0,7*	*0*	*0*	*3,7*	*0*

Impacts:

0. No significant impact
1. Larger culvert may increase flow to downstream reach
2. May increase flow rate to receiving water
3. Short-term impact during construction
4. Possible impact on habitat
5. Possible visual impact
6. Loss of water source to natural floodplain and habitat
7. Potential environmental enhancement

Conveyance Facilities

Culverts

The installation of new or replacement culverts in stream channels at road crossings is one method of increasing flow capacity and reducing the potential for upstream flooding. When culverts are too small to convey the design flow, stormwater backs up behind the roadway. This is normally not acceptable if there is a danger of the road failing or if upstream structures are being damaged by floodwaters. By increasing the size or number of culverts, the possibility of upstream damage and road failure is reduced and the ability of fish to migrate upstream is increased. One potential negative effect from increasing the conveyance is the potential for additional downstream flooding caused by the loss of the existing active storage immediately upstream of the roadway.

Steep Slope Pipelines

On steep erosive slopes, high density polyethylene (HDPE) pipes can be used to convey stormwater to the bottom of the steep slope in place of an open channel. These pipes can efficiently convey large quantities of water on much steeper slopes than can conventional concrete or metal pipes. They also can be welded into one continuous pipeline and can be installed directly on top of the existing ground, thereby avoiding the need to disturb the existing site. Installation of these pipes is expensive, but much cheaper than other structural solutions to prevent erosion caused by increased stormwater runoff on steep slopes.

At the upstream end of the pipe, a control structure is needed to fix the pipe in place and to back the water up to a sufficient depth to allow the design flow to enter the pipe. At the downstream end of the pipe, an energy dissipater is needed to prevent erosion and to stabilize the end point of the pipe. Normally, several anchors are installed along the length of the pipe to maintain its alignment and prevent it from flexing uncontrollably.

Storm Drain Pipelines

Underground storm drain lines are commonly installed to convey stormwater runoff from urban developments to a receiving body such as a lake, river, or stream. Small pipes are inexpensive to install, but may result in frequent flooding. This can be alleviated by installing pipelines of adequate size to convey larger design flows. Installation of new pipelines in developed areas is always more expensive and disruptive than the installation of pipelines in an undeveloped area.

Storm water cannot flow uphill, so storm drains work only where there is adequate gradient to maintain flow rates and keep the pipe from filling with sediment. Typically, these lines are installed in road right-of-ways, so there is little land acquisition cost, although some temporary easements may be required.

Bypass Pipelines

Bypass pipelines are used to convey flows that existing channels or pipelines cannot handle without flooding or erosion. They are used only during times of high flow to safely divert floodwaters around constrictions in channels, existing pipelines, or sensitive areas. By eliminating the erosion, valuable habitat can be saved. A control structure is needed at the upstream end to ensure that normal flows enter the pipeline, but that flood flows are diverted to the bypass pipeline. In addition, a bypass pipeline can be used to decrease the size of required detention facilities, or even eliminate them. Piping all of the runoff from a new or existing development until it can safely enter a stream or Puget Sound can accomplish this.

Stream Bank Stabilization

Eroding stream banks can be stabilized by a variety of methods to prevent the loss of economically valuable land, the loss of valuable habitat, or the addition of undesired sediments into the stream system. Bioengineered designs that emphasize the use of native vegetation are generally preferred over the armoring of stream banks with riprap, concrete, or gabions. This is because of the potential increase of riparian habitat when bioengineered designs are used instead of the other techniques. Also, they are typically much less expensive to build and maintain. Habitat improvement features are much more easily incorporated into bioengineering methods than into the more standard type of engineered bank stabilization. This is an important consideration whenever construction on a salmonid stream is considered.

Detention Facilities

The temporary storage of floodwaters in detention or retention facilities can result in a wide range of flood-modifying effects. The effects include a reduction in peak flow rates, the extent of flooded area, and downstream erosion potential; changed timing of flood peaks; and an opportunity to provide water quality treatment by deposition of sediment.

Detention Facilities

Detention facilities are constructed for any one or a combination of the above reasons. By providing detention upstream of an inadequate conveyance system and reducing the peak flow rate, the need for upgrading or replacing the conveyance system can be eliminated. If the land is available, this is frequently a less expensive option than installing new pipes, and is preferred due to the multiple benefits possible. Detention basins can also be used to mitigate stormwater runoff downstream of development, reducing peak flows before being discharged into a creek or over a steep slope.

Detention facilities can be constructed either in the stream channel or at a site not located within a riparian corridor (off-channel). Both options can be effective. Although in-stream sites are attractive because they make use of existing flooded lands, disadvantages include the requirements for fish passage, potential disturbance of habitat, and the associated permits required for construction and maintenance. Siting of off-channel sites is more flexible, but may require a great deal of excavation to create an effective storage volume.

All detention facilities require the construction of an outlet flow control structure, an emergency spillway, possibly the excavation of additional storage volume, revegetation of the site once construction is complete, and frequently a dike or dam to contain the water within the facility.

Water Quality Control Measures

Pipeline Outfalls

Reconstruction of existing stormwater pipeline outfalls to rivers, lakes, and streams to provide improved water quality may include the addition of energy dissipaters, oil-water separators and grass-lined swales. Some of these devices, especially some types of oil-water separators, are expensive to install, but will provide significant water quality benefits if properly maintained. Grass-lined swales and oil-water separators work best with low flows, and may be more effective at the collection points rather than at the outfalls of the pipe systems.

Cost Estimates

A significant element of selecting a proposed solution is the cost associated with implementing it. Table 3-4 provides an estimate of the unit costs for the components to provide the structural items discussed in this section. These are intended to provide a planning level estimate; actual costs are affected significantly by the quantity required for each project. The costs are derived from recent projects in the Puget Sound region and do not include design, contingency, or land acquisition costs that may be necessarily incurred.

TABLE 3-4.
ESTIMATED COSTS OF COMMON STORMWATER STRUCTURAL COMPONENTS

ITEM	UNITS	COST	COMMENTS
Drainage Elements			
96" Storm Drain, RCP - Installed	LF	$590	All RCP cost estimates include
84" Storm Drain, RCP - Installed	LF	$520	catch basins every 300 feet,
72" Storm Drain, RCP - Installed	LF	$440	utility relocation, shoring, and
60" Storm Drain, RCP - Installed	LF	$370	6" AC surface restoration
54" Storm Drain, RCP - Installed	LF	$330	
48" Storm Drain, RCP - Installed	LF	$300	
42" Storm Drain, RCP - Installed	LF	$240	
36" Storm Drain, RCP - Installed	LF	$220	
30" Storm Drain, RCP - Installed	LF	$180	
27" Storm Drain, RCP - Installed	LF	$160	
24" Storm Drain, RCP - Installed	LF	$150	
21" Storm Drain, RCP - Installed	LF	$140	
18" Storm Drain, RCP - Installed	LF	$130	
15" Storm Drain, RCP - Installed	LF	$107	
12" Storm Drain, RCP - Installed	LF	$100	
Manhole - 48" Diameter - 12' std height	EA	$3,300	use for up to 24" pipe
Manhole - 54" Diameter - 12' std height	EA	$4,300	use for 27" and 30" pipe
Manhole - 60" Diameter - 12' std height	EA	$5,300	use for 36" pipe
Manhole - 72" Diameter - 12' std height	EA	$7,100	use for 42" and 48" pipe
Manhole - 84" Diameter - 12' std height	EA	$8,800	use for 54" pipe
Manhole - 96" Diameter - 12' std height	EA	$11,000	use for 60" pipe
Manhole - 108" Diameter - 12' std height	EA	$16,500	use for 72" pipe
Manhole - 120" Diameter	EA	$22,000	use for box sections
Manhole Extra Depth (greater than 12 feet)	VF	$330	regardless of manhole size
18" Force Main, DI - Installed	LF	$140	
18" Force Main, DI - Jacked With Casing	LF	$410	
42" Storm Drain, RCP - Jacked With Casing	LF	$590	
8' X 4' Precast Box Section - Installed	LF	$610	
10' X 4' Precast Box Section - Installed	LF	$830	
Dewatering	LS	$2-5,000	depending on depth
Traffic Control	LF	$5	assumes $30/hr and 0.15 hr/lf
Temporary Erosion Control	LS	5%-10%	
Pipeline Incidentals	LS	5%-10%	a factor used to account for unexpected issues specific to pipeline construction.
Streambed Stabilization			
Boulder Streambank Protection	LF	$50	2-man rock
Log Deflector	EA	$1,300	18" diameter fir, spruce or cedar
Bank Log	EA	$1,800	
Log Weir	EA	$3,500	2-3 man rock
Rock Weir	EA	$2,500	

TABLE 3-4. (continued)
ESTIMATED COSTS OF COMMON STORMWATER STRUCTURAL COMPONENTS

ITEM	UNITS	COST	COMMENTS
Slope Stabilization			
Light Loose Riprap	CY	$100	
Hand Placed Riprap	CY	$100	
Hydroseed	SY	$5	
Jute Matting	SY	$1	
Coir Matting	SY	$5	
Cabled Concrete Matting	SY	$5	
General Items			
Asphalt Overlay, Class B	SY	$5	
Pump Station - 70 CFS	CFS	$525,000	extrapolated from existing proj.
Pump Station - 100 CFS	CFS	$75,000	extrapolated from existing proj.
Plug And Abandon Existing Pipe	EA	$200	
Outfall (Headwall And Flap Gate)	LS	$55,000	lump sum, regardless of pipe size
Flap Gate - Installed, 60"	EA	$13,300	
Flap Gate - Installed, 48"	EA	$8,500	
Flap Gate - Installed, 42"	EA	$6,400	
Flap Gate - Installed, 30"	EA	$4,400	
Flap Gate - Installed, 24"	EA	$3,400	
Removal Of Existing Pipe	LF	$10	
Embankment Armoring (Rip Rap)	CY	$80	
Quarry Spalls	TN	$40	
Detention Ponds			
Clearing And Grubbing	AC	$5,000	
Excavation Using Large Equipment	CY	$10	scrapers; used for projects greater than 2 surface acres
Excavation Using Small Equipment	CY	$10	excavators, 'dozers, etc.; accounts for more detailed earthwork at small sites
Disposal Of Unsuitable (Excess) Material	CY	$5-$10	higher cost associated with wetland soils or saturated soils
Embankment Construction	CY	$40	including material, transportation, and compaction
Maintenance (Access) Road	LF	$30	assume 12 foot wide gravel road
Hydroseed Disturbed Areas	SY	$5	
Perimeter Fence	LF	$10	
Imported Topsoil	CY	$20	one foot thick layer over entire project; includes compaction and shaping
Straw Blanket Mulch	SY	$5	for permanent slope stabilization
Bottom Treatment (Clay Liner)	CY	$20	assume 1 foot thick bentonite clay layer

TABLE 3-4. (continued)
ESTIMATED COSTS OF COMMON STORMWATER STRUCTURAL COMPONENTS

ITEM	UNITS	COST	COMMENTS
Mitigation Landscaping (Commercial)	LS	$22,000	landscaping requirements for screening and project mitigation
Mitigation Landscaping (Residential)	LS	$110,000	landscaping requirements for screening and project mitigation
Outlet Control Structure	LS	$10,000-$20,000	
Sedimentation Pond	LS	10%	
Wetland Plantings	AC	$37,500	assume individual plug plantings
Detention Pond Incidentals	LS	10%	
Dewatering	LS	5%	
Temporary Erosion Control	LS	10%	includes channel diversion
Wetland Mitigation	AC	$44,000	does not include associated property acquisition
Wet Ponds			
Same Line Items As For Detention Ponds With The Following Exceptions:			
Wetland Plantings	AC	$37,500	assume wetland plantings over entire pond bottom
Excavation Using Small Equipment	CY	$20	backhoes, 'dozers, etc for fine grading of water quality facilities
Infiltration Ponds			
Same Line Items As For Detention Ponds With The Following Exceptions:			
Imported Gravel Backfill	CY	$40	one foot layer over entire pond bottom
Biofiltration Swales			
Clearing And Grubbing	AC	$5,000	
Channel Excavation	CY	$20	tight locations
Channel Fill	CY	$5	
Disposal Of Unsuitable (Excess) Material	CY	$5-$10	
Underdrain	LF	$20	installation of perforated pipe system
Imported Topsoil	CY	$20	one foot thick layer over entire project; includes compaction and shaping
Biofiltration Wetland Plantings	AC	$37,500	assumes use of emergent wetland plugs at 2' o.c. for wet swales
Biofiltration Seeding And Establishment	AC	$11,000	assumes use of grass seed and/or sod for dry swales
Inlet/Outlet Control	LS	$22,000	flow spreader
Permanent Erosion Control	SY	$5	geotextile fabric
Temporary Erosion Control	LS	10%	includes channel diversion
Landscape Plantings	LS	5%	

TABLE 3-4. (continued)
ESTIMATED COSTS OF COMMON STORMWATER STRUCTURAL COMPONENTS

ITEM	UNITS	COST	COMMENTS
Infiltration Trenches			
Same Line Items As For Detention Ponds With The Following Exceptions:			
Trench Excavation	CY	$10	
Native Backfill/Compaction	CY	$10	
Manhole - 48" Diameter	EA	$3,300	
Surface Restoration (Sodding)	SF	$5	
Drain Rock	CY	$30	
Disposal Of Unsuitable (Excess) Material	CY	$5-$10	
Underdrain	LF	$20	
Hydroseed Disturbed Areas	SY	$5	
Flow Spreader (Inlet Control Structure)	LS	$11,000	
Landscaping	LS	$5,500	
Pretreatment	LS	10%	
Add Ons (Percentages Added Onto Entire Project)			
Contingency	LS	35%	
Mobilization	LS	8%	
Sales Tax	LS	8.8%	
Property Acquisition	LS	Variable	provided by city staff
Engineering, City Admin, Construction Mngmt	LS	35%	
Wetland Delineation For Pond Construction	LS	Variable	
Permitting For Pond Construction	LS	5%	
Outfall Permitting	LS	5%-15%	

CHAPTER 4.
HYDROLOGIC / HYDRAULIC ANALYSIS

This chapter presents an overview of the hydrologic and hydraulic analyses performed for each of the City's drainage basins. The approach is described and significant elements, such as rainfall and effective impervious area, are defined. The modeling results are presented in subsequent chapters.

MODELING APPROACH

In order to evaluate the hydraulic capacity and hydrologic process in Mukilteo, simulation models were generated to predict the current and future runoff. Because of its ability to simulate backwater conditions and urban systems containing both culverts and open channels, XP's Stormwater Management Model (XPSWMM) was selected to conduct these analyses.

Storm Drainage Inventory and Data Sources

To model the drainage basins, XPSWMM uses actual system configuration characteristics, so it is necessary to collect storm drainage inventory data, including culvert locations, pipe sizes, pipe materials, invert elevations, slopes, and cross sections for the creeks and ravines receiving most of the City's runoff. A comprehensive inventory of the City's storm drainage network was not available for use in modeling at the beginning of the planning effort; therefore, a variety of sources were utilized to collect the information required.

A map in the City archives provided plan view pipe and creek locations, as well as limited pipe diameter information, for the area of the City known as Old Town (approximately all of the City north of Big Gulch). The map was originally hand drawn and has not been updated to reflect capital improvements undertaken by the City over the years. In this report, this map is referred to as the Old Drainage Map (ODM).

Most development in the basins south of Old Town predates the incorporation of that area. The City obtained available record drawings from Snohomish County when the area was annexed and has since required drawings for new development, but many areas remain undocumented. City staff began preparing a plan view showing locations of catchbasins, manholes, culverts, and major drainage pathways on a parcel map, but this has not been completed. None of the mapping contains invert elevations. In this report, the City's map is referred to as the Plan View Parcel Map (PVPM). Although available electronically, this map is not at a consistent scale.

Inventory data were taken from the ODM or PVPM where current. Additional details, such as pipe size or invert elevation, were collected from as-built drawings if available. Field visits were conducted to verify and supplement construction records and to obtain invert elevations as required. Where storm drainage facilities cross private property or busy streets or are inaccessible (e.g., in a steep ravine) and no as-built information exists, information was estimated based on adjacent conditions and standard installations.

In 1998, the City obtained aerial photographs covering the entire town. From these, Walker and Associates generated electronic files containing roads, structures, and 2-foot elevation contours. These maps were used to determine cross-sections of significant creeks and ravines and to estimate invert elevations when necessary. Additional sources of information include the 1986 Federal Emergency Management Agency (FEMA) flood insurance study, previous stormwater studies, and reports from the U.S. Geological Survey (USGS).

Appendix C contains a schematic of each model and a list of the associated conveyance network elements.

Simulation Models

Drainage systems are often modeled using the U.S. Environmental Protection Agency's (EPA) Stormwater Management Model (SWMM). The current version, 4.03, is particularly applicable to urban drainage systems. It can simulate unit hydrograph runoff from pervious and impervious surfaces and perform dynamic flow routing through an interconnected network of storm sewers under surcharged flow conditions.

For this report, the drainage system was modeled using XPSWMM Version 6.1. This program's algorithms are similar to those of SWMM, but its computational accuracy is improved. XPSWMM also uses a graphical interface to illustrate the conveyance system. Input and output data for the two programs are similar. Both use input data on rainfall and drainage basin features to predict runoff volume and flow through the drainage facilities. Modules of the program that were used for this analysis are the RUNOFF module, which predicts the volume of runoff over the course of a storm event, and the HYDRAULICS module, which models flow through drainage facilities. A detailed description of these modules is provided in Appendix D.

Current Conditions

The typical approach in XPSWMM modeling is to include all pipes 12 inches or more in diameter, although some are omitted if high in the basin or subbasin, where there is a small tributary drainage area and resulting low flows. This approach generally represents the public conveyance system; smaller pipes are frequently used for private connections, low flows, or individual structures like catch basins. Private systems, such as pipes located on private property, in parking lots, and in shopping centers, are not included since they are tributary to the trunk system and are commonly not well documented. In cases where significant pipe segments or open channels do cross private property, they were included in the model.

Detention facilities were not included in the hydraulic analyses although some areas with significant storage were modeled if visible in the two-foot contour data. Modeling the system without detention is a conservative approach for capacity evaluation since unattenuated peak flows are routed through the conveyance network. This also represents the worst case scenario of unmaintained ponds.

In order to examine the storm flows in the city at present, a current conditions analysis was performed based on the existing conveyance network and land use. This provides a baseline for comparison with future conditions or alternative measures. The model utilized a historically based regional design rainfall and a empirical rainfall distribution.

Rainfall

XPSWMM is an "event" model that simulates stormwater runoff into the conveyance system in response to a single storm event. The XPSWMM model simulates rainfall over the course of a 24-hour storm using an empirical distribution. For the Mukilteo area, the Natural Resources Conservation Service (NRCS, formerly the Soil Conservation Service or SCS) has adopted a storm rainfall designated as a Type IA distribution. In the Type IA distribution, a large percentage of the precipitation occurs within a 90-minute period. This results in simulated flows that rise very quickly to a peak and then just as quickly drop off. Single event models, such as XPSWMM are appropriate for use in estimating peak flows and evaluating conveyance capacity because the hydrographs produced are steeper (more conservative) than what historical rainfall records would produce. The Type IA rainfall distribution was designed for this purpose.

More detailed hydraulic/hydrologic modeling is often undertaken once a need for a stormwater control facility, such as a detention pond, is identified. One approach is to use "continuous" modeling, such as the USGS's HSPF model, which simulates historical rainfall over a longer time period. Continuous modeling, as HSPF provides, is appropriate during final design of any facility, once the layout is completed and more definitive information on the site conditions is available. The large-scale project recommendations in this plan would benefit from continuous modeling during design development in the future.

The 24-hour duration rainfall totals are shown in Table 4-1 and plotted in Figure 4-1. The 2-, 10-, 25-, and 100-year rainfall events are from the National Oceanic and Atmospheric Administration Atlas 2, Volume IX (Miller, et al, 1973); the 6-month event is defined as two-thirds of the 2-year event.

TABLE 4-1.
24-HOUR DESIGN RAINFALL

Return Period (years)	Rainfall Depth (inches)	Return Period (years)	Rainfall Depth (inches)
6-month	1.0	100-year	3.3
2-year	1.5	200-year	3.9
10-year	2.2	500-year	4.4
25-year	2.6		

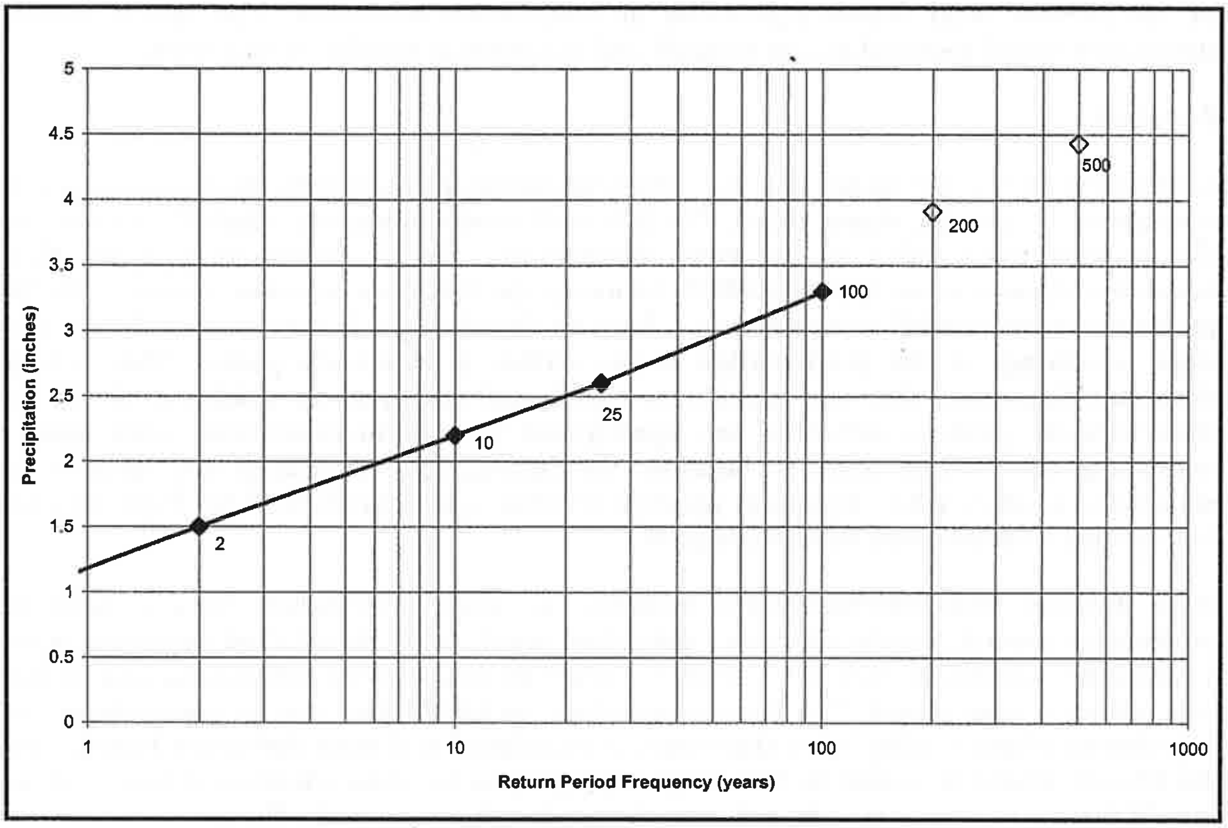


Figure 4-1. Statistical Rainfall Amounts

Current Land Use

Land use information is used to estimate impervious surface coverage. As ground is covered with impervious surfaces such as buildings and pavement, rainfall cannot infiltrate into the soil and, instead, stays on the surface as runoff. Typically in a comprehensive plan, the land uses that exist at the time the plan is written are denoted as the existing or current land use condition. Future land use conditions, also referred to as full buildout conditions, are generally determined from zoning maps or comprehensive land use maps. For this study, current land use was determined from aerial photos, digital orthography, and field visits. Table 4-2 lists typical effective impervious values for usual land use categories.

Effective imperviousness represents the amount of impervious area that actively contributes to runoff. For example, if a house's downspouts are not connected to the storm drain network and instead run out onto the lawn where runoff infiltrates or is slowed considerably, the effectiveness of the roof as a runoff producer is reduced. Effectiveness of impervious surfaces varies with the degree of urbanization or development. As urbanization increases, the total impervious area increases and the hydraulic connectivity of these surfaces to stream channels improves; therefore, the 'effectiveness' of surface runoff to quickly become streamflow increases.

TABLE 4-2.
EFFECTIVE PERCENT IMPERVIOUS VALUES

Land Use	Effective Percent Impervious
Open Space	2%
Parks and Recreation	5%
Schools (Public Use)	35%
City Hall/Community Center	60%
Single Family Residential (1-4 units/acre)	31%
Moderate Density Residential (5-6 units/acre)	36%
Medium Density Multi-Family (10-15 units/acre)	48%
High Density Multi-Family (20-25 units/acre)	48%
Business District	65%
Business or Industrial Park	70%
Light Industrial	85%
Heavy Industrial	90%

Future Land Use

To evaluate the change in water quantity from future development, the future stormwater flows were estimated for the City of Mukilteo based on the zoning map representing future, 'build-out' conditions (adopted in September 1997). The XPSWMM models were modified to analyze future conditions for each of the basins in Mukilteo using the zoning map to determine the anticipated development density in the future. Table 4-3 shows the percent imperviousness applied for each of the zoning categories. Similar Mukilteo categories were combined.

TABLE 4-3.
PERCENT IMPERVIOUSNESS BY LAND USE ZONE

Zoning Category	Effective Impervious	Includes zones
RD 20.0	20 %	RD 20.0
RD 12.5	30 %	RD 12.5, RD 12.5(S)
RD 9.6	30 %	RD 9.6, RD 9.6(S)
RD 8.4	30 %	RD 8.4
RD 7.5	40 %	RD 7.5
RD 7.2	40 %	RD 7.2, WFB
Multifamily Residential	50 %	MRD, MR
Business District	65 %	DB, CB, CB(S), PCB, PCB(S), BP, PSP
Industrial	90 %	PI, OP, LI, HI
Open Space	0 %	RUD, OS

It was assumed that the subbasin boundaries created for the current conditions analysis adequately represent future conditions. Subbasin impervious percentages were calculated using a weighted average based on area of each zoning category.

The effective impervious percentage based on the zoning was used for all future land use definitions. This resulted in some subbasins with decreased imperviousness in the buildout (future) condition. In order to maintain consistency across the basins, the zoning areas were used exclusively. A sensitivity study on one basin showed no significant flow changes due to the reduced 'future' impervious percentage. The specific subbasins where this occurred are described in the individual basin chapters.

The following chapters provide the basin description and modeling results for each of the basins in the City of Mukilteo. This is followed by a discussion of criteria to prioritize the identified problems, capital improvement plans as a function of program length, rate structures for funding, and a non-structural measures program for water quality management.

CHAPTER 5.
BASIN A—EDGEWATER CREEK AND BASIN B—JAPANESE GULCH

Edgewater Creek is the main conveyance facility for Basin A, which lies almost entirely within the City of Everett. The ravine starts just south of the intersection of Sound Avenue and 56th Street SW and is approximately 3,500 feet long, conveying runoff to Puget Sound. According to the digital topography, the ravine is 70 feet deep on average, with a side slope of about 40 percent for most of its length. The outfall for this basin is located within a restricted access area of the military reservation. Basin A is mainly residential development, with a commercial development in the south half of the basin. No model was developed for Basin A because only the outlet is within Mukilteo.

Japanese Gulch is the main conveyance facility in Basin B, and the majority of this basin lies outside the city limits. The ravine is approximately 10,000 feet long and 100 to 200 feet deep on average, with a side slope of about 40 percent for most of its length. The ravine begins just north of State Route 526 and continues north, just west of a railroad spur for Boeing, eventually conveying runoff into Puget Sound. The outfall for this basin is also located within a restricted access area of the military reservation. The southern portion of the basin includes a portion of the Boeing complex, which lies east of the ravine. The west portion of the complex conveys runoff to Basin B. The north portion of the basin is mostly undeveloped, but has some residential development near Puget Sound.

The Japanese Gulch basin was divided into 9 subcatchments shown in Figure 5-1. With no culvert information, the model was based on topographic mapping with 2-foot contours. It was assumed that surface water runoff from the Boeing complex in the southern part of the basin was routed overland to a small stream east of the runway, which flows under Highway 526. The culvert under Highway 526 was modeled as a 5-foot diameter concrete pipe, based on field observation by Snohomish County. As a conservative estimate of flow, the detention facilities were not modeled.

Downstream of the Boeing complex, Japanese Gulch meanders for approximately 8,500 feet beside the railroad tracks. Then it flows under the intersection of the railroad tracks and 5th Street. A natural channel 5 feet wide was used for the conveyance under the intersection. According to the topographic map, downstream of 5th Street the channel widens to approximately 200 feet. The width was modeled at 100 feet, the maximum width permitted by the model.

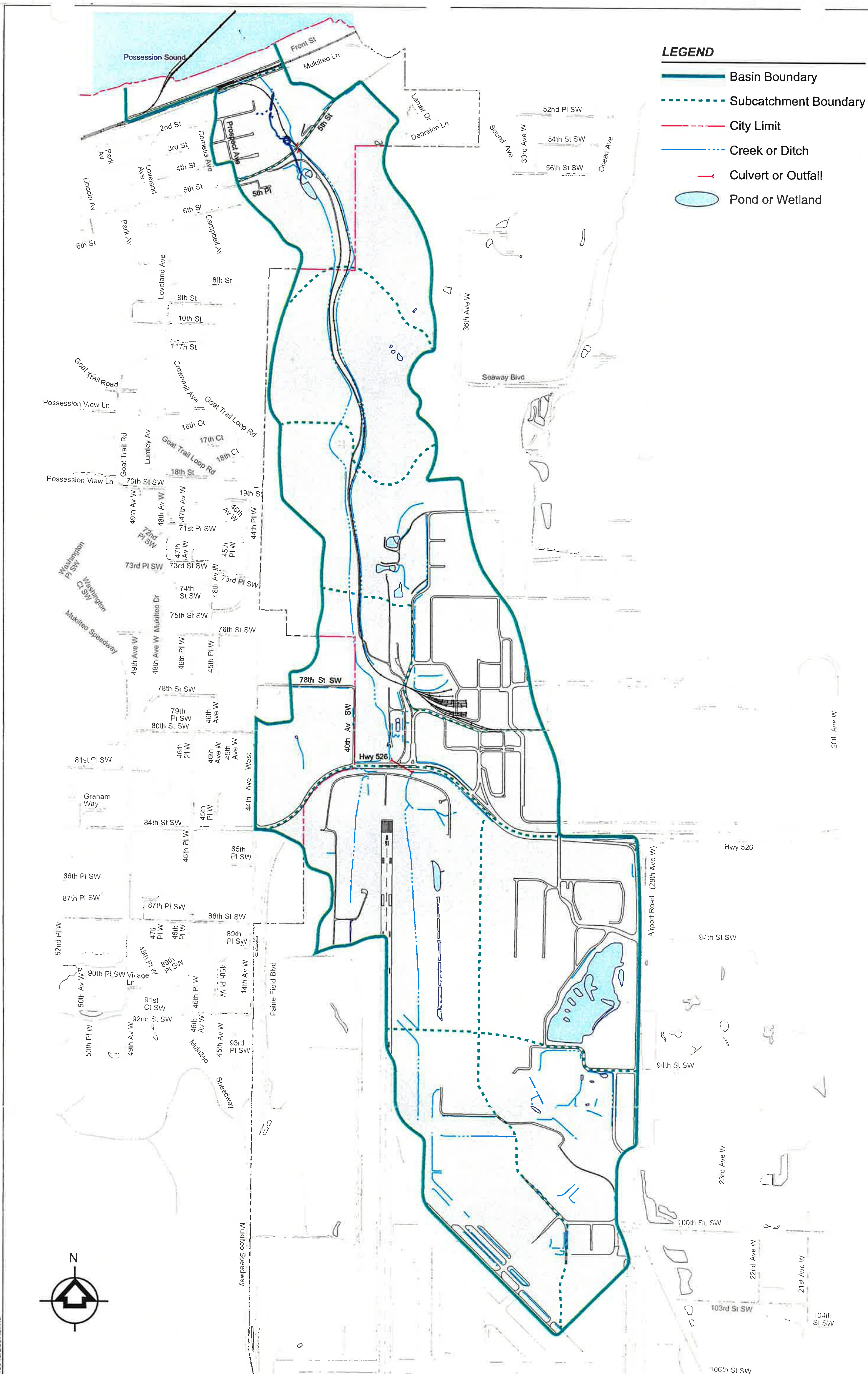
MODELING RESULTS

The 25-year and 100-year storm events were modeled for Basin B. Table 5-1 lists predicted flow at locations such as culverts, major tributaries, and outfalls. The locations are labeled in Figure 5-2 along with the flow and capacity of each conveyance element. The model predicts no flooding in the open channels of Basin B.

TABLE 5-1.
MODELED FLOW AT KEY LOCATIONS IN BASIN B

	Modeled Flow (cubic feet per second)			
	25-Year Storm Event		100-Year Storm Event	
Location	Current Conditions	Future Conditions	Current Conditions	Future Conditions
1	163.3		217.9	
2	239.6		331.7	
3	268.4		388.9	
4	266.0		386.6	

Future conditions were not modeled for basin B because the developable part of the basin lies outside of the City limits and outside of the zoning definition map.



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Tetra Tech/ KCM, Inc. 1917 First Ave.nue Seattle, Washington 98101	City of Mukilteo COMPREHENSIVE SURFACE WATER MANAGEMENT PLAN	Figure 5-1. BASIN AND SUBCATCHMENT BOUNDARIES AND EXISTING DRAINAGE SYSTEM; BASIN B

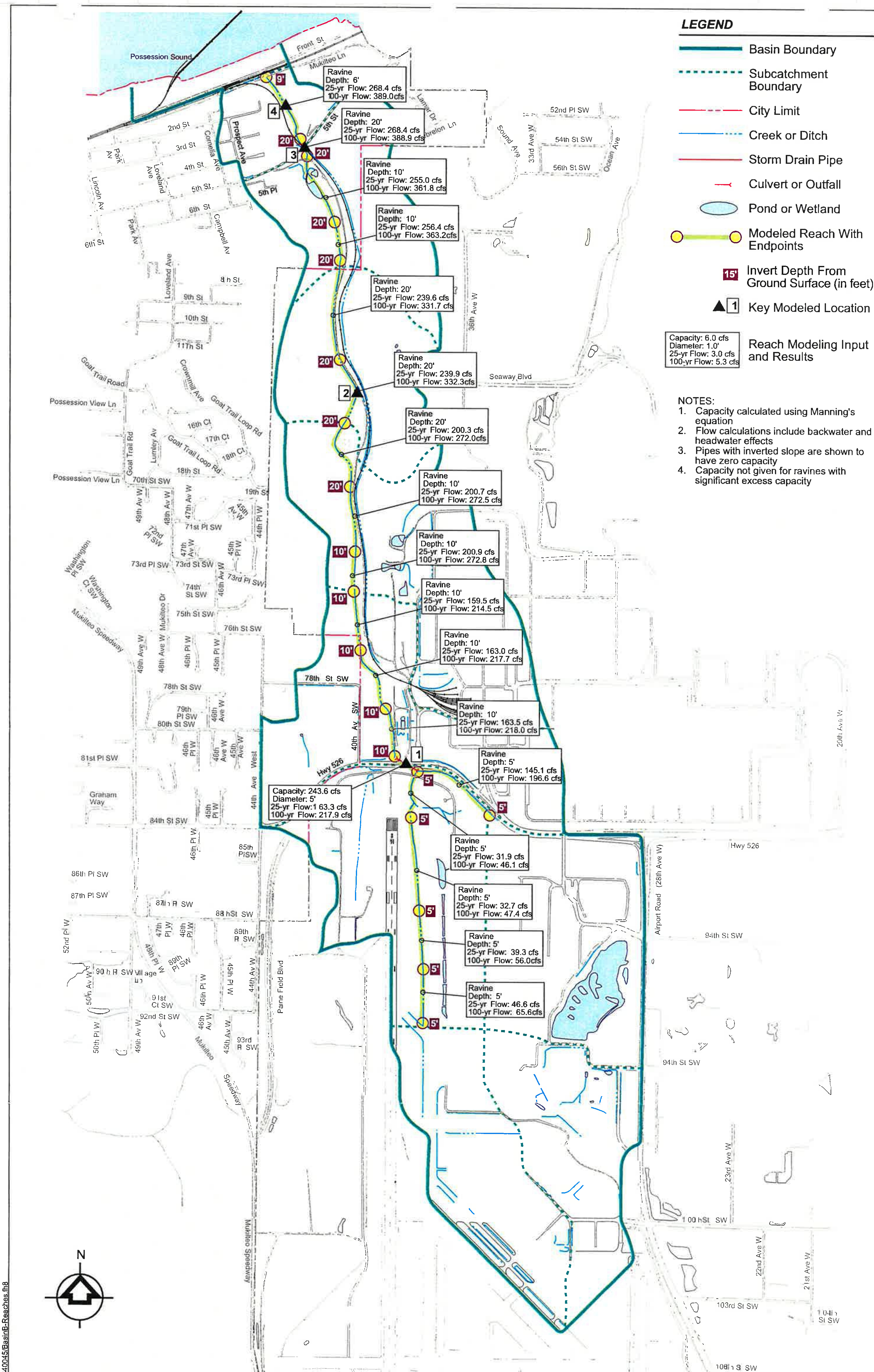

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Figure 5-2.
MODELED SYSTEM CHARACTERISTICS AND RESULTS BY REACH; BASIN B

CHAPTER 6.
BASIN C—BREWERY CREEK AND STATE PARK TIDEGATE

Basin C was divided into two subbasins for this study—Brewery Creek to the east and State Park Tidegate to the west—as shown in Figure 6-1. The Brewery Creek subbasin encompasses most of the downtown area and additional areas south that drain into Brewery Creek. The State Park Tidegate subbasin encompasses the rest of the basin west of the creek, from 8th Street to the ferry dock. This area drains directly to Puget Sound.

The headwaters of Brewery Creek begin south of the 19th Street cul-de-sac off Goat Trail Loop Road. The creek continues north in a deep ravine that reaches 90 feet deep from bank to creek bottom east of Washington Avenue. The stream gradient in the upper subbasin is relatively steep—on average dropping 1 foot in elevation every 10 feet—and flattens considerably through the downtown area.

The Brewery Creek subbasin was divided into 10 subcatchments. The upper basins are a mix of residential neighborhoods and undeveloped ravines and gullies. Most available area on the hilltops overlooking Puget Sound and the downtown area has been developed into residential neighborhoods. Steep ravines and gullies limit the remaining area available for development. The neighborhood from 11th Street to 8th Street east of Brewery Creek is on a high hill overlooking the downtown area. Runoff from one portion of this neighborhood drains directly into the creek; another portion drains north onto 6th Street at the bottom of the hill and follows Loveland Avenue to Front Street where it enters the channel above the outfall. The downtown area is also primarily residential with a small commercial district between 2nd and 3rd Avenues and on both sides of Mukilteo Boulevard and industrial areas north of the Burlington Northern Santa Fe Railroad and east of the ferry dock. The entire Brewery Creek subbasin drains via one outfall to Puget Sound.

The State Park Tidegate subbasin is made up of numerous small drainage networks that drain areas as small as one block. During site visits, numerous outfalls were identified from the beach south of Elliott Point. Total runoff volumes for the various drainage subcatchments were determined using the topographic mapping and the drainage networks that could be identified. Four subcatchments were delineated, based on existing drainage patterns. Three are relatively small, less than 10 acres. The fourth covers 47 acres and includes Mukilteo State Park, some downtown area, and areas east and west of Washington Avenue and Lincoln Avenue.

The Old Drainage Map (ODM) was used to determine the drainage facilities and pipe diameters in Basin C. The ODM does not have pipe inverts, so inverts for major drainage routes were measured in the field. Pipe invert elevations for minor drainage routes were modeled as 3 to 4 feet below the ground surface because this was within the range of the majority of catchbasins observed in the field. Upstream and downstream culvert invert elevations were assumed to match the corresponding adjacent ravine or ditch invert elevations.

MODELING RESULTS

The 25-year and 100-year storm events were modeled for Basin C for current and future conditions. Table 6-1 contains flow results at significant locations, identified in Figure 6-2, such as culverts into major tributaries, outfalls and modeled flooding locations for current and future conditions. The results are summarized in Figure 6-2, which lists the size and capacity of each modeled conveyance section along with the current 25- and 100-year flow rates.

As shown in Table 6-1, the flow at locations 6 and 8 decreased from current to future conditions. Future conditions were determined using the current zoning map. Past development west of the Mukilteo Speedway and north of 8th Street occurred at a higher density than the zoning map indicates for that area, therefore the percent impervious is greater and flow is greater under existing conditions.

TABLE 6-1.
MODELED FLOW AT KEY LOCATIONS IN BASIN C

	Modeled Flow (cubic feet per second)			
	25-Year Storm Event		100-Year Storm Event	
Location	Current Conditions	Future Conditions[1]	Current Conditions	Future Conditions[1]
1	12.4	12.3	22.4	22.5
2	21.8	28.7	41.2	45.4
3	21.7	27.3	41.4	43.7
4	14.1	21.6	23.6	25
5	36.4	36.7	47.1	47.2
6	23.2	16.5[2]	35.8	28.3[2]
7	2.1	2.1	3.6	3.6
8	2.1	1.7[2]	3.6	3.2[2]
9	4.5	4.7	7.7	7.9

Notes:
1) Future conditions based on zoning map
2) Current development higher than zoning imperviousness

Table 6-2 lists the flooding locations and duration of flooding. The model predicts flooding in two locations within Basin C, only for the 100-year storm event. Location 4 is a network of 18-inch and 24-inch pipes and catchbasins receiving runoff from the eastern portion of the basin. About 100 feet of 18-inch pipe conveys flow from a ditch system to a 24-inch pipe and has a capacity of approximately 20 cfs. There is about 200 feet of 24-inch pipe, downstream of the 18-inch pipe that only has a capacity of about 4 cfs due to a shallow slope. There is field evidence that overland flow has occurred in the vicinity of location 4. It appears that this flooding location correlates with the specific drainage problem identified as CB2 (see Table 3-1). The maintenance crew identified problem CB2 as a shallow sloped pipe that fills with sediment. The modeled flooding was routed downstream along Mukilteo Lane and back into the system at the inlet of the 24-inch outfall, which is location 5. Increasing the size and/or slope of these culverts would alleviate the potential for flooding.

TABLE 6-2.
MODELED FLOODING DURATION IN BASIN C

	Flooding Duration (hours)			
	25-Year Storm Event		100-Year Storm Event	
Location	Current Conditions	Future Conditions	Current Conditions	Future Conditions
4	—	—	0.5	0.5
5	—	—	2	2

It is likely that the outfall of Brewery Creek (location 5) will flood during high runoff conditions because records indicate it is 500 feet long and shallow-sloped. During a field check, the outfall was observed to be buried in the shore and at least half full of sand, which would limit the capacity of the pipe even further. Assuming the pipe would be replaced at the existing slope, a 48-inch pipe would be necessary to convey the current and future 100-year flow.

Additionally, the outfall is affected by high tides that can prevent stormwater from exiting the system. This could be alleviated with the installation of a flap gate.

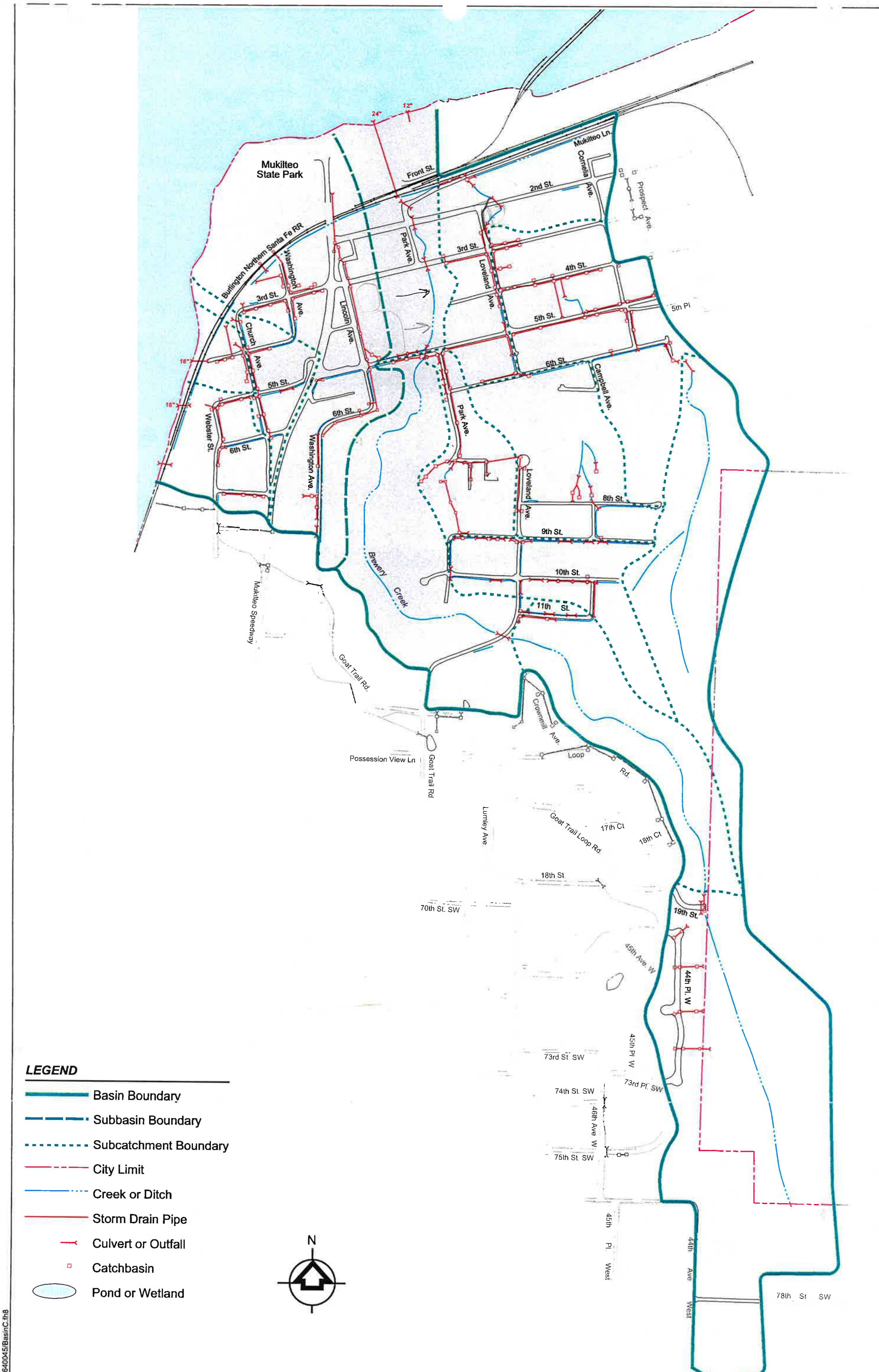

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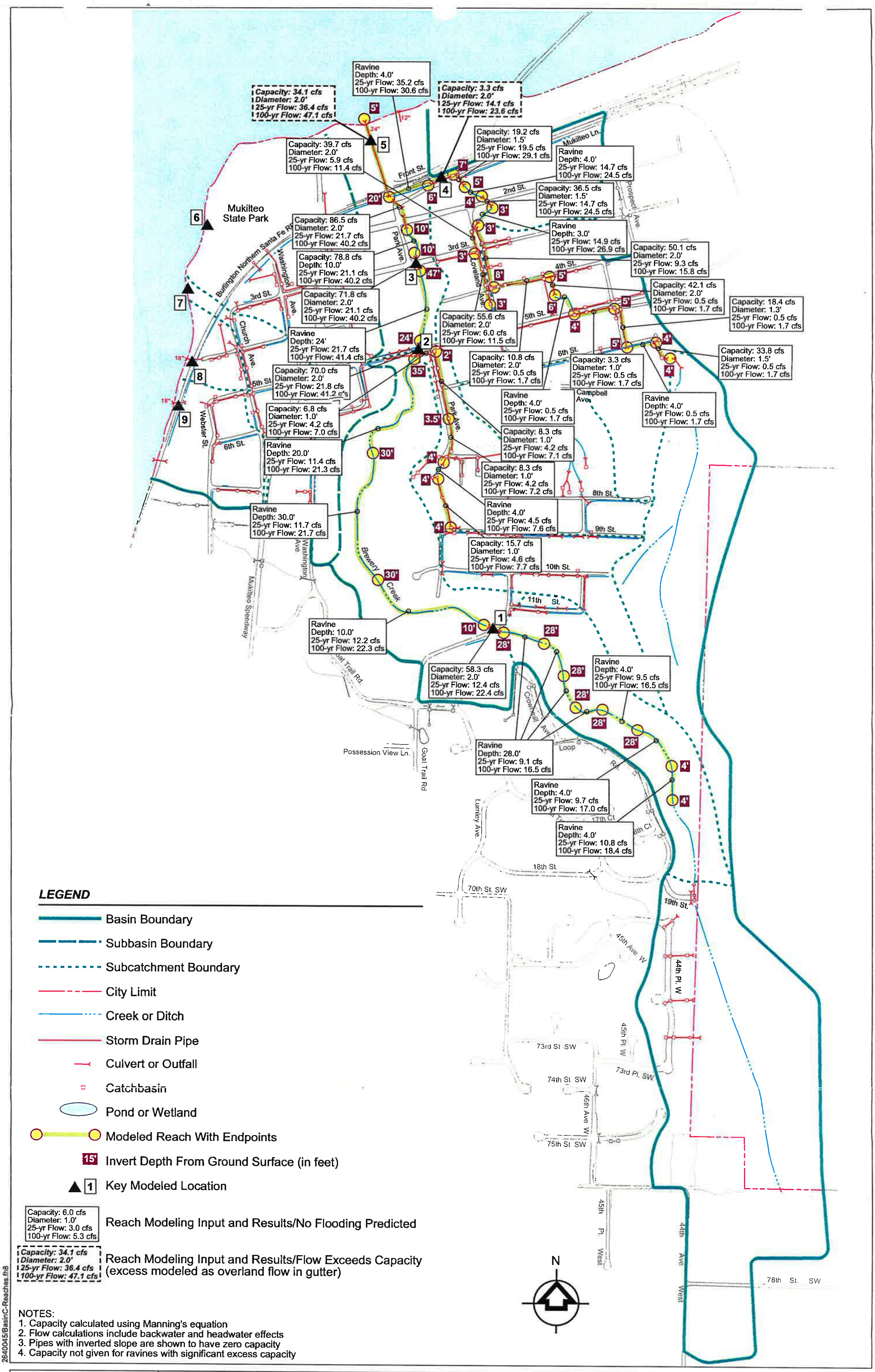
Figure 6-1.
BASIN AND SUBCATCHMENT BOUNDARIES AND EXISTING DRAINAGE SYSTEM; BASIN C



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COMPREHENSIVE SURFACE WATER MANAGEMENT PLAN

Figure 6-2.
MODELED SYSTEM CHARACTERISTICS AND RESULTS BY REACH; BASIN C

CHAPTER 7.
BASIN D—GOAT TRAIL RAVINE

Basin D has been divided into three subbasins as shown in Figure 7-1. The northern subbasin consists of a conveyance system of pipes that drains directly to Puget Sound through a separate 24-inch outfall with an invert elevation of 6 feet. This area was divided into two subcatchments that are moderately developed with a small creek running through most of the middle section of the subbasin.

Goat Trail Ravine is the major drainage system in Basin D. Its subbasin encompasses most of the area in the basin and is divided into 14 subcatchments. The ravine receives flow from two major tributaries that converge approximately 500 feet before the creek enters a 36-inch concrete culvert with an invert elevation of 0 feet conveying flow to Puget Sound. The northern tributary branch begins near the intersection of 18th Street and Goat Trail Loop Road and is more than 3,000 feet long. The southern tributary branch begins near the intersection of Washington Avenue and Clover Lane and is about 2,800 feet long.

Most of the ravine subbasin east of Mukilteo Speedway is highly developed with the only undeveloped area being the steep slope of the ravine itself. The portion of the subbasin west of Mukilteo Speedway is primarily composed of steep, deep ravines. The ravine is at least 100 feet deep from creek bottom to bank with an elevation drop of 1 foot for every 3 or 4 feet of length along most of its length.

The third subbasin is the shoreline south of the Goat Trail Ravine outfall. This area is a steep cliff that appears to drain directly to Puget Sound. Stormwater must cross the railroad tracks along the shoreline through a number of culverts in order to reach Puget Sound. The approximate locations of the outfalls were determined in the field during the outfall inventory and are shown on Figure 7-1. Several houses have been built on top of the cliff, but the majority of the area is vegetated hillside. The model was used only to predict runoff rates from this subbasin.

MODELING RESULTS

The 25-year and 100-year storm events were modeled for Basin D. Table 7-1 lists predicted flow at significant locations such as culverts into major tributaries, outfalls and model flooding locations. The locations are labeled in Figure 7-2. Table 7-2 lists duration of flooding as predicted by the model. The results are summarized in Figure 7-2, which lists the size and capacity of each modeled conveyance section along with the current 25- and 100-year flow rates.

As shown in Table 7-1, the flow at locations 2, 3, and 4 decreased from current to future conditions. Future conditions were determined using the current zoning map. The decrease in flow at locations 2 and 3 was caused by a decrease in the effective impervious area. The percent impervious increased at location 4, but the flow still decreased because of the significant decrease in flow at locations 2 and 3. The school property near location 2 is zoned RD 7.5. The current use includes an elementary school, a middle school, a ball field and various other buildings associated with the two schools. The impervious area of the school grounds is greater than if the entire area was developed single family residential at the zoned density; thus the future imperviousness was modeled at a lower percentage than the existing conditions.

Runoff from several developments affects the flow at location 3. Several of these developments were built at a greater density than is established on the zoning map. The three main developments involved are La Roma Terrace, Trophy Woodside, and Puget Sound Hills.

TABLE 7-1.
MODELED FLOW AT KEY LOCATIONS IN BASIN D

	Modeled Flow (cubic feet per second)			
	25-Year Storm Event		100-Year Storm Event	
Location	Current Conditions	Future Conditions[1]	Current Conditions	Future Conditions[1]
1	6.7	8.7	11.7	13.1
2	4.0	3.5[2]	6.2	5.5[2]
3	5.7	3.1[2]	10.8	8.0[2]
4	26.4	20.7[2]	37.7	32.2[2]
5	6.6	6.6	7.8	7.7
6	27.3	28.8	42.1	38.9
7	5.8	8.5	6.6	11.2
8	36.8	38.8	55.2	59.5
9	3.8	10.3	8.2	14.9

Notes:
1) Future conditions based on zoning map
2) Current development higher than zoning imperviousness

Table 7-2 lists the flooding locations and the duration of flooding at each location. The model predicts flooding in two locations in Basin D. Location 2 is the school property and the model predicts minor flooding for the 100-year storm event. The flooding predicted at location 2 correlates with the existing drainage problem number D11 identified by City staff. Problems D11 through D13 identify drainage problems associated with the school property. School and City officials are currently assessing these drainage problems.

Location 3 is another flooding location, unrelated to the flooding at location 2. According to the ODM, approximately 150 feet of shallow-sloped 12-inch pipe connects a ditch to the beginning of the ravine, south of Possession View Lane. The pipe was not located during field visits, so invert elevations were assumed from adjacent ground elevation. It is possible that the pipe has been replaced by a larger pipe, or is buried at a steeper slope than the topographic map indicates. More detailed survey and analysis should be performed when addressing this flooding problem.

TABLE 7-2.
MODELED FLOODING DURATION IN BASIN D

	Flooding Duration (hours)			
	25-Year Storm Event		100-Year Storm Event	
Location	Current Conditions	Future Conditions	Current Conditions	Future Conditions
2	—	—	0.5	0.5
3	4	4	6	6

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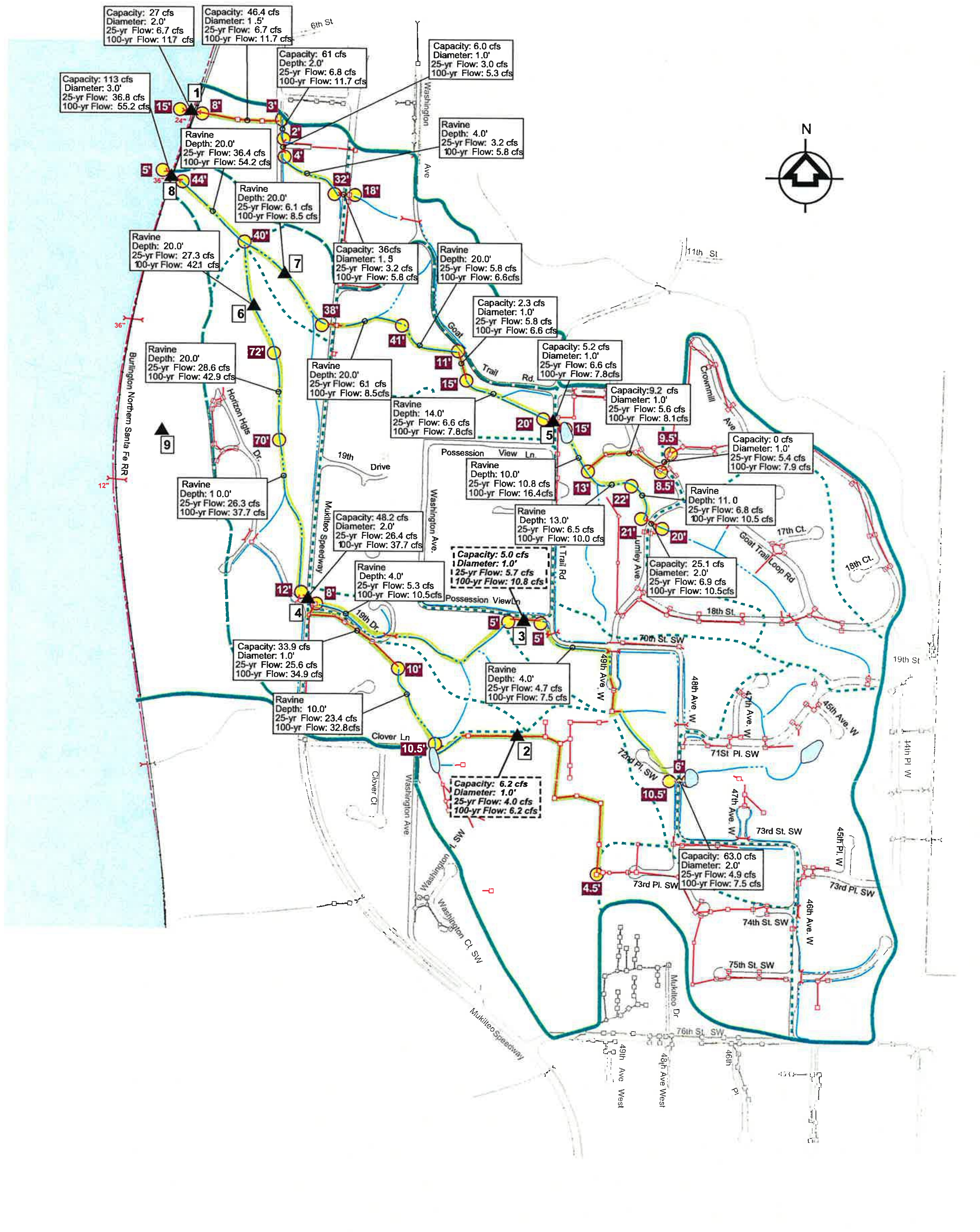
Tetra Tech/ KCM, Inc. 1917 First Avenue Seattle, Washington 98101	City of Mukilteo COMPREHENSIVE SURFACE WATER MANAGEMENT PLAN	Figure 7-1. BASIN AND SUBCATCHMENT BOUNDARIES AND EXISTING DRAINAGE SYSTEM; BASIN D



LEGEND

- Basin Boundary
- Subbasin Boundary
- Subcatchment Boundary
- City Limit
- Creek or Ditch
- Storm Drain Pipe
- Culvert or Outfall
- Catchbasin
- Pond or Wetland
- Modeled Reach With Endpoints
- 15' Invert Depth From Ground Surface (in feet)
- 1 Key Modeled Location
- Capacity: 6.0 cfs Diameter: 1.0' 25-yr Flow: 3.0 cfs 100-yr Flow: 5.3 cfs — Reach Modeling Input and Results/ No Flooding Predicted
- *Capacity: 34.1 cfs Diameter: 2.0' 25-yr Flow: 36.4 cfs 100-yr Flow: 47.1 cfs* — Reach Modeling Input and Results/ Flow Exceeds Capacity (excess modeled as overland flow in gutter)

NOTES:
1. Capacity calculated using Manning's equation
2. Flow calculations include backwater and headwater effects
3. Pipes with inverted slope are shown to have zero capacity
4. Capacity not given for ravines with significant excess capacity

2640045/BasinD-Reaches.fh8

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Figure 7-2.
MODELED SYSTEM CHARACTERISTICS AND RESULTS BY REACH; BASIN D

CHAPTER 8.
BASIN E—UNNAMED RAVINE

Basin E has been divided into four subbasins, as shown in Figure 8-1. The northern subbasin consists of two subcatchments that convey flow via a ditch system upstream and a short ravine downstream. The upstream part of the subbasin is a moderately sloped (about 10 percent) fully-developed single-family residential area. Houses are located near the cliff, where the slope abruptly changes to over 60 percent. The subbasin discharges to Puget Sound through a 36-inch concrete culvert with an invert elevation of 5 feet.

Just south of the northern subbasin is a small single-catchment subbasin that receives road runoff from approximately 700 feet of the Mukilteo Speedway. The runoff is discharged onto a steep cliff. Because of its small size, the model was used only to predict runoff rates from this subbasin.

An unnamed ravine is the major drainage system in Basin E. Its subbasin encompasses most of the area in the basin and is divided into nine subcatchments. The ravine varies from 100 to 200 feet deep from creek bottom to bank. The channel drops 1 foot in elevation for every 3 or 4 feet of length for most of the downstream area. Two major tributaries contribute flow to the ravine, converging approximately 900 feet upstream of where the creek enters Puget Sound. The northern tributary branch is approximately 1,100 feet of steep ravine that receives water from a piped conveyance system. The tributary receives storm runoff from two subcatchments that encompass about 60 acres of developed residential area. According to the ODM, runoff from these two subcatchments is routed under the Mukilteo Speedway through a 24-inch concrete pipe. The southern tributary is a steep ravine, approximately 1,800 feet long with characteristics similar to those of the northern tributary. The steep ravine receives runoff from a pipe and ditch system that serves roughly 70 acres of developed residential area. Flow from the unnamed ravine subbasin discharges through a 36-inch concrete pipe with an invert elevation of 4 feet.

The fourth subbasin is a small area, approximately 16 acres, located south of the unnamed ravine. Most of the subbasin is a steep cliff, although topographic information indicates there is a small creek. This passes under the railroad tracks through an 18-inch concrete culvert with an invert elevation of 0 feet. The area is not fully developed. Again, because of the small size, only total runoff was calculated in the model.

MODELING RESULTS

The 25-year and 100-year storm events were modeled for Basin E. Table 8-1 lists predicted flow at locations such as outfalls and culverts into major tributaries. The locations are labeled in Figure 8-2. The model predicts no flooding for the conveyance system in Basin E. The results are summarized in Figure 8-2, which lists the size and capacity of each modeled conveyance section along with the current 25- and 100-year flow rates.

TABLE 8-1.
MODELED FLOW AT KEY LOCATIONS IN BASIN E

Location	Modeled Flow (cubic feet per second)			
	25-Year Storm Event		100-Year Storm Event	
	Current Conditions	Future Conditions[1]	Current Conditions	Future Conditions[1]
1	3.6	7.0	7.1	10.5
2	6.8	8.3	10.1	11.7
3	8.3	16.3	15.8	24.0
4	14.2	28.2	27.6	41.8
5	11.4	15.4	18.8	23.4
6	27.1	53.8	55.2	79.8
7	7.0	8.8	10.6	12.4

Note:
1) Future conditions based on zoning map

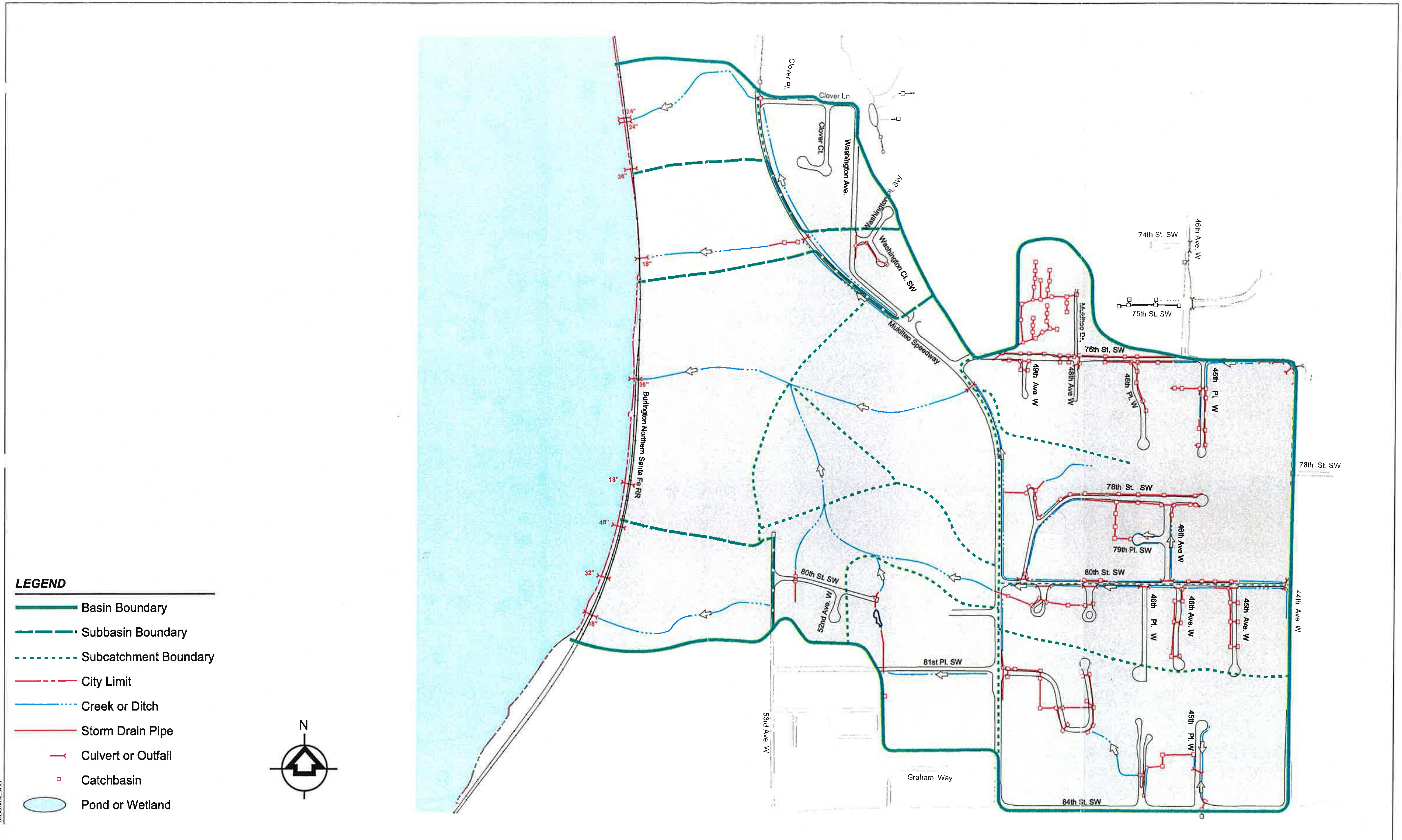

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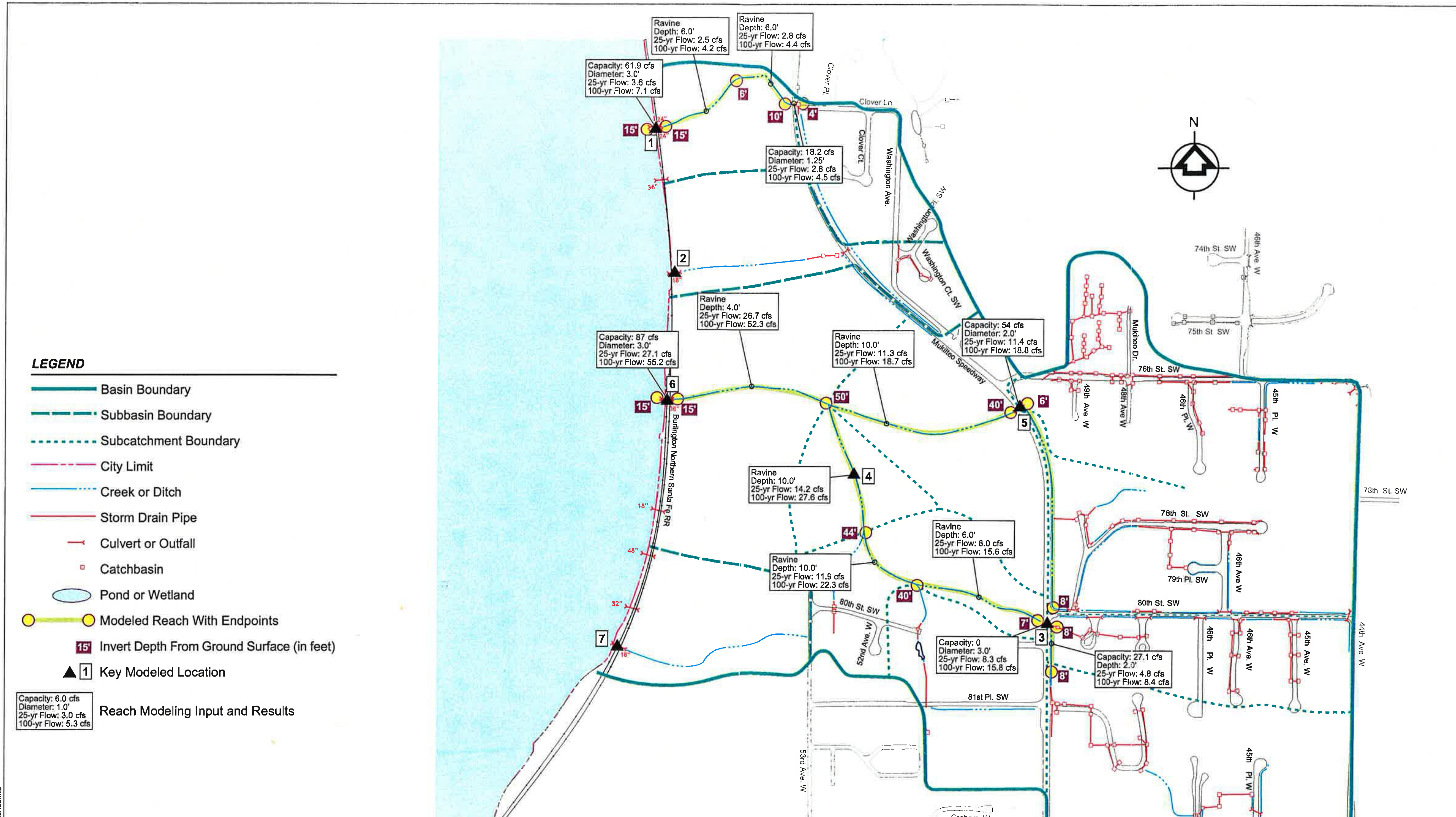
Figure 8-1.
BASIN AND SUBCATCHMENT BOUNDARIES AND EXISTING DRAINAGE SYSTEM; BASIN E



NOTES:
1. Capacity calculated using Manning's equation
2. Flow calculations include backwater and headwater effects
3. Pipes with inverted slope are shown to have zero capacity
4. Capacity not given for ravines with significant excess capacity

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Figure 8-2.
MODELED SYSTEM CHARACTERISTICS AND RESULTS BY REACH; BASIN E

CHAPTER 9.
BASIN F—NAKETA BEACH

Basin F, shown in Figure 9-1, is composed of five subcatchments that route flow to a 48-inch outfall with an invert elevation of 0 feet. The outfall is in a bulkhead that supports about 10 houses along the waterfront. Upstream, approximately 1,500 feet of steep ravine receives water from a system of pipes, ditches and small creeks. The ravine is at least 100 feet deep for its entire length with a side slope of about 100 percent. Most of Basin F is only partially developed with single-family residential units. A small area in the northern part of the basin is multi-family residential.

A storage node was used to model a significant depression area east of the outfall that could store water when large flows occur. The characteristics of the storage area were estimated from topographic information.

The entire basin area east of the Mukilteo Speedway was modeled as one subcatchment with flows conveyed under the Speedway through a pipe at the intersection of 84th Street SW. There may be other pipes that transport the water under the highway, but none were located during field visits. It is recommended that additional investigation be performed to locate any other culverts.

MODELING RESULTS

The 25-year and 100-year storm events were modeled for Basin F. Table 9-1 lists predicted flow at locations such as culverts into major tributaries, outfalls and modeled flooding locations. The locations are labeled in Figure 9-2. Table 9-2 lists duration of flooding.

TABLE 9-1.
MODELED FLOW AT KEY LOCATIONS IN BASIN F

	Modeled Flow (cubic feet per second)			
	25-Year Storm Event		100-Year Storm Event	
Location	Current Conditions	Future Conditions[1]	Current Conditions	Future Conditions[1]
1	5.3	14.7	9.2	17.0
2	3.8	12.0	8.1	12.0
3	29.6	36.8	39.6	44.4
4	4.9	7.4	8.0	10.6
5	36.2	45.9	55.5	59.2

Note:
1) Future conditions based on zoning map

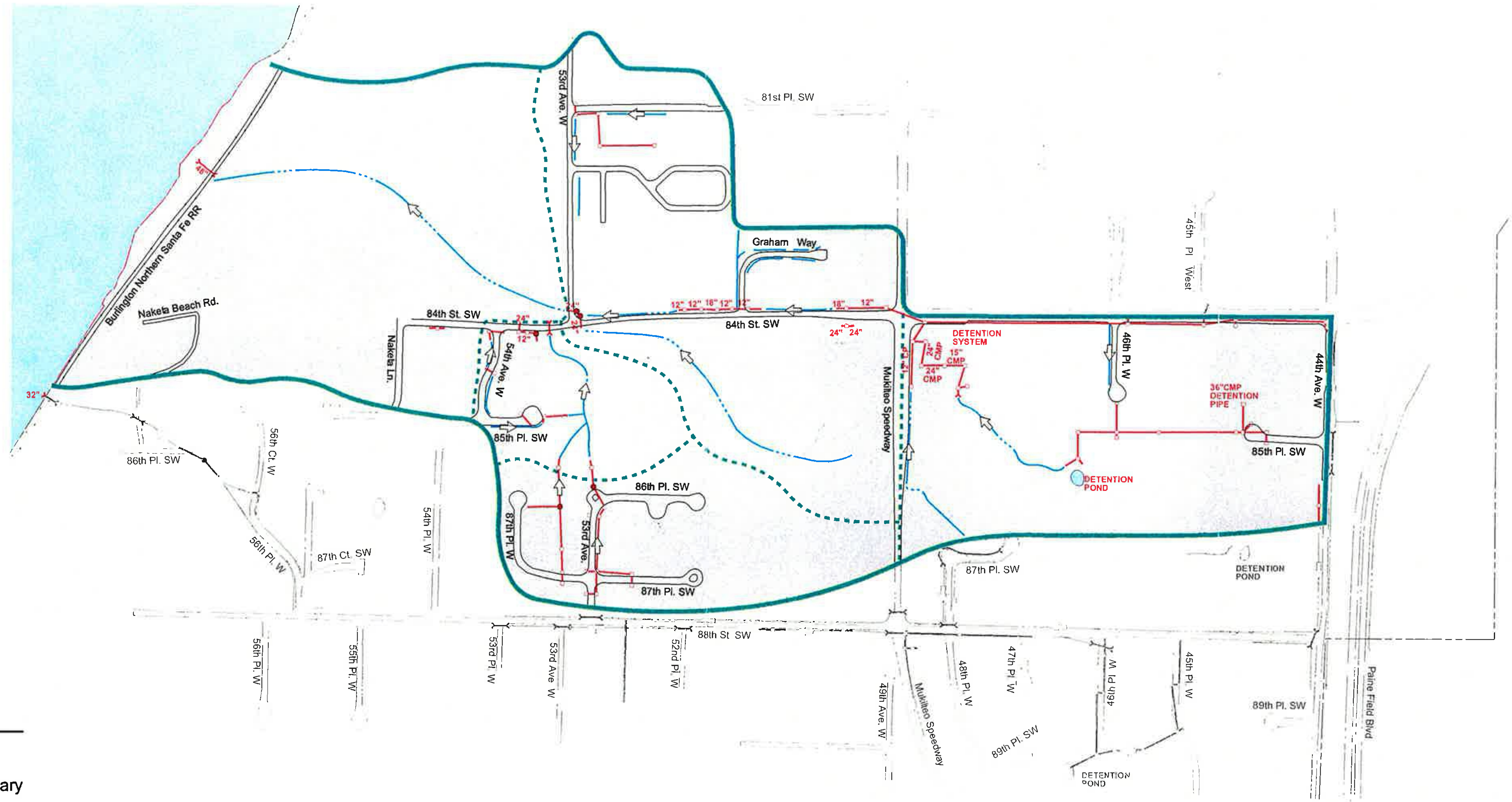
The model predicts flooding in two locations in Basin F, as determined by the presence of stormwater in the curb and gutter segment above the pipe. Location 1 is a 12-inch pipe receiving runoff from the easternmost subcatchment, which is approximately 38 acres. Before upgrading this system, more detailed inventory should be obtained, and the existing detention systems in the upper subcatchment should be evaluated. Otherwise, the flooding predicted by the model at location 1 could be alleviated by replacing the 12-inch culvert with an 18-inch culvert.

The runoff is routed downstream through approximately 200 feet of ditch and back into a network of catchbasins and 12-inch pipes, which is location 2. The series of 12-inch pipes, about 330 feet long, does not have capacity for high runoff conditions. Location 2 flooding correlates with a past identified problem that has been corrected according to the City. The as-built information that was used to create the model may not have been updated since the pipe was upgraded, so the model should be reanalyzed when the new as-built information becomes available.

TABLE 9-2.
MODELED FLOODING DURATION IN BASIN F

	Flooding Duration (hours)			
	25-Year Storm Event		100-Year Storm Event	
Location	Current Conditions	Future Conditions	Current Conditions	Future Conditions
1	0.5	3	4	6
2	3	7	6	11

The results are summarized in Figure 9-2, which lists the size and capacity of each modeled conveyance section along with the current 25- and 100-year flow rates.



LEGEND

- Basin Boundary
- Subcatchment Boundary
- City Limit
- Creek or Ditch
- Storm Drain Pipe
- Culvert or Outfall
- Catchbasin
- Pond or Wetland

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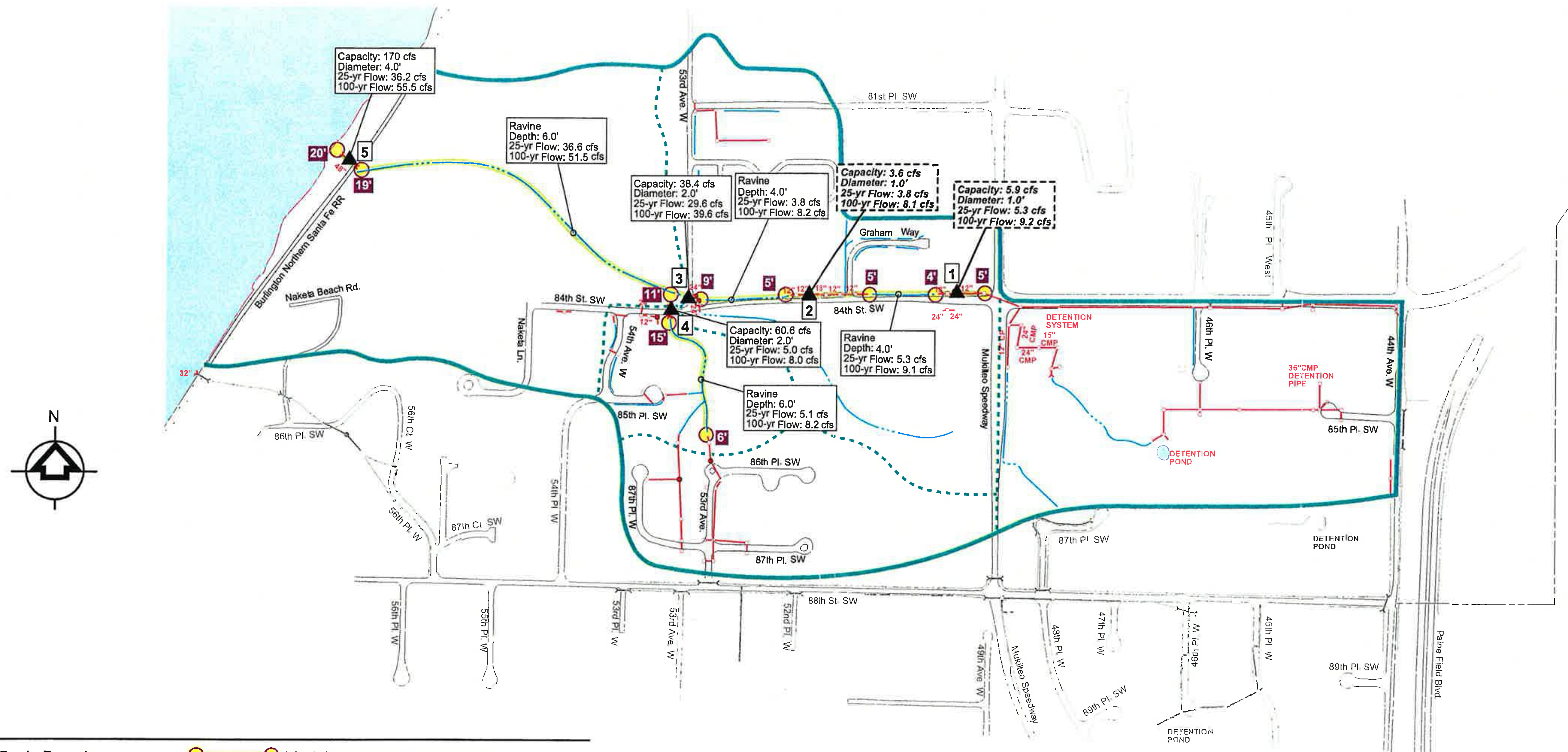
Tetra Tech/ KCM, Inc. 1917 First Avenue Seattle, Washington 98101	City of Mukilteo COMPREHENSIVE SURFACE WATER MANAGEMENT PLAN	Figure 9-1. BASIN AND SUBCATCHMENT BOUNDARIES AND EXISTING DRAINAGE SYSTEM; BASIN F



LEGEND

- Basin Boundary
- Subcatchment Boundary
- City Limit
- Creek or Ditch
- Storm Drain Pipe
- Culvert or Outfall
- Catchbasin
- Pond or Wetland
- Modeled Reach With Endpoints
- 15' Invert Depth From Ground Surface (in feet)
- 1 Key Modeled Location
- Capacity: 6.0 cfs / Diameter: 1.0' / 25-yr Flow: 3.0 cfs / 100-yr Flow: 5.3 cfs — Reach Modeling Input and Results/ No Flooding Predicted
- Capacity: 34.1 cfs / Diameter: 2.0' / 25-yr Flow: 36.4 cfs / 100-yr Flow: 47.1 cfs — Reach Modeling Input and Results/ Flow Exceeds Capacity (excess modeled as overland flow in gutter)

NOTES:
1. Capacity calculated using Manning's equation
2. Flow calculations include backwater and headwater effects
3. Pipes with inverted slope are shown to have zero capacity
4. Capacity not given for ravines with significant excess capacity

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Figure 9-2.
MODELED SYSTEM CHARACTERISTICS AND RESULTS BY REACH; BASIN F

CHAPTER 10.
BASIN G—SMUGGLER'S GULCH

Basin G has been divided into three subbasins, as shown in Figure 10-1. The northern subbasin consists of two subcatchments that convey flow via a ditch system upstream and a short ravine (approximately 300 feet long) downstream. The outfall culvert is a 32-inch concrete pipe with an invert elevation of 0 feet.

Smuggler's Gulch is the major drainage system in Basin G, and its subbasin was divided into 12 subcatchments. The steep ravine is approximately 2,200 feet long and varies from 100 to 200 feet deep from creek bottom to bank; the channel falls 1 foot in elevation for every 3 or 4 feet of length for most of the downstream area. Smuggler's Gulch discharges to Puget Sound through two 24-inch culverts with invert elevations of 0 feet.

Approximately 50 acres of the Boeing property drains to Smuggler's Gulch. This area is located outside the City of Mukilteo, east of the city limits. Flow from Boeing is routed under Paine Filed Blvd via an 18-inch HDPE pipe and under 44th Avenue W through a 12-inch concrete culvert to a network of ditches and 12-inch driveway culverts along 89th Place SW. Runoff enters a shallow 12-inch pipe that conveys stormwater from 89th Place SW to a swale that routes flow to 45th Place W. Field measurements were used to describe the stormwater network described above. Design drawings were available for the drainage system downstream of 45th Place W.

The third subbasin is a small isolated depression area, approximately 9 acres, located in the south-central portion of the basin. There is no outlet for this area.

MODELING RESULTS

The 25-year and 100-year storm events were modeled for Basin G. Table 10-1 lists predicted flow at significant locations such as outfalls and culverts into major tributaries. The locations are labeled in Figure 10-2. The predicted flooding locations and duration are listed in Table 10-2. The results are summarized in Figure 10-2, which lists the size and capacity of each modeled conveyance section along with the current and future 25- and 100-year flow rates. For the future condition, the same land use/impervious area as current was used for the area outside the city limits.

The model predicts flooding in three locations in Basin G. Two of the locations (2a and 2b) are directly downstream of the Boeing complex subcatchment. Location 2a is the 12-inch pipe under 44th Avenue W. If upstream detention were not improved, upgrading the culvert to an 18-inch would provide enough additional capacity to carry the predicted flooding.

From 44th Avenue W, runoff flows downstream through approximately 200 feet of a ditch and 12-inch driveway culvert system along the 89th Place SW cul-de-sac, which is location 2b. Residents and city officials have reported flooding at this location. If the capacity were improved in this section, flooding would be relieved, but it would transfer downstream to location 2 which also has predicted flooding.

TABLE 10-1.
MODELED FLOW AT KEY LOCATIONS IN BASIN G

	Modeled Flow (cubic feet per second)			
	25-Year Storm Event		100-Year Storm Event	
Location	Current Conditions	Future Conditions[1]	Current Conditions	Future Conditions[1]
1	2.1	4.0	3.8	4.8
2	10.5	11.0	13.7	13.9
2a	6.1	6.1	7.6	8.6
2b	6.0	6.0	7.6	8.7
3	20.5	25.7	27.9	30.0
4	20.8	27.3	30.9	33.4
5	23.8	34.3	40.5	46.7
6	3.2	3.8	5.1	5.6
7	8.1	11.2	14.6	17.6

Note:
1) Future conditions based on zoning map

The third flooding area is location 2, which is a 12-inch pipe and ditch along the Mukilteo Speedway. This is due to inadequate capacity to carry the incoming flows; there is more than adequate capacity downstream of the Speedway. Detaining the flows from east of 44th Avenue W may be adequate to resolve the flooding, although a culvert enlargement to 18-inch diameter may be required depending on the volume of detention and rate of release.

TABLE 10-2.
MODELED FLOODING DURATION IN BASIN G

	Flooding Duration (hours)			
	25-Year Storm Event		100-Year Storm Event	
Location	Current Conditions	Future Conditions	Current Conditions	Future Conditions
2	1	1	2	2
2a	0	0	0.5	0.5
2b	0.5	0.5	1.5	1.5

CHAPTER 10.
BASIN G—SMUGGLER'S GULCH

Basin G has been divided into three subbasins, as shown in Figure 10-1. The northern subbasin consists of two subcatchments that convey flow via a ditch system upstream and a short ravine (approximately 300 feet long) downstream. The outfall culvert is a 32-inch concrete pipe with an invert elevation of 0 feet.

Smuggler's Gulch is the major drainage system in Basin G, and its subbasin was divided into 12 subcatchments. The steep ravine is approximately 2,200 feet long and varies from 100 to 200 feet deep from creek bottom to bank; the channel falls 1 foot in elevation for every 3 or 4 feet of length for most of the downstream area. Smuggler's Gulch discharges to Puget Sound through two 24-inch culverts with invert elevations of 0 feet.

Approximately 50 acres of the Boeing property drains to Smuggler's Gulch. This area is located outside the City of Mukilteo, east of the city limits. Flow from Boeing is routed under Paine Filed Blvd via an 18-inch HDPE pipe and under 44th Avenue W through a 12-inch concrete culvert to a network of ditches and 12-inch driveway culverts along 89th Place SW. Runoff enters a shallow 12-inch pipe that conveys stormwater from 89th Place SW to a swale that routes flow to 45th Place W. Field measurements were used to describe the stormwater network described above. Design drawings were available for the drainage system downstream of 45th Place W.

The third subbasin is a small isolated depression area, approximately 9 acres, located in the south-central portion of the basin. There is no outlet for this area.

MODELING RESULTS

The 25-year and 100-year storm events were modeled for Basin G. Table 10-1 lists predicted flow at significant locations such as outfalls and culverts into major tributaries. The locations are labeled in Figure 10-2. The predicted flooding locations and duration are listed in Table 10-2. The results are summarized in Figure 10-2, which lists the size and capacity of each modeled conveyance section along with the current and future 25- and 100-year flow rates. For the future condition, the same land use/impervious area as current was used for the area outside the city limits.

The model predicts flooding in three locations in Basin G. Two of the locations (2a and 2b) are directly downstream of the Boeing complex subcatchment. Location 2a is the 12-inch pipe under 44th Avenue W. If upstream detention were not improved, upgrading the culvert to an 18-inch would provide enough additional capacity to carry the predicted flooding.

From 44th Avenue W, runoff flows downstream through approximately 200 feet of a ditch and 12-inch driveway culvert system along the 89th Place SW cul-de-sac, which is location 2b. Residents and city officials have reported flooding at this location. If the capacity were improved in this section, flooding would be relieved, but it would transfer downstream to location 2 which also has predicted flooding.

**TABLE 10-1.
MODELED FLOW AT KEY LOCATIONS IN BASIN G**

	Modeled Flow (cubic feet per second)			
	25-Year Storm Event		100-Year Storm Event	
Location	Current Conditions	Future Conditions[1]	Current Conditions	Future Conditions[1]
1	2.1	4.0	3.8	4.8
2	10.5	11.0	13.7	13.9
2a	6.1	6.1	7.6	8.6
2b	6.0	6.0	7.6	8.7
3	20.5	25.7	27.9	30.0
4	20.8	27.3	30.9	33.4
5	23.8	34.3	40.5	46.7
6	3.2	3.8	5.1	5.6
7	8.1	11.2	14.6	17.6

Note:
1) Future conditions based on zoning map

The third flooding area is location 2, which is a 12-inch pipe and ditch along the Mukilteo Speedway. This is due to inadequate capacity to carry the incoming flows; there is more than adequate capacity downstream of the Speedway. Detaining the flows from east of 44th Avenue W may be adequate to resolve the flooding, although a culvert enlargement to 18-inch diameter may be required depending on the volume of detention and rate of release.

**TABLE 10-2.
MODELED FLOODING DURATION IN BASIN G**

	Flooding Duration (hours)			
	25-Year Storm Event		100-Year Storm Event	
Location	Current Conditions	Future Conditions	Current Conditions	Future Conditions
2	1	1	2	2
2a	0	0	0.5	0.5
2b	0.5	0.5	1.5	1.5

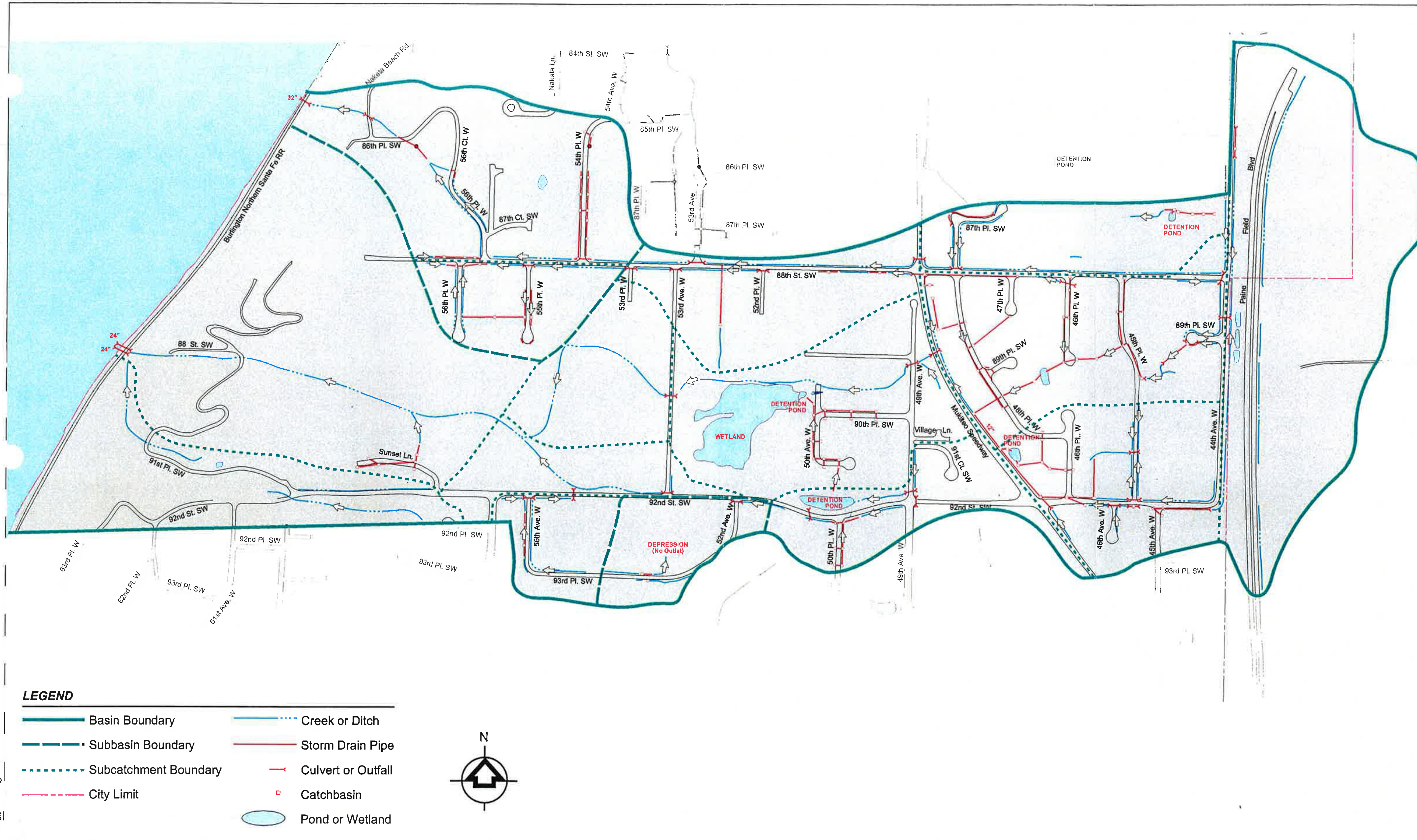

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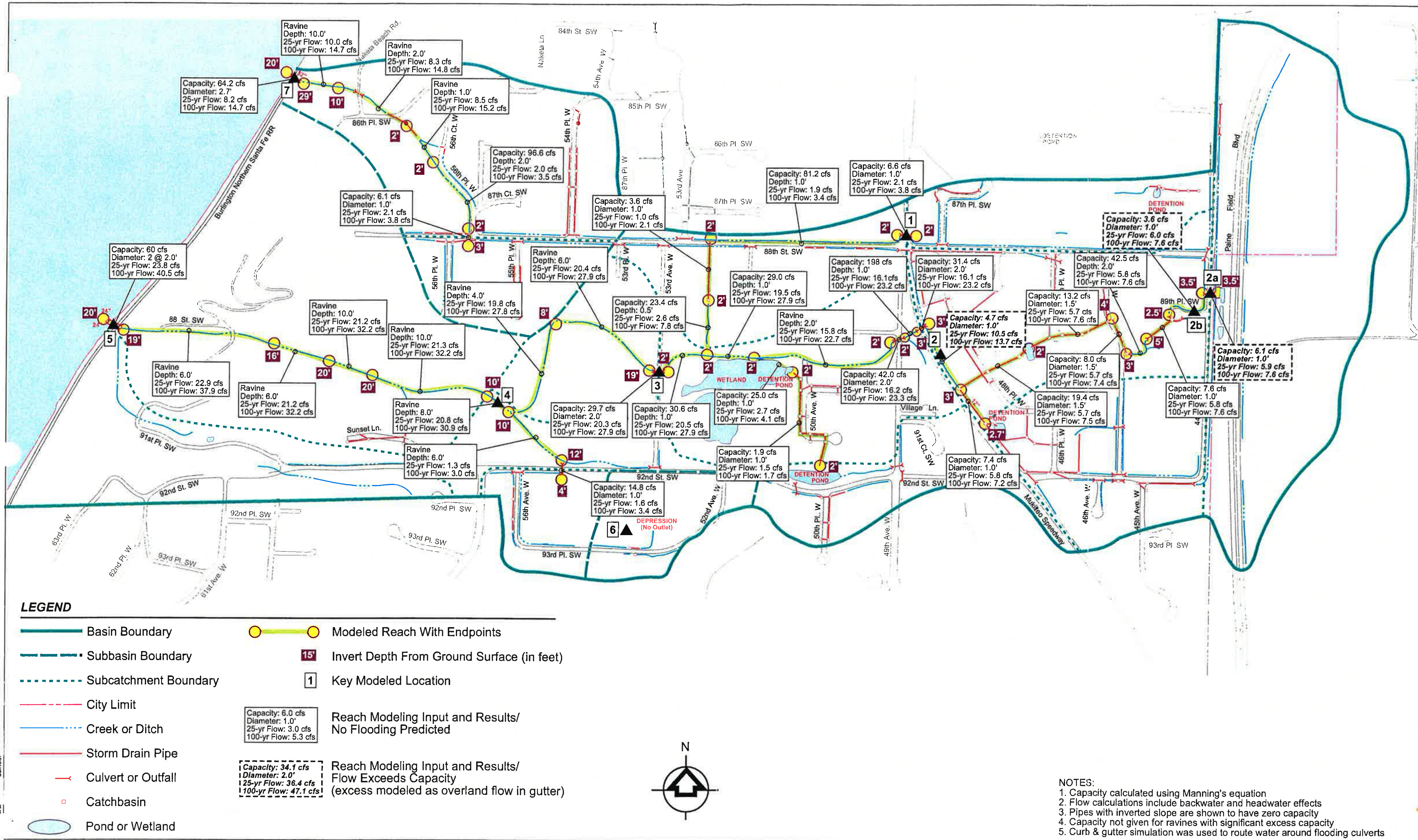
Figure 10-1.
BASIN AND SUBCATCHMENT BOUNDARIES AND EXISTING DRAINAGE SYSTEM; BASIN G



NOTES:
1. Capacity calculated using Manning's equation
2. Flow calculations include backwater and headwater effects
3. Pipes with inverted slope are shown to have zero capacity
4. Capacity not given for ravines with significant excess capacity
5. Curb & gutter simulation was used to route water around flooding culverts

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Figure 10-2.
MODELED SYSTEM CHARACTERISTICS AND RESULTS BY REACH; BASIN G

CHAPTER 11.
BASIN H—BIG GULCH

Big Gulch is the main conveyance mechanism in Basin H and the largest ravine in Mukilteo. The ravine is 200 to 300 feet deep on average with a side slope of about 100 percent for most of its length. At its outlet, it flows past the Olympus Terrace Sewer District treatment plant and under the railroad through a 60-inch corrugated metal culvert. Several major tributary branches feed into Big Gulch. Most of the basin within the city is fully-developed single-family residential area; however, just over half of the basin is located outside the city on the airport property (everything east of the Speedway). Figure 11-1 shows the entire Big Gulch basin, with delineation of the portion east of Mukilteo Speedway by Reid Middleton (1995). Figure 11-2 enlarges the area of Big Gulch within the City and shows the drainage network.

South of Harbour Pointe Boulevard is a large school site that includes multiple sports facilities. The schools located on this site are Kamiak High School, Harbour Pointe Middle School and Columbia Elementary. All of the schools were combined into one subcatchment.

East of Paine Field Boulevard is the Paine Field Airport, which routes most of its drainage to Big Gulch. In order to more accurately determine flows through Big Gulch, a rough estimate of flows from the airport was included in the model. The airport was divided into two subcatchments that drain to the system at separate locations.

MODELING RESULTS

The 25-year and 100-year storm events were modeled for Basin H. Table 11-1 lists predicted flow at locations such as outfalls and culverts into major tributaries. The locations are labeled in Figure 11-1. The model predicts no urban flooding for Basin H. There are no areas where the constructed or natural conveyance capacity is inadequate to carry the predicted runoff. The results are summarized in Figure 11-3, which lists the size and capacity of each modeled conveyance section along with the current 25- and 100-year flow rates.

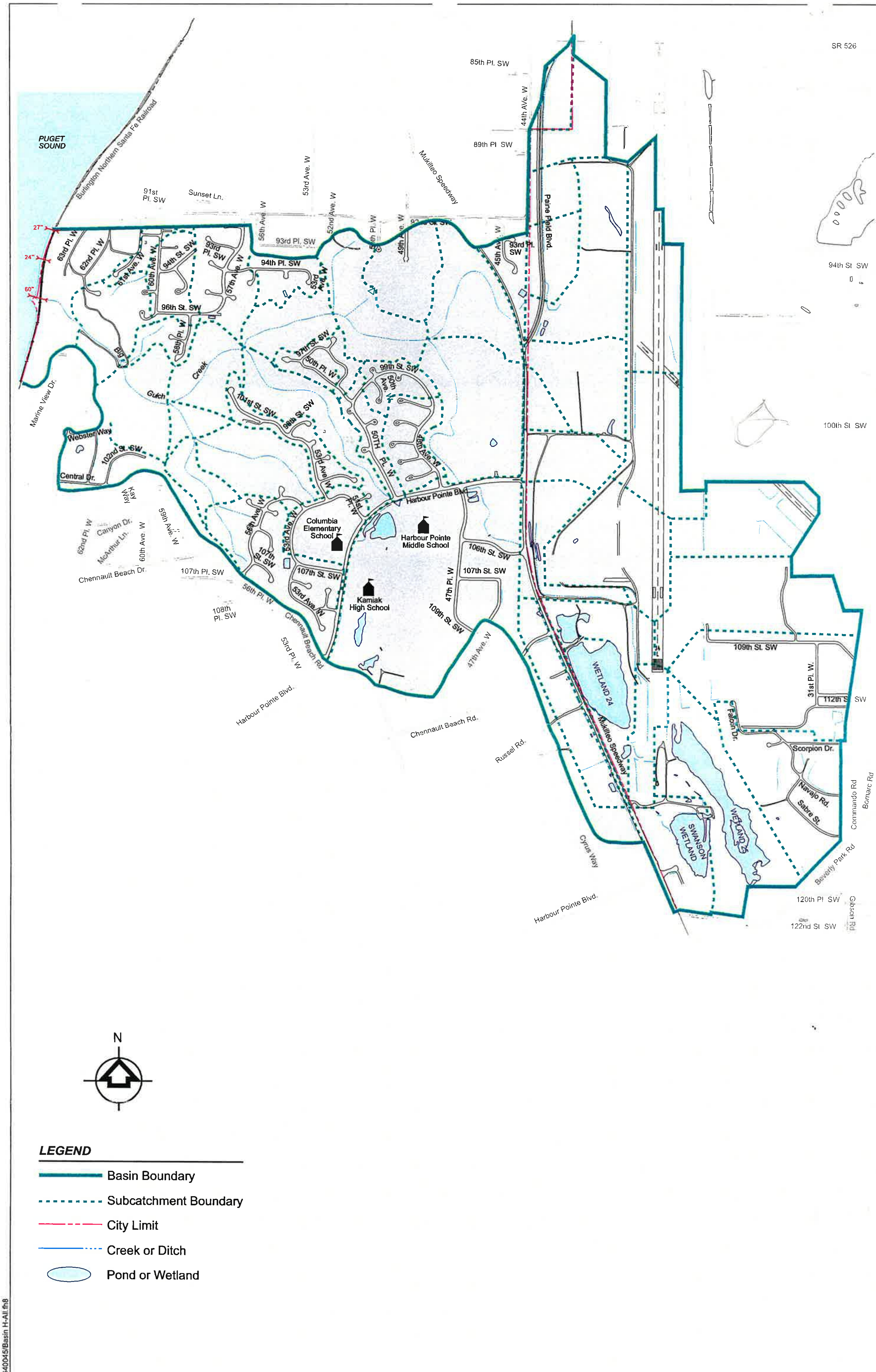
As shown in Table 11-1, the flow at location 5 decreased from current to future conditions. Future conditions were determined using the current zoning map. Similar to Basin D, the decrease in flow can be attributed to school property that is zoned as residential use. There is currently an elementary school located in the residential zone. The impervious area of the school grounds is greater than if the entire area was developed single family residential at the zoned density.

The future conditions model does not take into account any future change in runoff from the airport, which could change the results. CH2MHill is currently analyzing the airport runoff in greater detail, and the results will be published separately.

TABLE 11-1.
MODELED FLOW AT KEY LOCATIONS IN BASIN H

Location	Modeled Flow (cubic feet per second)			
	25-Year Storm Event		100-Year Storm Event	
	Current Conditions	Future Conditions[1]	Current Conditions	Future Conditions[1]
1	17.6	10.4[3]	22.3	15.6[3]
2	43.5	43.5	56.7	56.7
3	90.8	96.3	127.0	131.0
4	131.0	130.0	176.0	167.0
5	28.3	20.3[2]	47.0	36.3[2]
6	142.0	140.0	207.0	192.0
7	152.1	147.2	200.0	194.2

Notes:
1) Future conditions based on zoning map
2) Percent impervious values for current development conditions are higher than those for predicted future developed conditions
3) Paine Field detention facilities result in a reduction of future condition peak flows



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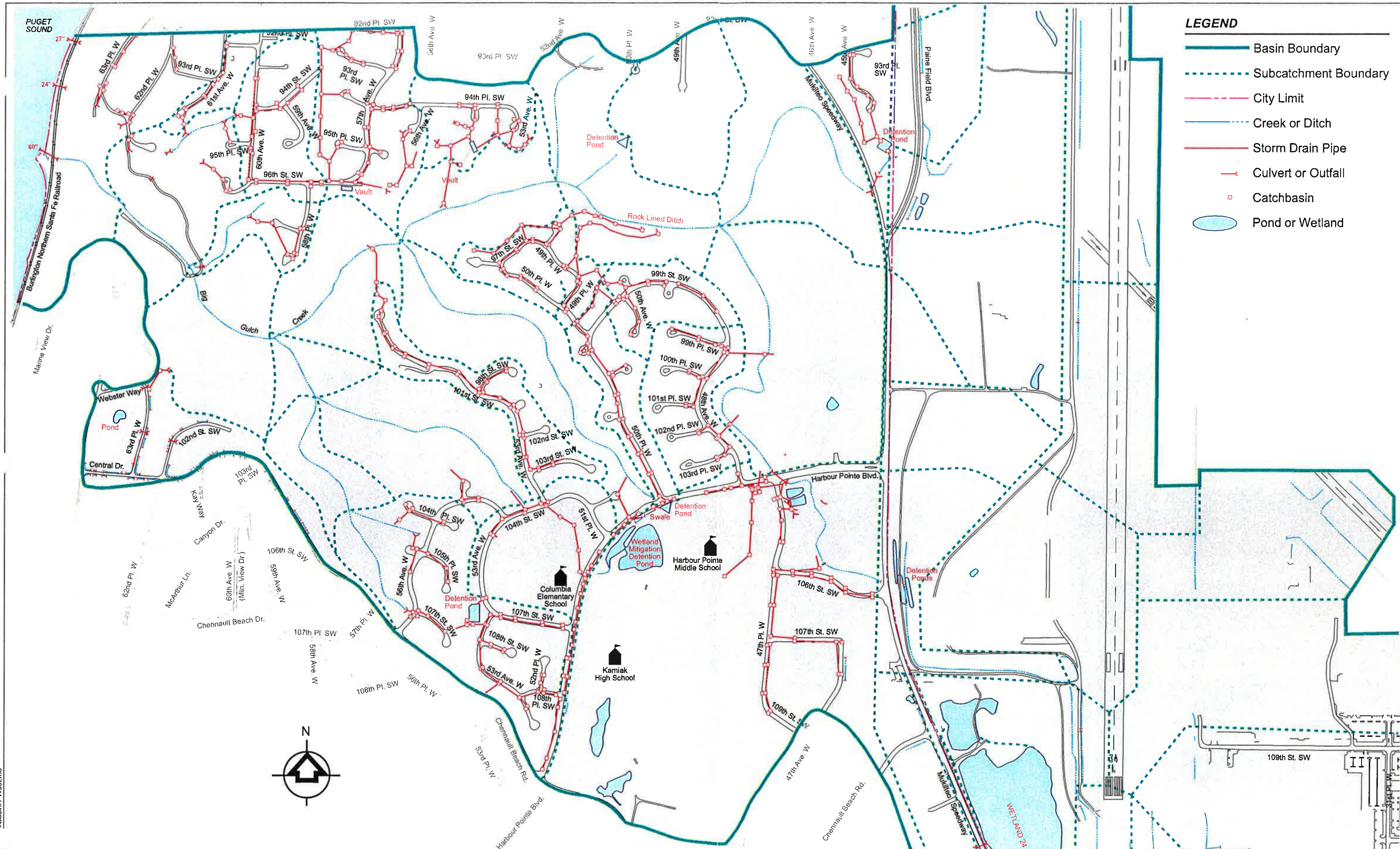
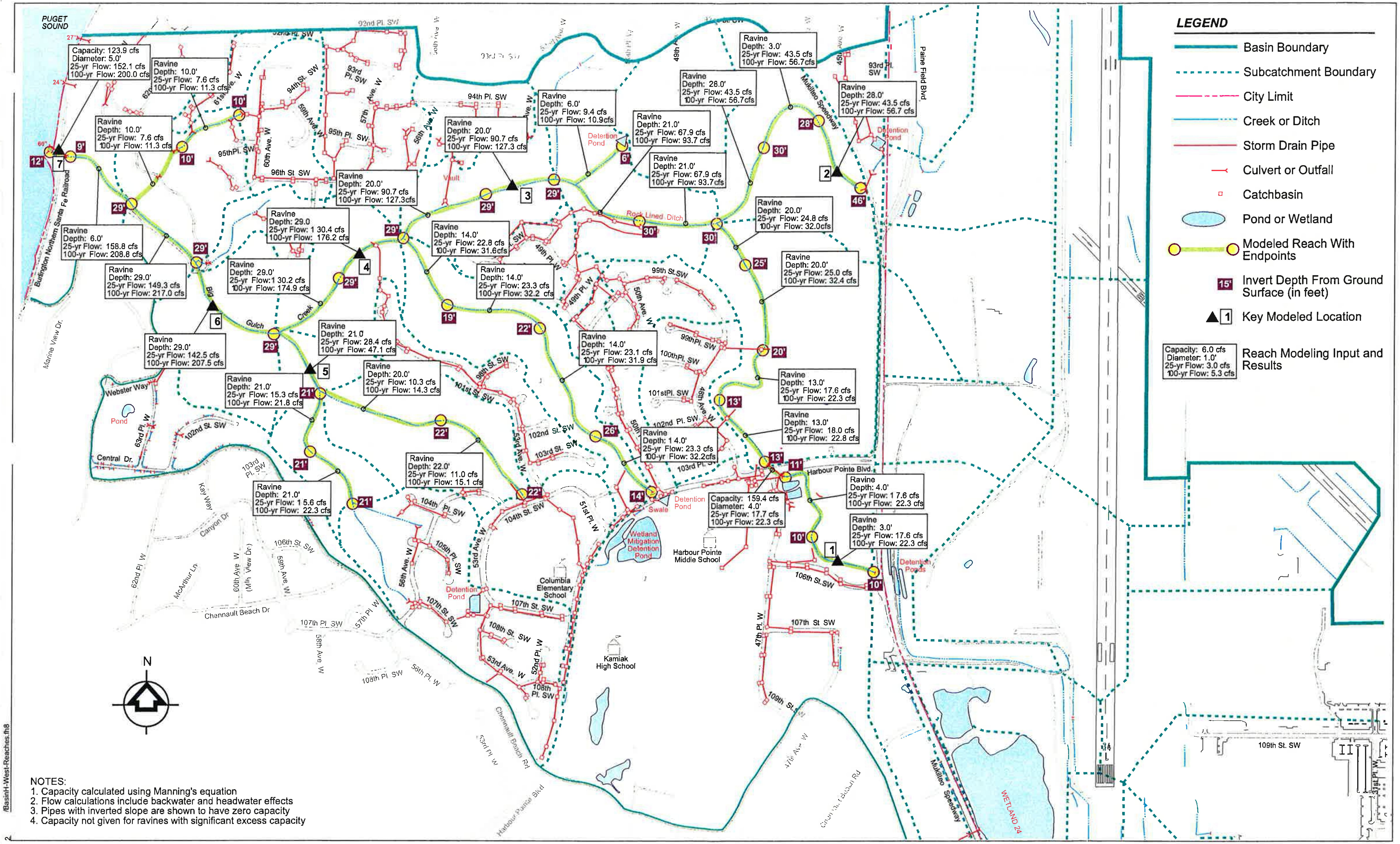
Tetra Tech/ KCM, Inc. 1917 First Avenue Seattle, Washington 98101	City of Mukilteo COMPREHENSIVE SURFACE WATER MANAGEMENT PLAN	Figure 11-1. BASIN AND SUBCATCHMENT BOUNDARIES; BASIN H



Tetra Tech/ KCM, Inc. 1917 First Avenue Seattle, Washington 98101	City of Mukilteo COMPREHENSIVE SURFACE WATER MANAGEMENT PLAN	Figure 11-2. BASIN AND SUBCATCHMENT BOUNDARIES AND EXISTING DRAINAGE SYSTEM; BASIN H WEST



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COMPREHENSIVE SURFACE WATER MANAGEMENT PLAN

Figure 11-3.
MODELED SYSTEM CHARACTERISTICS AND RESULTS BY REACH; BASIN H WEST

CHAPTER 12.
BASIN I—CHENNAULT BEACH AND BASIN J—UPPER CHENNAULT CREEK

Because of their relatively small size and interlocking shapes, Basin I and J were combined on to one figure, Figure 12-1.

Basin I was divided into four subbasins. Unlike the other basins, Basin I does not have a major ravine as the main drainage system. The entire basin is a network of catchbasins and pipes. Topographic information indicates several small segments of creeks that help convey flow through the subbasins. The northern subbasin consists of two subcatchments that convey flow via a piped system along Marine View Place. The outfall culvert is an 18-inch concrete pipe with an invert elevation of 4.5 feet.

The largest subbasin was divided into 8 subcatchments. Its flow is routed under the railroad tracks in a 24-inch concrete outfall with an invert elevation of 0 feet. Just east of the outfall is a depression area, shown in Figure 12-1, that stores water. The areas north and south of the outfall discharge directly into Puget Sound, because the entire length of the shoreline along Basin I is a steep cliff with approximately 100 percent slope for most of its length. This area was modeled as two subbasins. Except for the cliffs on the coast, Basin I is nearly fully-developed for residential use.

Basin J is composed of six subcatchments that route flow into Upper Chennault Creek, which conveys the flow to a 24-inch concrete culvert with an invert elevation of 1 foot. Upper Chennault Creek is approximately 6,000 feet long and receives water from a system of pipes and ditches. A long span of ditches follows along Chennault Beach Drive and enters the creek about 400 feet upstream of the outfall. Basin J is a fully-developed residential area with mostly single family units and a small area of multi-family units east of Harbour Pointe Boulevard.

MODELING RESULTS

The 25-year and 100-year storm events were modeled for Basins I and J. Tables 12-1 and 12-2 list predicted flow at locations such as outfalls and culverts into major tributaries for Basins I and J, respectively. The locations are labeled in Figure 12-2. The model predicts no flooding in the conveyance systems in Basins I and J. The results are summarized in Figure 12-2 which lists the size and capacity of each modeled conveyance section along with the current 25- and 100-year flow rates.

As shown in Table 12-2, the flow at location 2 in Basin J decreases from current to future conditions. Future conditions were determined using the current zoning map. The decrease in the flow at location 2 is related to developments that were constructed at a higher density than the zoning map predicts. The two developments in Basin J that appear to be the main contributors are Tatoosh and Sea Watch.

TABLE 12-1.
MODELED FLOW AT KEY LOCATIONS IN BASIN I

	Modeled Flow (cubic feet per second)			
	25-Year Storm Event		100-Year Storm Event	
Location	Current Conditions	Future Conditions[1]	Current Conditions	Future Conditions[1]
1	11.1	11.5	15.6	16.1
2	4.0	4.1	6.5	6.7
3	4.7	4.8	7.8	8.2
4	4.1	4.5	7.9	8.1
5	1.7	1.7	3.1	3.1
6	11.1	12.3	20.1	21.3
7	23.6	25.9	42.6	43.9
8	2.2	2.4	3.9	4.0

Note:
1) Future conditions based on zoning map

TABLE 12-2.
MODELED FLOW AT KEY LOCATIONS IN BASIN J

	Modeled Flow (cubic feet per second)			
	25-Year Storm Event		100-Year Storm Event	
Location	Current Conditions	Future Conditions[1]	Current Conditions	Future Conditions[1]
1	39.6	39.7	63.2	62.1
2	26.9	24.5[2]	43.5	40.8[2]
3	4.8	4.0	7.8	7.1
4	17.0	17.1	24.9	25.1

Notes:
1) Future conditions based on zoning map
2) Current development higher than zoning imperviousness

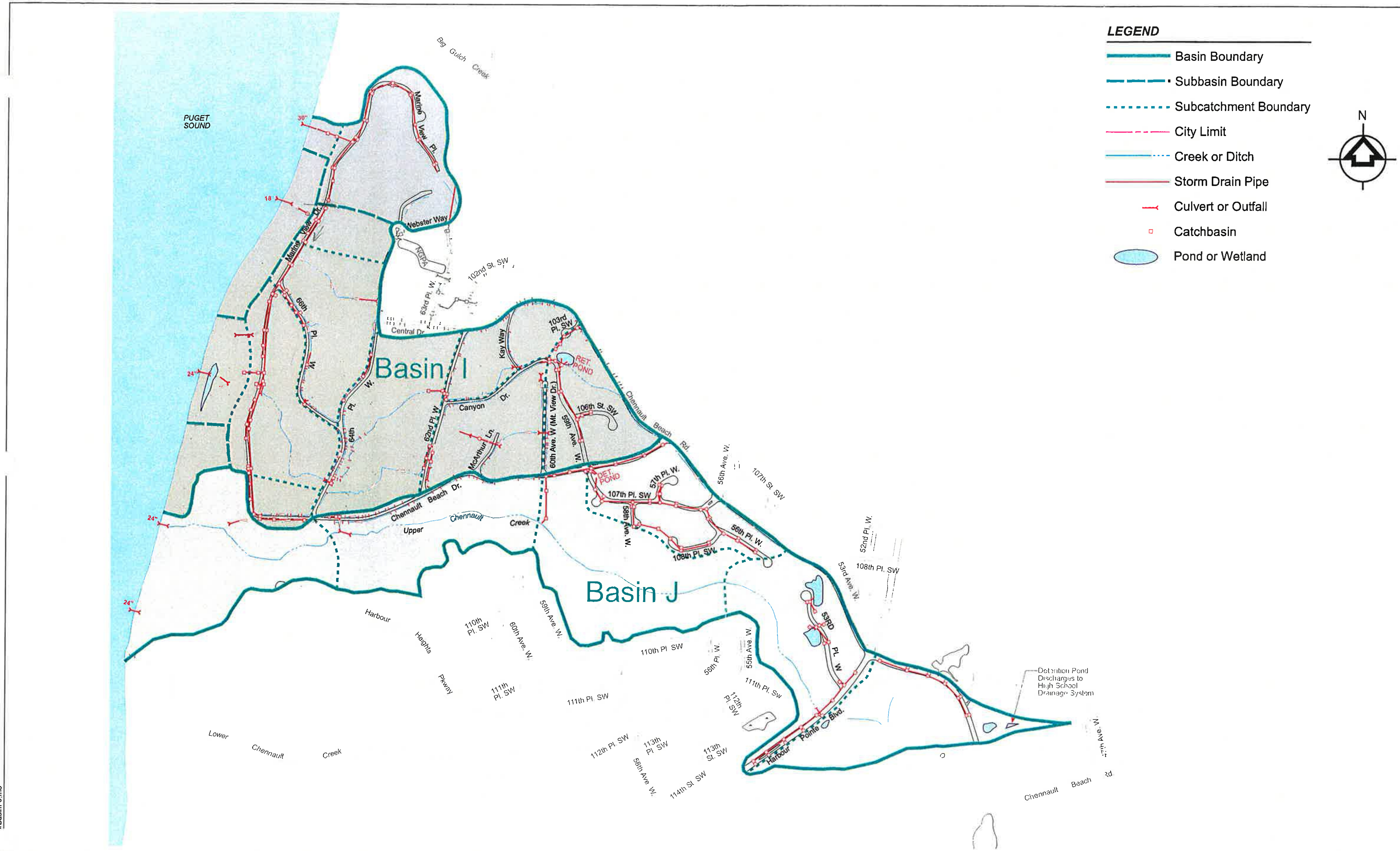

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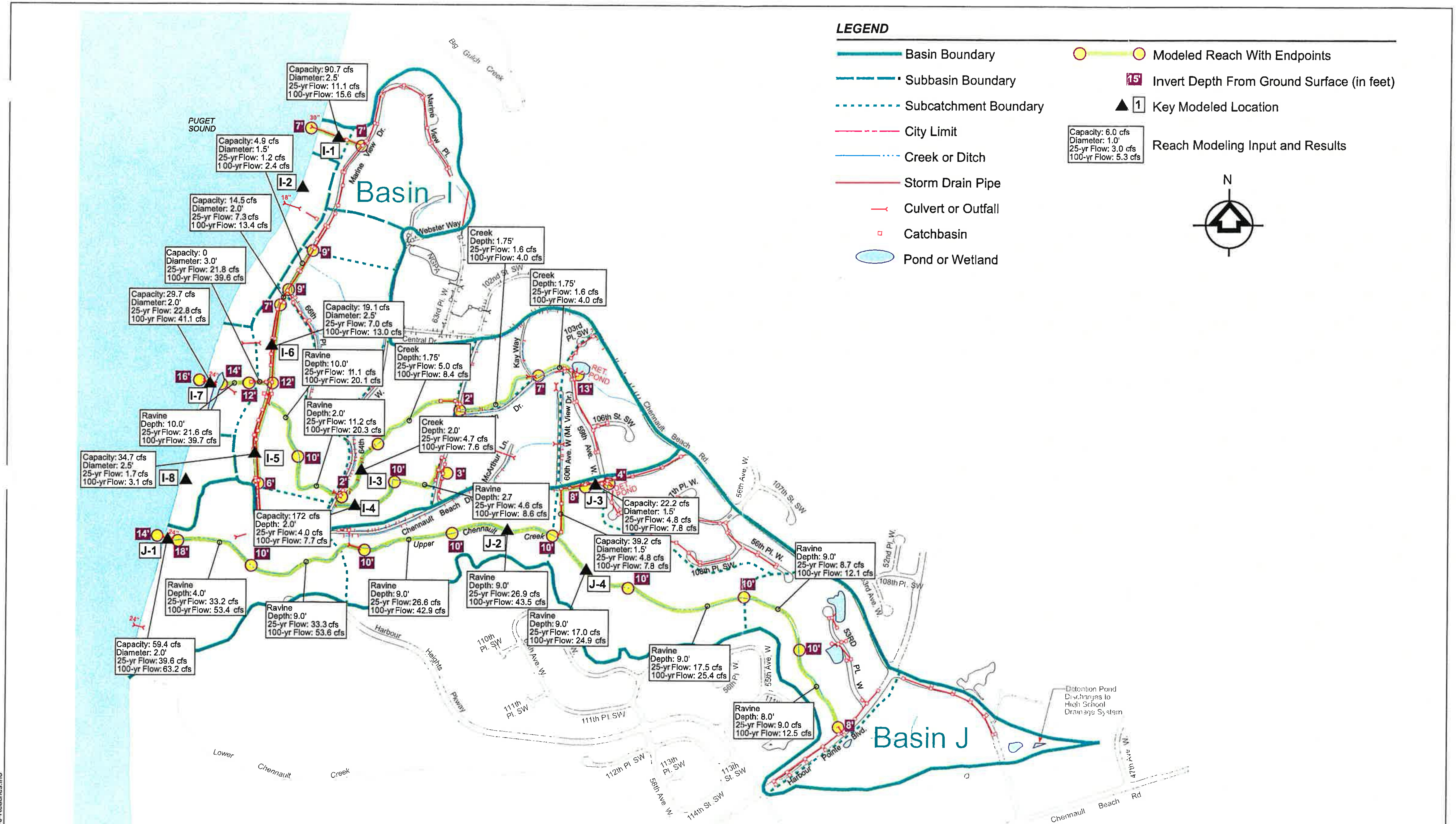
Figure 12-1.
BASIN AND SUBCATCHMENT BOUNDARIES AND EXISTING DRAINAGE SYSTEM; BASINS I AND J



NOTES:
1. Capacity calculated using Manning's equation
2. Flow calculations include backwater and headwater effects
3. Pipes with inverted slope are shown to have zero capacity
4. Capacity not given for creeks and ravines with significant excess capacity

Tetra Tech/ KCM, Inc. 1917 First Ave.nue Seattle, Washington 98101	City of Mukilteo COMPREHENSIVE SURFACE WATER MANAGEMENT PLAN	Figure 12-2. MODELED SYSTEM CHARACTERISTICS AND RESULTS BY REACH; BASINS I AND J

CHAPTER 13.
BASIN K—LOWER CHENNAULT CREEK

Basin K has been divided into 12 subcatchments, as shown in Figure 13-1. Lower Chennault Creek, the main conveyance element in Basin K, is approximately 4,000 feet long—half the length of the basin from east to west. The creek ravine is generally 50 feet deep with a side slope of 50 to 100 percent. Creek flow is conveyed under the railroad tracks via two 42-inch concrete culverts with invert elevations of 0 feet.

A large portion of the basin consists of the Harbour Pointe Golf Course, located east of Harbour Pointe Boulevard. For modeling purposes, the golf course was represented as a single subcatchment with 4 acre-feet of storage. This value was estimated from the aerial photographs and digital topography.

East of the golf course and Harbour Beach Drive is approximately 90 acres of light industrial/commercial area. The drainage system in this area consists of a network of pipes and catchbasins. Runoff from the light industrial/commercial area was modeled as a basin that drains directly to the culvert under Harbour Pointe Boulevard from the golf course to Lower Chennault Creek. This approach eliminates the need to model the varying drainage conveyance and capacity of the golf course ponds and channels.

The north-central section of Basin K is fully-developed multi-family residential. For modeling purposes, runoff from the multi-family residential area was routed down a series of 12-inch pipes along Harbour Pointe Boulevard and into Lower Chennault Creek at approximately the same location as the golf course drainage.

North of Lower Chennault Creek in the western portion of the basin is the Raytheon facility. No information was available regarding the drainage on the Raytheon premises, although a series of pipes and catchbasins convey flow along Harbour Heights Parkway and into the creek approximately 200 feet before it enters Puget Sound.

The remainder of the basin is partially-developed single-family residential area north and south of the creek in the western part of Basin K. Stormwater is routed through the neighborhoods in a system of catchbasins and pipes that discharge into the creek at numerous locations. The model combines major sections of the basin and introduces the runoff at various points along the creek channel.

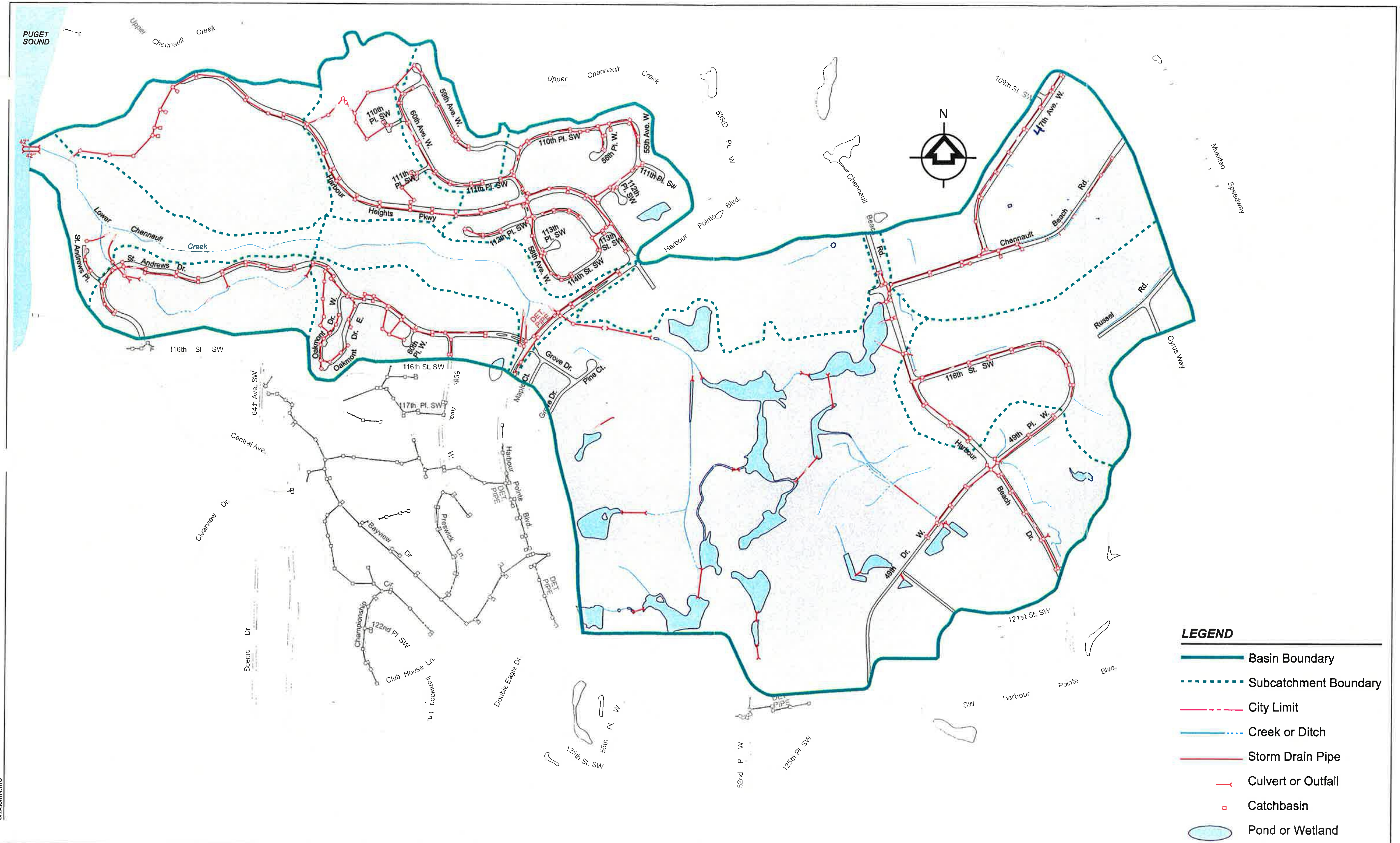
MODELING RESULTS

The 25-year and 100-year storm events were modeled for Basin K. Table 13-1 lists predicted flow at locations, labeled on Figure 13-2, such as outfalls and culverts into major tributaries. The model predicts no flooding for the conveyance system in Basin K. The results are summarized in Figure 13-2, which lists the size and capacity of each modeled conveyance section along with the current 25- and 100-year flow rates.

TABLE 13-1.
MODELED FLOW AT KEY LOCATIONS IN BASIN K

	Modeled Flow (cubic feet per second)			
	25-Year Storm Event		100-Year Storm Event	
Location	Current Conditions	Future Conditions[1]	Current Conditions	Future Conditions[1]
1	57.9	96.6	102.4	141.2
2	32.9	53.2	53.8	71.3
3	24.2	46.6	36.1	50.0
4	11.7	13.2	22.3	23.6
5	16.2	16.8	28.4	28.0
6	16.4	17	28.7	28.3
7	2.3	4	5.4	6.9
8	11.5	10.5	18.0	16.9

Note:
1) Future conditions based on zoning map



5/BasinK.fh8

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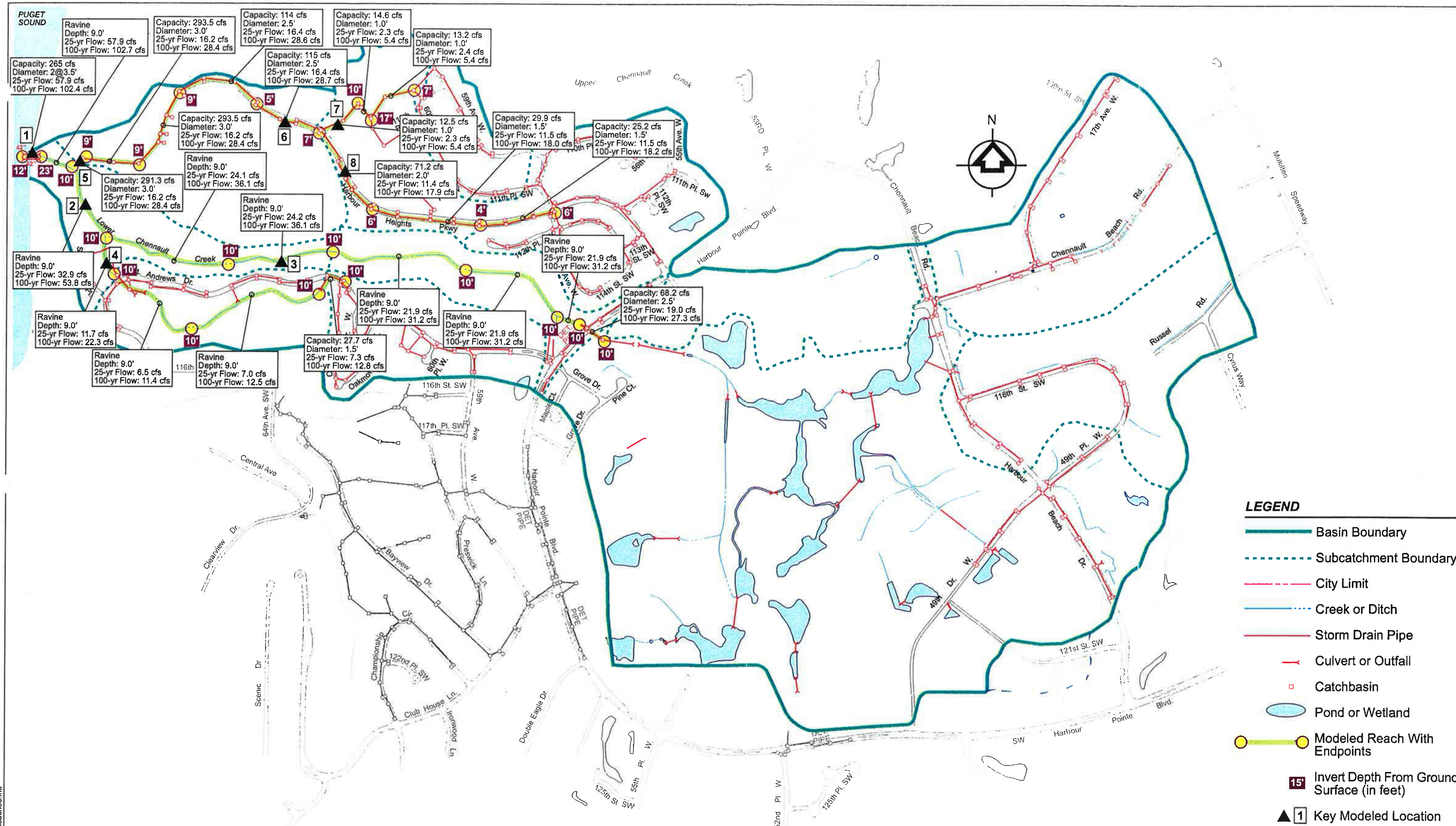
Figure 13-1.
BASIN AND SUBCATCHMENT BOUNDARIES AND EXISTING DRAINAGE SYSTEM; BASIN K



NOTES:
1. Capacity calculated using Manning's equation
2. Flow calculations include backwater and headwater effects
3. Pipes with inverted slope are shown to have zero capacity
4. Capacity not given for ravines with significant excess capacity

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Figure 13-2.
MODELED SYSTEM CHARACTERISTICS AND RESULTS BY REACH; BASIN K

CHAPTER 14.
BASIN L—HULK CREEK

Basin L, shown in Figure 14-1, is west of the Harbour Pointe Golf Course and divided into seven subcatchments. Approximately 50 percent of the basin area is located outside the city limits to the west, and the majority of this area is undeveloped, though residential construction is ongoing. Hydraulic characteristics of the subcatchments outside the City were roughly estimated in order to determine the approximate peak flow through the outfall which is inside the city limits (just north of 116th Street Southwest). Hulk Creek conveys runoff to a 24-inch outfall that routes water under the railroad tracks and into Puget Sound.

MODELING RESULTS

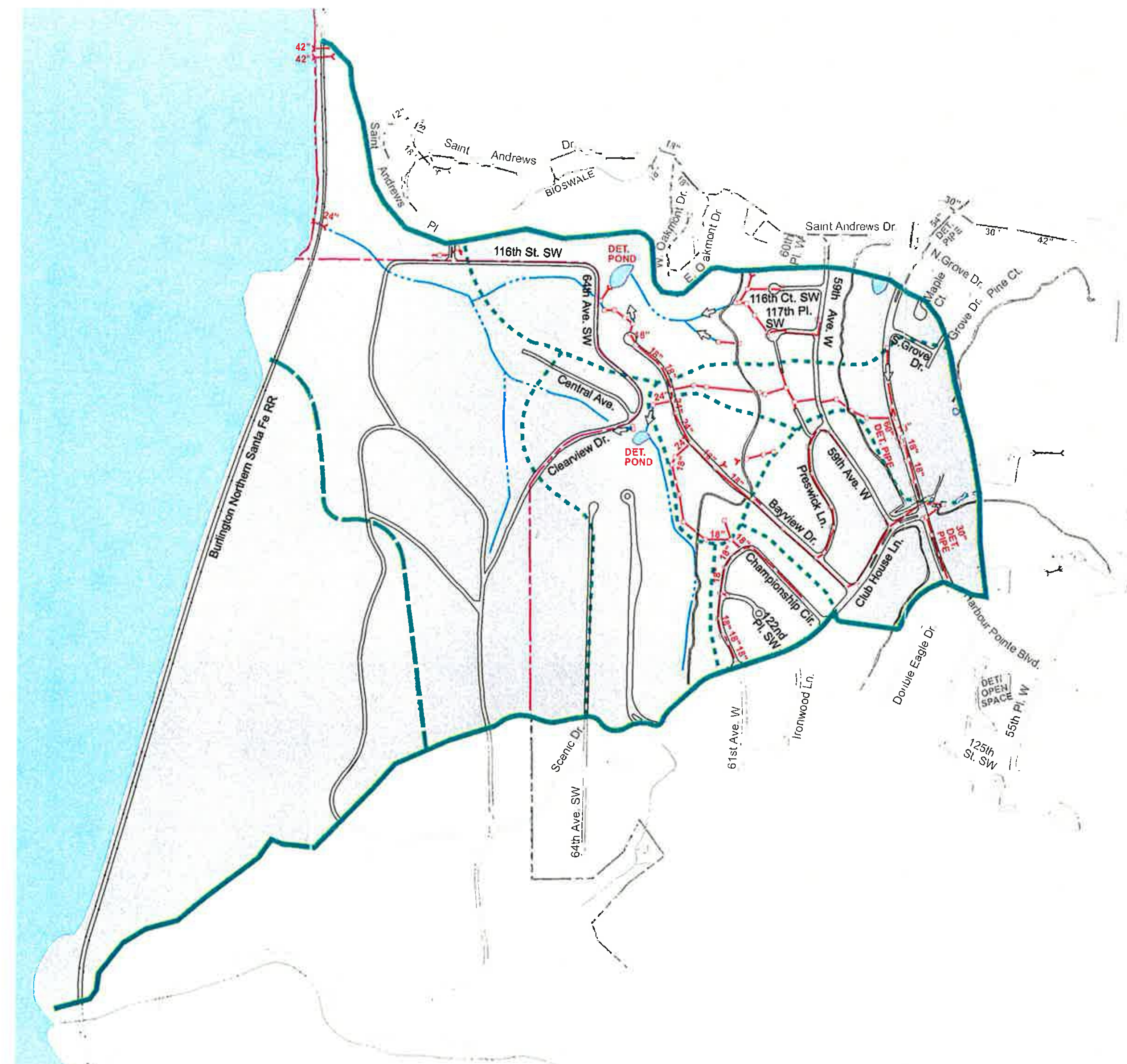
The 25-year and 100-year storm events were modeled for Basin L. Table 14-1 lists predicted flow at points of interest. The locations are labeled in Figure 14-2. The model predicts no flooding for the conveyance system in Basin L. The results are summarized in Figure 14-2, which lists the size and capacity of each modeled conveyance section along with the current 25- and 100-year flow rates.

As shown in Table 14-1, the flow at location 4 decreased from current to future conditions. Future conditions were determined using the current zoning map. A small development called Championship Court located near Championship Circle appears to have been constructed at a higher density than estimated using the zoning map.

TABLE 14-1.
MODELED FLOW AT KEY LOCATIONS IN BASIN L

	Modeled Flow (cubic feet per second)			
	25-Year Storm Event		100-Year Storm Event	
Location	Current Conditions	Future Conditions[1]	Current Conditions	Future Conditions[1]
1	7.2	8.3	17.2	17.8
2	7.3	8.7	17.2	27.5
3	6.6	7.9	11.1	12.7
4	4.0	3.2[2]	6.2	5.3[2]
5	13.8	19.1	26.8	26.6
6	13.7	23.8	19.0	32.8
7	17.3	27.5	25.9	54.0
8	20.3	37.1	32.7	68.6

Notes:
1) Future conditions based on zoning map
2) Current development higher than zoning imperviousness

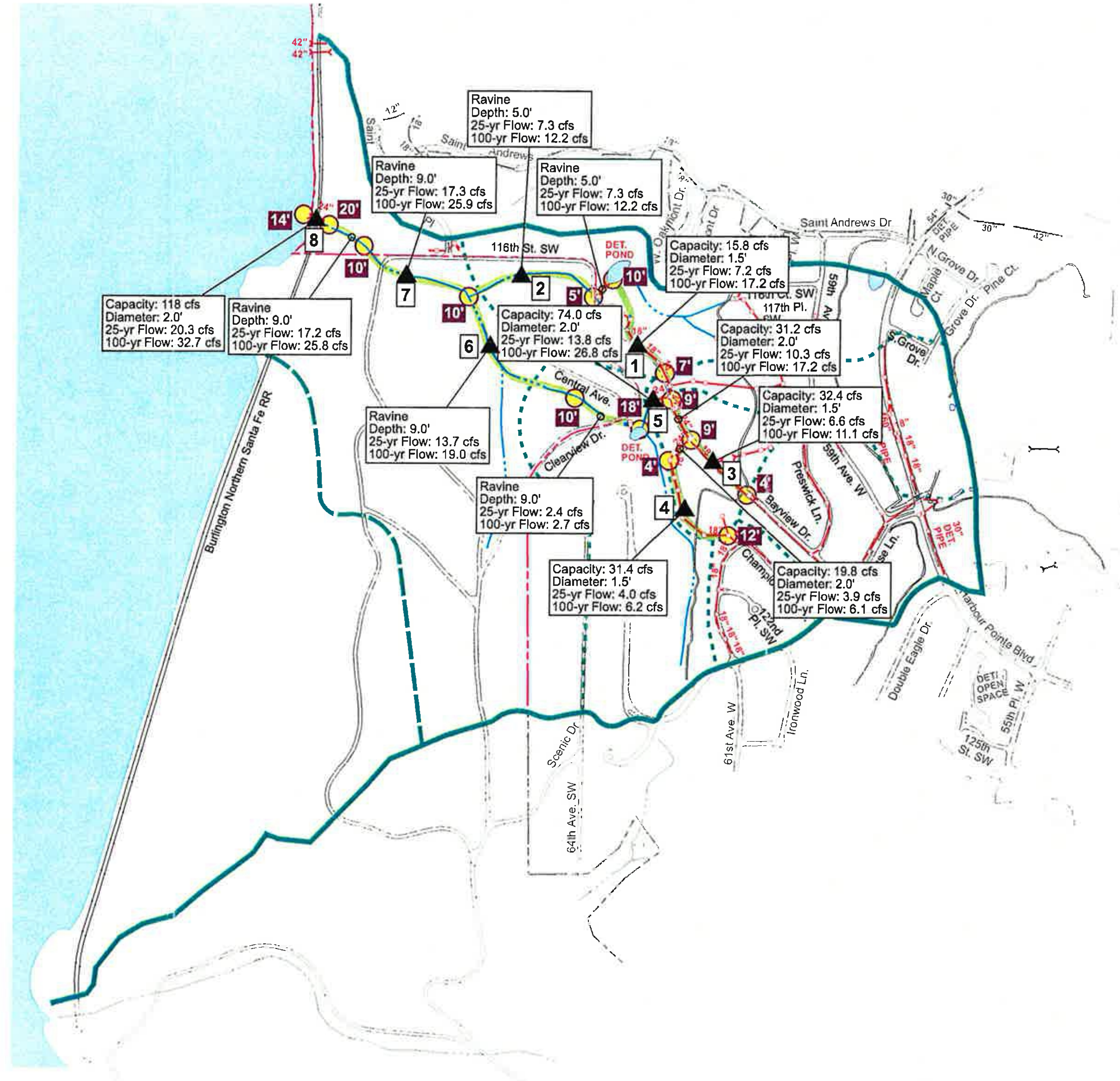


LEGEND

- Basin Boundary
- Subbasin Boundary
- Subcatchment Boundary
- City Limit
- Creek or Ditch
- Storm Drain Pipe
- Culvert or Outfall
- Catchbasin
- Pond or Wetland

N

Tetra Tech/ KCM, Inc. 1917 First Avenue Seattle, Washington 98101	City of Mukilteo COMPREHENSIVE SURFACE WATER MANAGEMENT PLAN	Figure 14-1. BASIN AND SUBCATCHMENT BOUNDARIES AND EXISTING DRAINAGE SYSTEM; BASIN L



LEGEND

Basin Boundary		Modeled Reach With Endpoints	
Subbasin Boundary		Invert Depth From Ground Surface (in feet)	15'
Subcatchment Boundary		Key Modeled Location	1
City Limit		Reach Modeling Input and Results	Capacity: 6.0 cfs Diameter: 1.0' 25-yr Flow: 3.0 cfs 100-yr Flow: 5.3 cfs
Creek or Ditch			
Storm Drain Pipe			
Culvert or Outfall			
Catchbasin			
Pond or Wetland			

NOTES:
1. Capacity calculated using Manning's equation
2. Flow calculations include backwater and headwater effects
3. Pipes with inverted slope are shown to have zero capacity
4. Capacity not given for ravines with significant excess capacity

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Figure 14-2.
MODELED SYSTEM CHARACTERISTICS AND RESULTS BY REACH; BASIN L

CHAPTER 15.
BASIN M—PICNIC POINT CREEK

Basin M, shown in Figure 15-1, consists of 23 subcatchments covering approximately 1,455 acres, of which 50 percent lies within the city limits. The Picnic Point Ravine is the major drainage system in Basin M, and its tributary area encompasses most of the area in the basin. It varies from 100 to 300 feet deep from creek bottom to bank and drops 1 foot in elevation for every 4 to 5 feet of length for most of the downstream area. The ravine receives flow from three major tributaries in the lower 4,000 feet of the channel before the creek enters Puget Sound. The upper basin receives flow from two lesser ravines. The focus of this analysis was the network inside the City. Drainage area outside the city was represented in the model to include the impact, if any, on the drainage system originating within the City.

The ravine is undeveloped and does not contain piped conveyance systems. The area above the ravines, particularly to the north, is highly developed with residential and commercial areas and contains a network of typically small diameter storm drainage pipes and local detention systems. These individual collection systems ultimately discharge into the main ravine, either through open channels or down-drains.

The single undocumented outfall, located outside the city limits, crosses under the railroad tracks and discharges directly into Puget Sound. Without outfall details, the outfall element of Basin M was modeled as an open channel.

Numerous neighborhood detention facilities were constructed with recent residential developments in the basin. Detailed information was obtained for the detention pond north of Harbour Heights Drive, west of 44th Avenue W, and this was incorporated into the model. Several of the larger detention facilities were approximated in the model with constant storage at the node according to the topographic mapping.

MODELING RESULTS

The 25-year and 100-year storm events were modeled for Basin M. Table 15-1 lists predicted flow at locations such as culverts into major tributaries, outfalls and modeled flooding locations. The locations are labeled in Figure 15-1. The results are summarized in Figure 15-2, which lists the size and capacity of each modeled conveyance section along with the current 25- and 100-year flow rates. The model predicts no flooding for the conveyance system in Basin M.

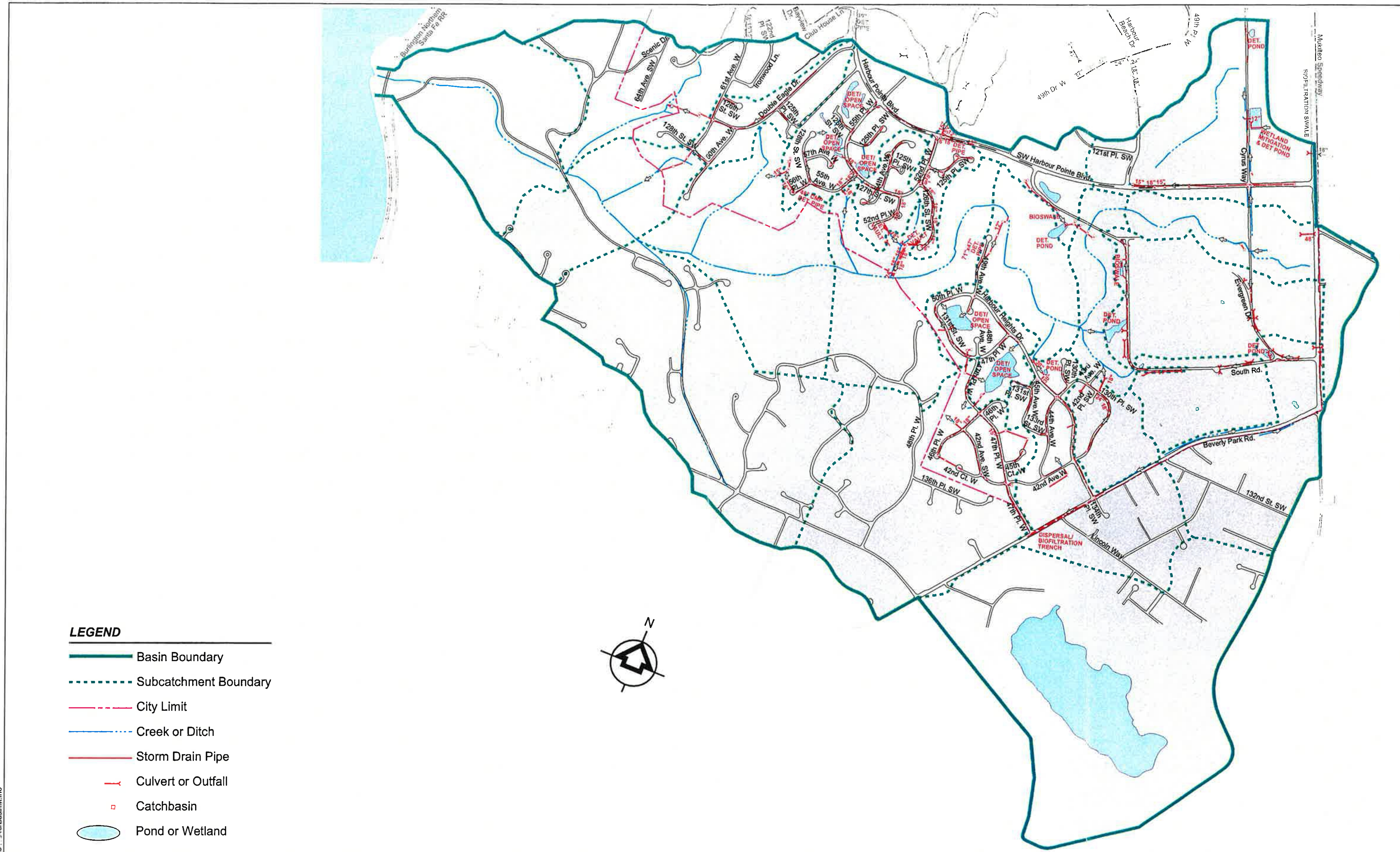
As shown in Table 15-1, the flow at locations 2, 6, 8, 9, 11, and 15 decreased from current to future conditions. Future conditions were determined using the current zoning map. Quite a large portion of Basin M was developed at a greater density than was estimated using the zoning map. The entire development along Harbour Heights Drive, west of Beverly Park Road seems to have been built at a greater density than the zoning category. The zoned percent impervious was modeled at 30 percent based on RD 8.4, while the current effective impervious is approximately 50 percent. Another development, called Waterford Park, near 127th Street SW and 55th Place W, was also constructed at a greater density than the zoning category. Presumably these developments occurred prior to incorporation and the current zoning limits.

The other main contributing factor to the decrease in flow is a school property that is zoned for single family residential (RD 8.4). Endeavor Elementary School is located east of Double Eagle Drive and south of Harbour Point Boulevard. It is unlikely that the school will be redeveloped as residences; therefore the effective impervious area will remain higher than currently zoned.

TABLE 15-1.
MODELED FLOW AT KEY LOCATIONS IN BASIN M

	Modeled Flow (cubic feet per second)			
	25-Year Storm Event		100-Year Storm Event	
Location	Current Conditions	Future Conditions[1]	Current Conditions	Future Conditions[1]
1	204.3	262.0	319.8	396.4
2	23.2	22.3[2]	37.0	35.8[2]
3	194.0	253.0	294.2	371.5
4	26.5	26.4	40.4	40.2
5	172.5	231.6	251.3	328.1
6	8.9	7.5[2]	11.7	11.0[2]
7	166.3	226.2	241.4	319.6
8	8.6	5.3[2]	12.0	8.0[2]
9	5.8	3.8[2]	8.7	6.6[2]
10	154.8	216.0	222.1	301.5
11	55.1	34.8[2]	79.3	52.2[2]
12	104.7	181.9	142.8	245.5
13	52.3	96.5	79.3	130.0
14	29.4	57.4	39.2	81.0
15	9.4	2.9[2]	9.3	8.7[2]
16	46.6	71.1	65.1	95.5
17	29.5	30.7	34.4	34.3
18	23.4	59.1	33.8	79.8

Notes:
1) Future conditions based on zoning map
2) Current development higher than zoning imperviousness



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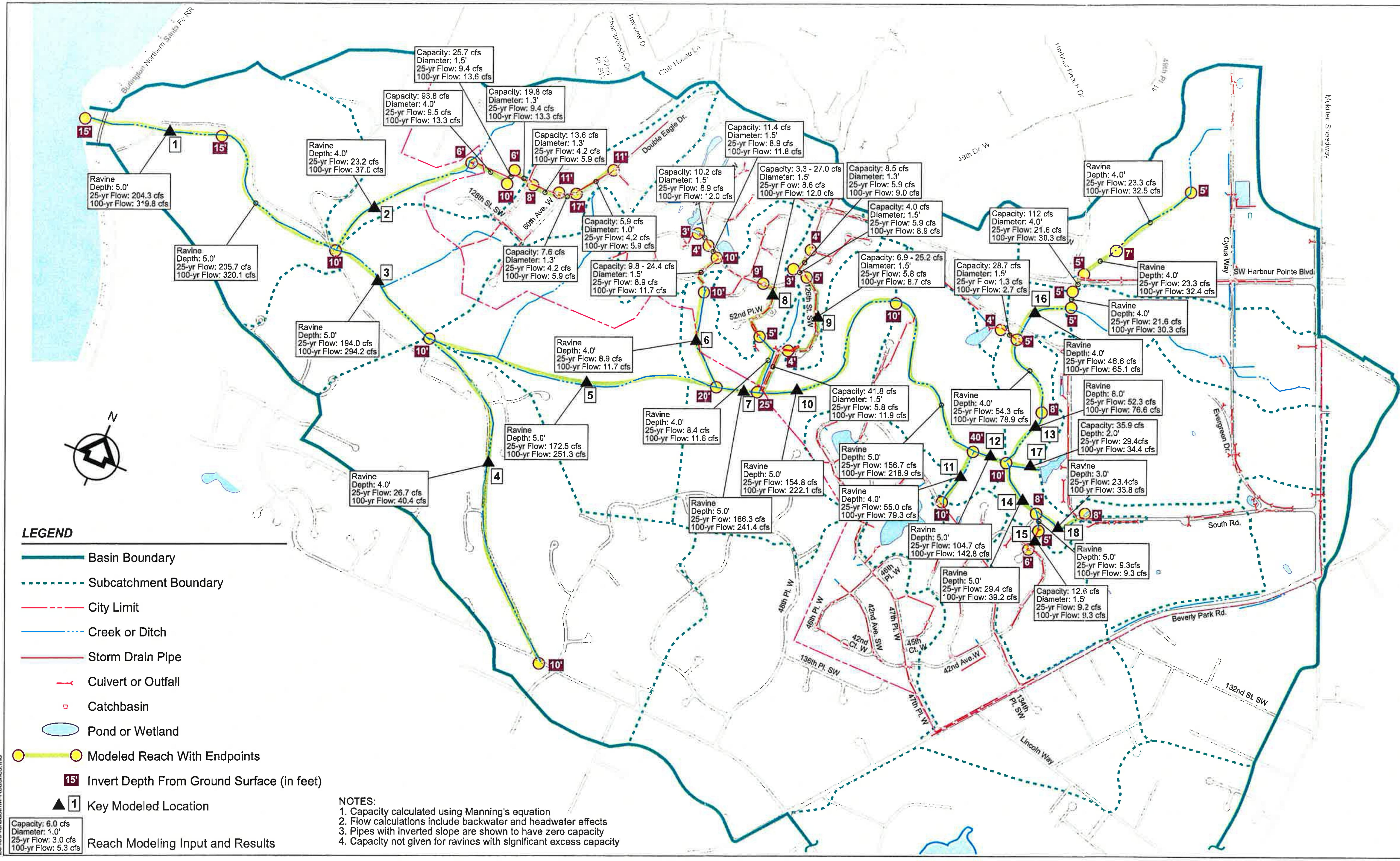
Seattle, Washington 98101

City of Mukilteo
COMPREHENSIVE SURFACE WATER MANAGEMENT PLAN

Figure 15-1.
BASIN AND SUBCATCHMENT BOUNDARIES AND EXISTING DRAINAGE SYSTEM; BASIN M



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COMPREHENSIVE SURFACE WATER MANAGEMENT PLAN

Figure 15-2.
MODELED SYSTEM CHARACTERISTICS AND RESULTS BY REACH; BASIN M

CHAPTER 16.
RANKING OF IDENTIFIED PROBLEMS

This chapter summarizes the problems predicted by the simulation modeling and presents criteria with which to evaluate all of the problems identified in this plan. The problems are rated according to these criteria and a priority list developed.

A large number of problems were documented in Table 3-1 from various sources. Additionally, the modeling revealed several areas where flooding is predicted under current or future conditions. Described in the basin chapters, these are summarized in Table 16-1. The problems have been numbered: the first one or two letters indicate the basin in which they occur; an M was inserted to indicate a "model" identified problem; and a unique sequential number was assigned.

In order to address all of the problems, an evaluation and ranking method was needed to prioritize the problems. This chapter describes an evaluation approach and uses it to rank the problems that have been identified. The chapter concludes with a planning level cost estimate of each of the identified problems.

EVALUATION PROCEDURE

Evaluation Criteria

The first step in problem evaluation is to identify appropriate evaluation criteria. Problems are rated by assigning each of them a numerical score for each selected criterion. The criteria should reflect the policies of the City as well as citizen concerns. Table 16-2 lists criteria commonly used to rate municipal drainage problems. The specific criteria listed are described in detail below, along with the scoring system associated with each.

Flood Hazard Reduction Criteria

Flooding of Public Streets

This criterion scores whether the problem causes flooding of public streets. A low score indicates that the problem does not involve flooding of public streets. A moderate score indicates a flood problem that impacts minor or collector roads. A high score indicates a serious flooding problem of a street or arterial.

Flooding of Properties

This criterion ranks whether the problem causes flooding of property, such as homes or businesses. A low score indicates that the problem does not involve flooding of properties. A moderate score indicates a flood problem that creates nuisance property flooding (not structural flooding). A high score indicates a serious property flooding problem, including structural flooding.

TABLE 16-1.
MODEL IDENTIFIED DRAINAGE PROBLEMS

ID No.	Description	Location	Type	Source of Information
CB-M1	Pipes have inadequate capacity for the 100-year storm according to the model. Location 4 on Figure 6-2. This modeled flooding correlates with problem ID No. CB2.	North side of Front Street, east of creek outfall	Inadequate capacity	XP-SWMM model
CB-M2	Outfall has inadequate capacity for the 100-year storm event. Location 5 on Figure 6-2.	Outfall of Brewery Creek.	Inadequate capacity	XP-SWMM model
D-M1	School property could flood during the 100-year storm event. Location 2 on Figure 7-2. This modeled flooding correlates with problem ID No. D11.	North of the Mukilteo Speedway, east of Washington Avenue.	Inadequate capacity	XP-SWMM model
D-M2	Pipe has inadequate capacity to convey flow from a ditch to the ravine in both the 25-year and 100-year storm events. Location 3 in Figure 7-2.	South of Possession View Ln., west of Goat Trail Rd., east of Washington Ave.	Inadequate capacity	XP-SWMM model
F-M1	Pipe has inadequate capacity for the 25-year and 100-year storm events. Flooding may also be caused by problems with detention facilities in the area. Location 1 on Figure 9-2.	North of 84th Street SW, between Mukilteo Speedway and Graham Way	Inadequate capacity	XP-SWMM model
F-M2	Flooding in a series of 12-inch pipes for both the 25-year and 100-year storm events. Location 2 on Figure 9-2. This modeled flooding correlates with problem ID No. F9.	North of 84th Street SW, just west of Graham Way	Inadequate capacity	XP-SWMM model
G-M1	Flooding during both 25-year and 100-year storm events. Location 2 on Figure 10-2.	Mukilteo Speedway at ~ 90th	Inadequate capacity	XP-SWMM model
G-M2	Flooding during 100-year storm event. Location 2a on Figure 10-2.	44th Avenue W at 89th Pl. SW	Inadequate capacity	XP-SWMM model
G-M3	Flooding during both 25-year and 100-year storm events. Location 2b on Figure 10-2. Same as problem No. G1	89th Pl. SW to 45th Pl. W	Inadequate capacity	XP-SWMM model
M-M1	This location could experience minor flooding during the 100-year storm event. This location corresponds to a detention pond. Location 17 on Figure 15-2.	South bend of South Road	Outlet control structure	XP-SWMM model

TABLE 16-2.
TYPICAL ALTERNATIVE EVALUATION CRITERIA

General Criterion	Associated Specific Criteria
Flood Hazard Reduction	• Flooding of public streets • Flooding of properties, public or private • Frequency of flooding • Magnitude of flooding • City responsibility
Environmental	• Stream bank erosion • Hillside erosion • Water quality • Habitat
Community Considerations	• Aesthetics • Socioeconomic consideration • Complaint history
Project Dependencies	• Project Coordination • Existing versus Future Problem

Frequency of Flooding

This criterion scores problems based on the frequency of predicted future flooding. A low score indicates that the problem represents an infrequent flooding condition, such as flooding only during a 100-year or larger storm. A high score is assigned to problems that involve frequent and chronic flooding, such as areas that have been the subject of frequent citizen complaints or that flood during the 6-month storm.

Magnitude of Flooding

This criterion assigns a score based on the predicted magnitude of flooding. A low score indicates that a relatively minor amount of flooding, as evaluated by duration, is predicted at this problem area. A high score is assigned to a problem with flooding for longer periods of time or with reported significant volumes.

City Responsibility

This criterion assigns a score based on the perceived responsibility of the City to address the problem. A low score indicates a relatively low level of perceived responsibility, such as may be expected from flooding of undeveloped remote property. A high score indicates that the problem has the potential for high City responsibility, such as flooding of a major roadway.

Environmental Criteria

Streambank Erosion

The criterion rates how a problem impacts streambank protection and whether it threatens stability through bank and bed erosion. A low score means erosion is not a factor in the problem, and a high score means erosion of the streambanks and streambed is part of the problem.

Hillside Erosion

The criterion rates how a problem impacts hillside stability. A low score means erosion is not a factor in the problem, and a high score means erosion of the hillside is part of the problem.

Water Quality

This criterion evaluates whether the problem affects the quality of stormwater runoff prior to its discharge to the receiving water course. A low score would be assigned to a problem that does not affect the water quality of runoff. A high score indicates that the problem significantly affects runoff water quality.

Habitat

This criterion rates whether the identified problem threatens habitat. A low score indicates that no habitat is threatened by the problem; a high score indicates that the problem does pose a threat to surrounding habitat.

Community Consideration Criteria

Aesthetics

This criterion measures a problem's aesthetic impact. A low score indicates that the problem has no significant aesthetic impact. A high score indicates that the problem has a negative aesthetic impact, such as severe erosion.

Socioeconomic Consideration

Depending on its size and location, a problem can diminish socioeconomic development opportunities in the community. A problem would be assigned a low score for this criterion if it has no impacts on socioeconomic development. A high score indicates negative impacts such as flooding that restricts development in a commercial zone or degradation of economic or environmental resources.

Complaint History

For some problems, there may be a long history of citizen complaints. This criterion considers both the frequency and number of citizen complaints. A problem would be assigned a low score if the area does not have a history of citizen complaints. A problem would receive a high score if the location has been the subject of many and frequent citizen complaints.

Project Dependency Criteria

Project Coordination

Frequently, a project to address a problem can be readily incorporated into another construction project in the same vicinity, such as replacing an undersized road culvert during a road widening project. Coordinating these construction projects can save considerable money and effort. Using this criterion, a problem is assigned a low score if there is no opportunity to incorporate measures to address it into other projects in the vicinity. If there is an opportunity to include the improvement with other construction in the area, then a high score is assigned.

Existing Versus Future Problem

The basin analyses performed for this study use existing and future land use conditions. Consequently, problems are identified for both existing and future conditions. If a problem is found to occur only under future land use conditions, then it is assigned a low score. A moderate score is assigned if a problem is both a minor existing problem and future problem. A high score is assigned if the problem is a moderate to large existing problem and a severe future problem.

Criteria Weighting and Rating System

The criteria described above were selected for use in evaluating the identified problems. Each problem is rated from 0 to 5 for each criterion, with the ratings indicating characteristics as described in the criteria discussions above. Each criterion was weighted to indicate its importance to the City. The most important criteria were given a numerical weight of 3, and the least were given a weight of 1. Each problem's weighted score for each criterion is the product of the weight and the rating. Table 16-3 shows the weight assigned to each criterion.

The problem's total score is the sum of the weighted scores for all criteria. High scores indicate high priority problems that should be addressed soon. Low scores indicate problems that can be scheduled as funding permits.

Other Considerations

Some situations can warrant re-evaluation of prioritized projects. These include emergency conditions such as a restrictive culvert identified for replacement becoming plugged during a storm and creating a road washout. The culvert restriction might have been assigned a relatively low priority, but its implementation would be accelerated as part of the road reopening.

TABLE 16-3.
WEIGHT ASSIGNED TO SELECTED EVALUATION CRITERIA

Criterion	Weight
Flood Hazard Reduction	
Flooding of public streets	2
Flooding of properties, public or private	1
Frequency of flooding	2
Magnitude of flooding	2
City responsibility	3
Environment	
Streambank erosion	2
Hillside erosion	2
Water quality	1
Habitat	1
Community Considerations	
Aesthetics	1
Socioeconomic consideration	2
Complaint history	2

A funding windfall such as a grant opportunity or mitigation money can also affect priorities. A grant might only apply to a specific problem, which would move a project to address that problem forward for implementation. Future regulatory or political mandates could also require addressing a problem out of the originally defined sequence.

The matrix should therefore be viewed only as a tool for establishing relative priorities. Many conditions could warrant a change in the priorities established from the matrix approach.

EVALUATION RESULTS

The drainage problems identified in this report were ranked using the evaluation criteria and weighting and rating systems described above. The Project Dependencies were not included in the initial problem evaluation because they relate to other capital projects in the city, not included in this analysis, and future conditions modeling results, which did not predict significantly more problems than at present.

Tables 16-4 through 16-13 show the results of the evaluation for each basin, with the problem receiving the highest score highlighted. Based on this assessment, nine problems citywide were identified as the top-priority problems for the City to address. Table 16-14 shows these problems prioritized based on the scores they received in the evaluation. These nine were selected because they each received a score greater than 60, out of a maximum possible 105.

TABLE 16-4.
PROBLEM EVALUATION RESULTS; BASIN A—EDGEWATER CREEK

Criteria	Weight	Rating A1	Rating A2	Rating A3
Flooding of public streets	2	1	3	2
Flooding of properties, public or private	1	1	5	4
Frequency of flooding	2	3	3	2
Magnitude of flooding	2	4	2	1
City responsibility	3	1	2	2
Stream bank erosion	2	5	1	1
Hillside erosion	2	1	1	1
Water quality	1	2	1	1
Habitat	1	3	1	1
Aesthetics	1	3	2	4
Socioeconomic consideration	2	2	4	2
Complaint history	2	2	4	2
Weighted Total Score		48	51	38

TABLE 16-5.
PROBLEM EVALUATION RESULTS; BASIN B—JAPANESE GULCH

Criteria	Weight	Rating B1	Rating B2
Flooding of public streets	1	1	1
Flooding of properties, public or private	1	1	4
Frequency of flooding	2	3	2
Magnitude of flooding	2	3	2
City responsibility	3	1	2
Stream bank erosion	2	1	1
Hillside erosion	2	5	1
Water quality	1	2	2
Habitat	2	4	2
Aesthetics	1	3	4
Socioeconomic consideration	2	2	3
Complaint history	2	4	4
Weighted Total Score		51	46

TABLE 16-6.
PROBLEM EVALUATION RESULTS; BASIN C—BREWERY CREEK & STATE PARK TIDEGATE

		Rating							
Criteria	Weight	CB3	CB4	CB5	CB7	CB8	CB10	CB11	CS1
Flooding of public streets	2	1	1	4	1	1	5	5	1
Flooding of properties, public / private	1	5	2	2	1	2	3	4	3
Frequency of flooding	2	3	2	3	2	2	3	3	2
Magnitude of flooding	2	3	1	2	1	1	3	3	1
City responsibility	3	3	4	3	3	5	5	5	3
Stream bank erosion	2	1	5	1	1	1	1	1	1
Hillside erosion	2	1	4	1	1	5	1	1	1
Water quality	1	2	1	2	1	1	3	5	1
Habitat	1	1	1	1	1	2	3	1	2
Aesthetics	1	2	3	1	1	4	3	3	3
Socioeconomic consideration	2	3	3	2	1	1	2	3	2
Complaint history	2	4	2	4	1	2	3	3	3
Weighted Total Score		51	55	49	29	50	63	66	40

TABLE 16-7.
PROBLEM EVALUATION RESULTS; BASIN D—GOAT TRAIL RAVINE

		Rating										
Criteria	Weight	D1	D2	D3	D4	D5	D6	D8	D9	D10	D13	D-M2
Flooding of public streets	2	1	1	2	1	1	4	2	4	3	1	2
Flooding of properties, public / private	1	3	3	3	2	5	2	2	3	1	5	3
Frequency of flooding	2	2	2	2	2	3	4	2	3	2	4	2
Magnitude of flooding	2	2	2	2	2	1	3	2	4	2	3	2
City responsibility	3	5	4	5	3	2	5	4	4	5	5	4
Stream bank erosion	2	3	3	1	1	5	1	2	1	1	1	3
Hillside erosion	2	1	1	1	1	1	1	2	1	1	1	3
Water quality	1	2	2	3	2	1	1	2	2	3	2	3
Habitat	1	3	3	1	1	1	1	2	1	1	3	3
Aesthetics	1	1	2	3	2	1	1	2	1	1	3	3
Socioeconomic consideration	2	2	2	2	2	3	2	2	1	2	3	2
Complaint history	2	1	1	1	3	5	5	3	4	2	4	1
Weighted Total Score		48	46	47	40	52	60	50	55	47	62	54

TABLE 16-8.
PROBLEM EVALUATION RESULTS; BASIN E—UNNAMED RAVINE

Criteria	Weight	Rating							
		E1	E2	E3	E4	E5	E6	E7	E8
Flooding of public streets	1	5	1	3	1	3	2	1	1
Flooding of properties, pub or priv	1	4	1	3	1	2	5	5	1
Frequency of flooding	2	3	2	2	1	3	4	3	1
Magnitude of flooding	2	3	3	2	1	3	3	3	1
City responsibility	3	5	5	3	2	5	3	3	3
Stream bank erosion	2	2	5	1	1	1	1	1	2
Hillside erosion	2	1	1	1	1	1	1	1	4
Water quality	1	2	1	1	1	2	1	1	1
Habitat	1	2	4	1	1	1	1	1	2
Aesthetics	1	1	3	1	3	1	2	1	3
Socioeconomic consideration	2	4	1	3	2	1	4	3	3
Complaint history	2	5	1	5	5	3	4	5	3
Weighted Total Score		70	52	49	36	51	56	51	46

TABLE 16-9.
PROBLEM EVALUATION RESULTS; BASIN F—NAKETA BEACH

Criteria	Weight	Rating						
		F1	F2	F3	F4	F6	F10	F-M1
Flooding of public streets	2	3	5	2	1	4	3	3
Flooding of properties, pub or priv	1	2	1	2	3	1	4	2
Frequency of flooding	2	2	4	2	2	2	3	2
Magnitude of flooding	2	2	2	2	2	2	3	1
City responsibility	3	5	4	4	1	5	4	4
Stream bank erosion	2	1	1	1	1	1	1	1
Hillside erosion	2	1	1	1	1	1	1	1
Water quality	1	3	1	1	1	3	1	1
Habitat	1	1	1	1	1	2	1	1
Aesthetics	1	1	2	1	1	3	2	3
Socioeconomic consideration	2	1	3	3	1	3	3	2
Complaint history	2	1	5	3	1	1	4	1
Weighted Total Score		44	59	45	27	52	56	41

TABLE 16-10.
PROBLEM EVALUATION RESULTS; BASIN G—SMUGGLER'S GULCH

Criteria	Weight	Rating										
		G1	G2	G4	G5	G7	G8	G9	G10	G11	G-M1	G-M2
Flooding of public streets	2	3	2	4	1	1	2	1	4	5	5	4
Flooding of properties, public or private	1	3	1	4	1	1	2	4	1	2	2	1
Frequency of flooding	2	4	2	3	2	1	2	5	4	4	3	1
Magnitude of flooding	2	2	2	2	2	1	2	1	2	3	2	2
City responsibility	3	3	1	4	3	4	5	3	5	5	4	3
Stream bank erosion	2	1	1	1	5	1	3	1	1	1	1	1
Hillside erosion	2	1	1	1	1	5	1	1	1	1	1	1
Water quality	1	2	3	1	3	1	3	1	1	1	1	2
Habitat	1	1	1	1	3	3	5	1	1	1	1	2
Aesthetics	1	2	1	1	3	3	2	1	3	1	1	2
Socioeconomic consideration	2	3	3	5	1	3	1	3	3	3	4	1
Complaint history	2	5	3	4	2	1	2	3	3	4	1	3
Weighted Total Score		55	37	59	47	46	53	46	57	62	51	42

TABLE 16-11.
PROBLEM EVALUATION RESULTS; BASIN H—BIG GULCH

Criteria	Weight	Rating										
		H1	H2	H3	H4	H5	H7	H8	H9	H10	H11	H12
Flooding of public streets	2	4	2	2	2	1	1	1	1	1	2	3
Flooding of properties, public or private	1	2	1	1	1	1	5	1	1	5	2	5
Frequency of flooding	2	3	2	2	2	1	4	2	1	3	2	3
Magnitude of flooding	2	3	2	3	3	1	1	2	1	2	2	3
City responsibility	3	5	4	5	5	5	3	5	3	5	5	4
Stream bank erosion	2	1	1	5	5	1	1	5	1	1	1	1
Hillside erosion	2	1	1	1	1	1	1	1	5	1	1	3
Water quality	1	1	1	2	2	5	1	1	4	1	1	1
Habitat	1	1	1	5	5	1	1	4	4	1	1	3
Aesthetics	1	1	1	3	3	5	1	2	4	1	2	1
Socioeconomic consideration	2	4	2	1	1	1	1	1	3	2	2	2
Complaint history	2	4	2	1	1	1	3	1	3	5	3	5
Weighted Total Score		60	40	56	56	41	41	49	52	53	47	62

TABLE 16-12.
PROBLEM EVALUATION RESULTS; BASIN I—CHENNAULT BEACH

Criteria	Weight	Rating I3	I4	I10	I11	I12	I15	I16	I18	I19
Flooding of public streets	2	1	1	1	3	1	4	1	1	4
Flooding of properties, public or private	1	1	1	3	2	1	2	5	5	1
Frequency of flooding	2	1	1	2	2	1	2	3	3	3
Magnitude of flooding	2	1	1	1	3	1	2	2	2	3
City responsibility	3	5	3	2	4	2	4	3	2	5
Stream bank erosion	2	1	1	1	1	1	1	1	1	2
Hillside erosion	2	1	1	3	2	1	1	1	2	1
Water quality	1	1	1	1	1	1	1	5	2	2
Habitat	1	1	1	2	1	1	1	2	2	2
Aesthetics	1	3	3	2	3	4	3	2	2	3
Socioeconomic consideration	2	5	2	3	3	2	2	2	2	3
Complaint history	2	3	1	3	3	3	4	5	4	4
Weighted Total Score		47	31	42	53	33	51	53	47	63

TABLE 16-13.
PROBLEM EVALUATION RESULTS; BASIN M—PICNIC POINT CREEK

Criteria	Weight	Rating M1	M2	M3	M4	M6	M9	M-M1
Flooding of public streets	2	5	1	1	3	1	1	2
Flooding of properties, public or private	1	1	1	1	1	1	1	2
Frequency of flooding	2	3	1	1	3	1	1	2
Magnitude of flooding	2	3	1	1	2	1	1	1
City responsibility	3	5	5	3	5	3	3	3
Stream bank erosion	2	4	1	1	5	5	2	1
Hillside erosion	2	1	1	5	1	1	1	1
Water quality	1	5	3	1	5	5	5	2
Habitat	1	5	5	3	5	5	5	1
Aesthetics	1	4	1	2	3	4	1	3
Socioeconomic consideration	2	2	1	4	2	2	1	2
Complaint history	2	3	1	5	3	2	1	1
Weighted Total Score		72	39	52	67	50	37	37

Four of the problems in Table 16-1, identified by the modeling (CB-M1, D-M1, F-M2 and C-M3), were correlated with problems in Table 3-1 and were not evaluated separately. Of the 101 problems identified through various sources other than modeling, 29 were not evaluated because they have already been solved, are being worked on at this time, or are on private property.

The seventy-eight remaining problems were rated as shown in Tables 16-4 through 16-13. The ratings can be broken down as follows:

score:	61 or greater:	9 problems
score:	51 to 60:	30 problems
score:	41 to 50:	26 problems
score:	40 or less:	13 problems

The nine highest priority problems are listed in Table 16-14.

TABLE 16-14.
RANKING OF TOP-PRIORITY CITYWIDE PROBLEMS

Problem	Description	Weighted Score
M1	At 126th Street SW cul-de-sac, in ravine below, there is erosion from outfall. Water from outfall flows along road into creek. Road is eroding causing siltation in creek.	72
E1	At 53rd Avenue W, north end of street past 80th Street SW, the area floods due to lack of drainage.	70
M4	West of Cyrus Way, upper end of creek, there is vehicular traffic across creek bed.	67
CB11	At intersection of First Street and the Mukilteo Speedway, storm water flow off ferry holding area in front of Ivars is a problem. Stormwater flows east down the middle of road to Park Ave. No water quality control or oil/water separator. Type 2 on First St. inadequate capacity, which all connects to State Park next to bulkhead on First St. Floods street and parking on First St. up to Buzz Inn.	66
CB10	No tide gate on the Park Street outfall. Water depth of 1.5 feet at high tide and runoff. Water backs up to First Street during high tide events (only).	63
I19	Pipe collapsing or groundwater transporting the pipe bedding material. Creating pond on 59th Ave. W.	63
D13	There is no outfall on the system. It dead-ends at the Bell property.	62
G11	Inadequate capacity due to open ditch, shallow pipe, steep grade, and small pipes.	62
H12	Sheet flow over all properties west of 63rd Place W.	62

PLANNING LEVEL COST ASSESSMENT

As a last component of the decision making process, the estimated construction cost can be a useful tool. The cost estimates provided here are based on limited information and should be considered planning level estimates only useful for providing a basis for comparison of relative costs. A better understanding of the actual problem and a field evaluation should be made before a more detailed cost can be provided. Table 16-15 lists the problems, the assumed repair scenario, and a general cost estimate provided as a size of project. Following the table is a discussion of items not included in Table 16-15 that would be a part of a detailed cost estimate.

TABLE 16-15.
CONCEPTUAL COST ASSESSMENT

Problem ID	Ranking	Type of Problem	Assumed Repair Methodology [1]	Estimated Project Size [2]
A1	48	Erosion, no drainage structures	CB + culvert + HDPE + anchors, ~800'	medium
A2	51	No drainage system	install drainage on Lamar Dr: CBs, pipes, outfall, asphalt, fill, ~1400'	medium
A3	38	Inadequate drainage	install CBs and drainage, ~2000'	large
B1	51	Erosion damaging pipe	refasten pipe, install anchors, hillside stabilization, install expansion joints	medium
B2	46	Erosion, inadequate ditch grading	regrade ditches, armor culvert entrance/exit, ~300'	small
CB1	--	Poor roadside drainage, sedimentation in ditches	solved	--
CB2	--	Roadside ditch erosion; sedimentation in cross-culvert causes flooding	solved	--
CB3	51	Undersized pipe, no access to pipe	install larger pipe, obtain easement, ~300'	small
CB4	55	Hillside erosion	hillside stabilization, clean out CB, ~600 sf	medium
CB5	49	Runoff not directed to ditches	install CBs and pipe on other side of street, ~1400'	large
CB6	--	Grade problem	Solved	--
CB7	29	No access to pipe	Install CBs or cut in CBs into existing pipe, ~2500'	small

Notes:
1 These are based on the problem list provided by the city. No site visits have been made. All assumptions should be field verified. Assumes access or easement available.
2 Projects are sized as follows: small: less than $50,000; medium: $50,000 to $100,000; large: $100,000 to $300,000; very large: greater than $300,000
Where an actual cost is shown, this is from the 1993 report with the cost indexed to 2000 levels

TABLE 16-15. (continued)
CONCEPTUAL COST ASSESSMENT

Problem ID	Ranking	Type of Problem	Assumed Repair Methodology [1]	Estimated Project Size [2]
CB8	50	Unstable hillside	inspect twice annually, repair separated joints as required, ~500'	small
CB9	--	Inadequate capacity	Solved	--
CB10	63	No tide gate	tide gate, possible 400' pipe enlargement	small
CB11	66	Inadequate drainage	add CBs, rechannel road runoff, ~400'	small
CB-M1	--	Inadequate capacity	solved (see CB2)	--
CB-M2	--	Inadequate capacity	install culvert	--
CS1	40	Inadequate drainage	install CB and culvert, ~400'	small
D1	48	Catchbasin may plug and cause flooding	install larger grate and trash rack	small
D2	46	No access to outfall, old CB possibly inadequate	armor outfall, repair CB	small
D3	47	Structure may plug and cause flooding; pipe undersized?	trash rack and upsized pipe	small
D4	40	Malfunctioning flow control structure	analysis and outlet structure	small
D5	52	Erosion problem	hillside stabilization, channel armoring & stabilization, ~200'	small
D6	60	Inadequate drainage	enclose ditch or add CBs to an underdrain pipe, ~250'	small
D7	--	Inadequate drainage	School Dist. working on	--

Notes:
1 These are based on the problem list provided by the city. No site visits have been made. All assumptions should be field verified. Assumes access or easement available.
2 Projects are sized as follows: small: less than $50,000; medium: $50,000 to $100,000; large: $100,000 to $300,000; very large: greater than $300,000
Where an actual cost is shown, this is from the 1993 report with the cost indexed to 2000 levels

TABLE 16-15. (continued)
CONCEPTUAL COST ASSESSMENT

Problem ID	Ranking	Type of Problem	Assumed Repair Methodology [1]	Estimated Project Size [2]
D8	50	Malfunctioning detention pond	outlet structure	small
D9	55	Grade problem; ditch under capacity?	convert ditch to pipe or create swale/ underdrain system	small
D10	47	Maintenance access restricted	install MH, connect to existing system, ~100'	small
D11	--	Inadequate drainage from development, no easement	School Dist. working on	--
D12	--	Maintenance, inadequate drainage capacity?	School Dist. working on	--
D13	57	No outfall	obtain easement, install outfall, pipe over hill and into gully, difficult construction access, ~200'	small
D-M1	--	Inadequate capacity	same as D11	--
D-M2	54	Inadequate capacity	upsize pipe	small
E1	70	No existing drainage	install CBs and pipeline, detention vault, ~300'	medium
E2	52	Erosion, storm line failed	bank and streambed stabilization, replace failed line, ~1000'	large
E3	49	Maintenance or inadequate capacity?	install larger grates in CBs	small
E4	36	Inadequate drainage	french drain and collection system	small
E5	51	Maintenance issue	replace control structure, ~300'	small

Notes:
1 These are based on the problem list provided by the city. No site visits have been made. All assumptions should be field verified. Assumes access or easement available.
2 Projects are sized as follows: small: less than $50,000; medium: $50,000 to $100,000; large: $100,000 to $300,000; very large: greater than $300,000
Where an actual cost is shown, this is from the 1993 report with the cost indexed to 2000 levels

TABLE 16-15. (continued)
CONCEPTUAL COST ASSESSMENT

Problem ID	Ranking	Type of Problem	Assumed Repair Methodology [1]	Estimated Project Size [2]
E6	56	Inadequate drainage	enclose ditch, add CBs, ~600'	small
E7	51	Inadequate drainage	install CBs and pipeline, obtain easement, ~800'	small
E8	46	Erosion	armor outfall	small
F1	44	No access to pipes	install CBs, ~300'	small
F2	59	Inadequate drainage	install CBs and pipeline, ~50'	small
F3	45	Malfunctioning detention pond	retrofit pond, install new outlet structure	small
F4	27	Malfunctioning detention pond	retrofit pond, install new outlet structure	small
F5	--	No pipe access. No easement.	no solution	--
F6	52	Improperly constructed drainage structure	repair MH, video pipes to document condition	small
F7	--	Erosion	Solved	--
F8	--	Flooding	Private	--
F9	--	Inadequate drainage	Solved	--
F10	56	Inadequate drainage	install CBs and pipeline, ~450'	small
F-M1	41	Inadequate capacity	upsize pipe	small
F-M2	--	Inadequate capacity	solved (see F9)	--
G1	51	Inadequate capacity	upstream detention or upgrade conveyance	large
G2	37	Maintenance	retrofit pond, install new outlet structure	small
G3	--	Inadequate drainage?	resolved	--

Notes:
1 These are based on the problem list provided by the city. No site visits have been made. All assumptions should be field verified. Assumes access or easement available.
2 Projects are sized as follows: small: less than $50,000; medium: $50,000 to $100,000; large: $100,000 to $300,000; very large: greater than $300,000
Where an actual cost is shown, this is from the 1993 report with the cost indexed to 2000 levels

TABLE 16-15. (continued)
CONCEPTUAL COST ASSESSMENT

Problem ID	Ranking	Type of Problem	Assumed Repair Methodology [1]	Estimated Project Size [2]
G4	59	Detention pond over capacity (undersized)	retrofit pond, install new outlet structure, bypass flows not designed for pond	small
G5	47	Maintenance; sedimentation problem?	creek clean up, bed and bank stabilization	small
G6	--	Inadequate drainage	rezone	--
G7	46	Erosion	bank stabilization, ~600'	very large
G8	53	No passage for salmon. Pipe inadequately sized	upsize pipe, add headwall arch	large
G9	46	Inadequate drainage	install CB and pipeline, ~400'	small
G10	57	Inadequate drainage	install pipeline, pump station, ~50'	medium
G11	62	Inadequate drainage	enclose ditch, capture hilltop drainage, construct pipeline to ravine bottom	small
G-M1	51	Inadequate capacity	culvert or upstream detention	medium
G-M2	42	Inadequate capacity	culvert or upstream detention	medium
G-M3	--	Inadequate capacity	same as G1	--
H1	60	Inadequate capacity.	replace pipe	small
H2	40	Erosion, capacity problem?	enclose ditch or armor existing ditch	small
H3	56	Erosion	bank stabilization, ~500 sf	medium
H4	56	Erosion	bank stabilization, ~500 sf	medium
H5	41	Maintenance	install CB	$23,500
H6	--	Maintenance	combined with H5	--

Notes:
1 These are based on the problem list provided by the city. No site visits have been made. All assumptions should be field verified. Assumes access or easement available.
2 Projects are sized as follows: small: less than $50,000; medium: $50,000 to $100,000; large: $100,000 to $300,000; very large: greater than $300,000
Where an actual cost is shown, this is from the 1993 report with the cost indexed to 2000 levels

TABLE 16-15. (continued)
CONCEPTUAL COST ASSESSMENT

Problem ID	Ranking	Type of Problem	Assumed Repair Methodology [1]	Estimated Project Size [2]
H7	41	Inadequate drainage	retrofit pond, install new outlet structure	$15,500
H8	49	Erosion	bank stabilization	$56,500
H9	52	Possible erosion problem, stormwater directed wrong way	bank stabilization	$97,500
H10	53	Existing road drainage outfalls onto lawn.	install pipeline and swale system through easement, ~100'	$31,000
H11	47	Damaged drainage structure	regrade road, install CBs and pipeline, ~100'	small
H12	62	Inadequate drainage	regrade road, install CBs and pipeline, ~500'	small
I1	--	Detention pond flooding	Solved	--
I2	--	None	not current problem	--
I3	47	Safety issue	enclose ditch both sides of road, ~600'	medium
I4	31	Improper drainage structure	install driveway culvert, ~200'	small
I5	--	None	not current problem (note only)	--
I6	--	Inadequate drainage on private lots. No easements	private	--
I7	--	High water table, natural spring causing flooding and erosion of bluff	solved	--

Notes:
1 These are based on the problem list provided by the city. No site visits have been made. All assumptions should be field verified. Assumes access or easement available.
2 Projects are sized as follows: small: less than $50,000; medium: $50,000 to $100,000; large: $100,000 to $300,000; very large: greater than $300,000
Where an actual cost is shown, this is from the 1993 report with the cost indexed to 2000 levels

TABLE 16-15. (continued)
CONCEPTUAL COST ASSESSMENT

Problem ID	Ranking	Type of Problem	Assumed Repair Methodology [1]	Estimated Project Size [2]
I8	--	High water table? Stormwater from outfall eroding bluff	solved	--
I9	--	High water table, bluff erosion	solved	--
I10	42	Inadequate ditch, pipe needed to convey flow?	fill ditch	$21,500
I11	53	Drainage structures not located correctly to catch runoff. Erosion problems.	armor ditch	$11,000
I12	33	Inadequate roof drain connection to street	make connection, ~50'	small
I13	--	Malfunctioning outfall pipe	solved	--
I14	--	Capacity problem	solved	--
I15	51	Inadequate conveyance, no drainage structures on west side of street.	install CBs and pipeline, ~500'	$78,500
I16	53	Groundwater seepage into sanitary sewer	repair sanitary sewer	$28,000

Notes:
1 These are based on the problem list provided by the city. No site visits have been made. All assumptions should be field verified. Assumes access or easement available.
2 Projects are sized as follows: small: less than $50,000; medium: $50,000 to $100,000; large: $100,000 to $300,000; very large: greater than $300,000
Where an actual cost is shown, this is from the 1993 report with the cost indexed to 2000 levels

TABLE 16-15. (continued)
CONCEPTUAL COST ASSESSMENT

Problem ID	Ranking	Type of Problem	Assumed Repair Methodology [1]	Estimated Project Size [2]
I17	--	Roof drains not connected to storm sewer system	Private Problem	--
I18	47	Inadequate drainage	install CBs and pipeline, ~1000'	medium
I19	63	Damaged drainage pipe	replace drainage pipe and bedding material, ~400'	small
J1	--	None.	not a current problem	--
J2	--	Inadequate drainage capacity, erosion problems, water quality degraded	private system	$43,000
M1	72	Inadequate roadside ditch capacity causing erosion	bank & ditch stabilization	$33,000
M2	39	Inadequate fish passage through culverts	upsize culverts and rebuild streambed, ~400'	large
M3	52	Erosion	bank stabilization?	very large
M4	67	Water quality, erosion, stream degradation, and no culvert.	install culvert, build road, stabilize channel?	small
M5	--	Malfunctioning detention pond. Sedimentation in creek downstream.	outside city limits	--

Notes:
1 These are based on the problem list provided by the city. No site visits have been made. All assumptions should be field verified. Assumes access or easement available.
2 Projects are sized as follows: small: less than $50,000; medium: $50,000 to $100,000; large: $100,000 to $300,000; very large: greater than $300,000
Where an actual cost is shown, this is from the 1993 report with the cost indexed to 2000 levels

TABLE 16-15. (continued)
CONCEPTUAL COST ASSESSMENT

Problem ID	Ranking	Type of Problem	Assumed Repair Methodology [1]	Estimated Project Size [2]
M6	50	Stream sedimentation, erosion upstream	outfall stabilization	small
M7	--	Flooding sidewalk	private system	--
M8	--	High water table	sump pumps, foundation drains, private	--
M9	37	Water quality issue, erosion upstream?	test water quality	small
M-M1	37	outlet control structure	replace outlet control structure	small

Notes:
1 These are based on the problem list provided by the city. No site visits have been made. All assumptions should be field verified. Assumes access or easement available.
2 Projects are sized as follows: small: less than $50,000; medium: $50,000 to $100,000; large: $100,000 to $300,000; very large: greater than $300,000
Where an actual cost is shown, this is from the 1993 report with the cost indexed to 2000 levels

In addition to labor and materials, the following items are typically included in a detailed construction cost estimate:

- Traffic Control (3 to 5 percent)—This cost items depends on the type of project. If the project is a detention pond on private property, there is likely to be little need for traffic control. A project operating in or near the road right-of-way will have some signing and barrier requirements (3 percent of construction costs), while a project requiring road closures and detours will have higher traffic control costs (5 percent).
- Erosion Control (5 to 10 percent)—This is the cost associated with temporary erosion control measures used during the construction process. The percentage of total construction costs depends on whether the construction is located primarily in a roadway or in a creek system, respectively. The percentage is applied as a subtotal of all construction components.
- Mobilization (6 to 8 percent)—This is the cost associated with transporting construction equipment and supplies to and from the job site. Smaller projects may have higher mobilization costs, larger projects can be operated a little more efficiently so costs can be reduced. This cost is applied to the subtotal of all construction cost elements, including erosion control.
- State Sales Tax—Drainage improvements are assessed the state sales tax, which the city must pay. This cost is applied to project materials on a per

project basis as determined by the City's legal consultant. Road drainage work directly associated with road improvement projects are exempt from the state sales tax.

- Contingency—This is a factor applied to construction cost estimates to reflect the variability inherent in construction. The contingency percentage is a subjective function of the known level of detail. Early in an assessment, the contingency may be as high as 30 percent. For final estimates it drops to 0-10 percent.
- Engineering, City Administration, and Construction Management (~30 percent)—To extend the construction cost to the total project cost (the ultimate cost to the City), costs due to the engineering design, City administration, and construction management must be included. These cost components are applied to the subtotal of the construction costs, plus state sales tax and contingency. Costs may be higher for small projects.
- Land Acquisition—This cost, when applicable, represents the estimated cost of land required to accomplish a construction project. This cost is a function of the availability and developability of land and is generally only a component in larger-scale projects occurring outside of the right-of-way.

CHAPTER 17.
CAPITAL IMPROVEMENT PROGRAM

This chapter discusses the development of the annual capital expenditures, and costs for increased maintenance, and presents three schedules for capital projects implementation. The subsequent chapter describes the calculation of the required rate structure for these implementation plans.

The list of all identified problems, their priority ranking, and an estimated project size or cost estimate was presented in Table 16-14. This forms the basis of the drainage capital improvement plan. In addition, the City requested funding estimates for three maintenance activities:

- Increase the frequency of catchbasin maintenance from approximately one-quarter of the catchbasins each year to every catchbasin annually
- Take over maintenance of the approximately 50 private detention ponds in the City
- Establish a program to enclose all of the roadside ditches, about 3.9 miles, and replace them with catchbasins and storm drains.

Costs were calculated for the three maintenance activities based on discussion with City staff and the maintenance crew. These calculations are presented in Table 17-1. The annual costs were used to develop the incremental additional costs to the stormwater program rates discussed in the next chapter.

TABLE 17-1
COST CALCULATIONS FOR ADDITIONAL MAINTENANCE ACTIVITIES

Activity	Crew & Equipment Cost	Approx. Number	Annual Cost
Annual CB Maintenance	$100 each	2,500 catchbasins	$250,000
Detention Pond Maintenance	$12,400 each[1]	50 ponds & tanks	$620,000
Ditch Enclosure	$155 per linear foot	39 miles	$1,600,000 [2]

[1] 1-2 days per pond, 3-man crew, mobilization, trackhoe, dumptruck
[2] Total cost is $32 million. Assume 20-year implementation.

In addition to the above costs and the following capital program, the City directed that two additional alternatives be analyzed in the rate analysis. One was an estimate of the effect on rates if the ditch enclosure program were simplified and the costs dropped to $75 per lineal foot. The other is the cost associated with the additional problems located through the public mailing (letter displayed in Chapter 3). This program, designated Citizen

Response, used the city-estimated cost to address all of the problems identified by the citizens. There may be some overlap with the previously defined projects, which are included in the capital improvement program (CIP) below. All these items are included in the rate analysis in Chapter 18.

CIP SCHEDULE

The total planning level cost for drainage capital improvements was determined by summing the costs estimated in Table 16-14. This results in a total cost of approximately 13.5 million dollars. This cost does not include those additional required items discussed in Chapter 16, such as traffic control, erosion control, mobilization, land acquisition, etc. It also does not reflect the potential savings possible by combining projects with other drainage, roadway or other public facility improvements. It is, however, useful for establishing a schedule of prioritized projects.

Three alternative levels of implementation, defined as addressing all of the currently identified problems in a 6-year, 10-year, or 20-year program are presented. Inflationary increases are covered with the rate structure. The annual required expenditures are determined by dividing the total cost by the number of years. They are:

Program	Annual Budget
6-year	~$2.25 Million
10-year	~$1.35 Million
20-year	~$675,000

The schedule was developed by listing the projects in ranked order and distributing their estimated costs up to the dollar amount available each year. Large and Very Large projects were divided over several years, reflecting the longer time lines typically required for bigger projects. Because the City utilizes a pay-as-you-go capital funding program, rather than bonding or local improvement districts, a 'savings' account for the very large projects was established to accrue enough funds in advance of the implementation.

The three schedules presented in Tables 17-2 through 17-4. provide a general planning approach for scheduling in the Mukilteo's budget. The actual schedule will be adjusted based on detailed project development, other work in the city, emergency repairs, new grant sources, etc.

TABLE 17-2 6-YEAR IMPLEMENTATION SCHEDULE

Project	Priority	Estimated Project Size	2001	2002	2003	2004	2005	2006
M1	72	$33,000						
E1	70	medium						
M4	67	small						
CB11	66	small						
CB10	63	small						
I19	63	small						
D13	62	small						
G11	62	small						
H12	62	small						
D6	60	small						
H1	60	small						
F2	59	small						
G4	59	small						
G10	57	medium						
E6	56	small						
F10	56	small						
H3	56	medium						
H4	56	medium						
CB4	55	medium						
D9	55	small						
G1	55	large						
CB-M2	54	large						
D-M2	54	small						
G8	53	large						
H10	53	$31,000						
I11	53	$11,000						
I16	53	$28,000						
D5	52	small						
E2	52	large						
F6	52	small						
H9	52	$97,500						
M3	52	very large						
A2	51	medium						
B1	51	medium						
CB3	51	small						
E5	51	small						
E7	51	small						
G-M1	51	medium						
I15	51	$78,500						
CB8	50	small						
D8	50	small						
M6	50	small						
CB5	49	large						
E3	49	small						
H8	49	$56,500						
A1	48	medium						
D1	48	small						
D3	47	small						
D10	47	small						
G5	47	small						
H11	47	small						
I3	47	medium						
I18	47	medium						
B2	46	small						
D2	46	small						
E8	46	small						
G7	46	very large						
G9	46	small						
F3	45	small						
F1	44	small						
G-M2	42	medium						
I10	42	$21,500						
F-M1	41	small						
H5	41	$23,500						
H7	41	$15,500						
CS1	40	small						
D4	40	small						
H2	40	small						
M2	39	large						
A3	38	large						
G2	37	small						
M9	37	small						
M-M1	37	small						
E4	36	small						
I12	33	small						
I4	31	small						
CB7	29	small						
F4	27	small						

TABLE 17-3 10-YEAR IMPLEMENTATION SCHEDULE

Project	Priority	Estimated Project Size	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
M1	72	$33,000	■									
E1	70	medium	■									
M4	67	small	■									
CB11	66	small	■									
CB10	63	small	■									
I19	63	small	■									
D13	62	small	■									
G11	62	small	■									
H12	62	small	■									
D6	60	small	■									
H1	60	small	■									
F2	59	small	■									
G4	59	small	■									
G10	57	medium	■									
E6	56	small	■									
F10	56	small	■									
H3	56	medium	■									
H4	56	medium	■	■								
CB4	55	medium		■								
D9	55	small		■								
G1	55	large		■	■							
CB-M2	54	large		■	■							
D-M2	54	small			■							
G8	53	large			■	■						
H10	53	$31,000			■							
I11	53	$11,000			■							
I16	53	$28,000			■							
D5	52	small			■							
E2	52	large			■	■						
F6	52	small				■						
H9	52	$97,500				■						
M3	52	very large		■	■	■	■	■	■	■	■	■
A2	51	medium					■					
B1	51	medium					■					
CB3	51	small					■					
E5	51	small					■					
E7	51	small					■					
G-M1	51	medium						■				
I15	51	$78,500						■				
CB8	50	small						■				
D8	50	small						■				
M6	50	small						■				
CB5	49	large						■	■			
E3	49	small							■			
H8	49	$56,500							■			
A1	48	medium							■			
D1	48	small							■			
D3	47	small							■			
D10	47	small							■			
G5	47	small							■			
H11	47	small								■		
I3	47	medium							■	■		
I18	47	medium								■		
B2	46	small								■		
D2	46	small								■		
E8	46	small								■		
G7	46	very large		■	■	■	■	■	■	■	■	■
G9	46	small								■		
F3	45	small								■		
F1	44	small								■	■	
G-M2	42	medium									■	
I10	42	$21,500									■	
F-M1	41	small									■	
H5	41	$23,500									■	
H7	41	$15,500									■	
CS1	40	small										■
D4	40	small										■
H2	40	small										■
M2	39	large									■	■
A3	38	large									■	■
G2	37	small										■
M9	37	small										■
M-M1	37	small										■
E4	36	small										■
I12	33	small										■
I4	31	small										■
CB7	29	small										■
F4	27	small										■

TABLE 17-4 20-YEAR IMPLEMENTATION SCHEDULE																						
Project	Priority	Estimated Proj. Size	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13	'14	'15	'16	'17	'18	'19	'20
M1	72	$33,000	■																			
E1	70	medium	■																			
M4	67	small	■																			
CB11	66	small	■																			
CB10	63	small	■																			
I19	63	small	■																			
D13	62	small	■																			
G11	62	small	■																			
H12	62	small	■																			
D6	60	small	■																			
H1	60	small	■																			
F2	59	small		■																		
G4	59	small		■																		
G10	57	medium		■																		
E6	56	small		■																		
F10	56	small		■																		
H3	56	medium		■																		
H4	56	medium		■	■																	
CB4	55	medium			■																	
D9	55	small			■																	
G1	55	large			■	■																
CB-M2	54	large				■	■															
D-M2	54	small				■																
G8	53	large					■	■														
H10	53	$31,000				■																
I11	53	$11,000				■																
I16	53	$28,000				■																
D5	52	small					■															
E2	52	large					■	■	■													
F6	52	small							■													
H9	52	$97,500							■	■												
M3	52	very large			■	■	■	■	■	■	■	■	■									
A2	51	medium									■	■										
B1	51	medium									■	■										
CB3	51	small											■									
E5	51	small											■									
E7	51	small												■								
G-M1	51	medium												■								
I15	51	$78,500												■								
CB8	50	small												■								
D8	50	small													■							
M6	50	small													■							
CB5	49	large													■	■						
E3	49	small													■							
H8	49	$56,500														■						
A1	48	medium														■	■					
D1	48	small														■						
D3	47	small														■						
D10	47	small															■					
G5	47	small															■					
H11	47	small															■					
I3	47	medium															■	■				
I18	47	medium																■	■			
B2	46	small																■				
D2	46	small																■				
E8	46	small																■				
G7	46	very large								■	■	■	■	■	■	■	■	■	■	■	■	
G9	46	small																■				
F3	45	small																	■			
F1	44	small																	■			
G-M2	42	medium																	■	■		
I10	42	$21,500																	■			
F-M1	41	small																	■			
H5	41	$23,500																		■		
H7	41	$15,500																		■		
CS1	40	small																		■		
D4	40	small																		■		
H2	40	small																		■		
M2	39	large																		■	■	
A3	38	large																			■	■
G2	37	small																			■	
M9	37	small																			■	
M-M1	37	small																				■
E4	36	small																				■
I12	33	small																				■
I4	31	small																				■
CB7	29	small																				■
F4	27	small																				■

CHAPTER 18.
FINANCIAL ANALYSIS

The goal of the financial analysis is to provide financial and rate information in support of the projects and programs recommended in this Comprehensive Surface Water Management Plan. Two issue papers, examining implementation of a capital facilities charge and rate credits, are provided in Appendix E. The financial analysis produced projected utility rates and charges for a number of levels of service.

INTRODUCTION

The broad objectives of the funding element of the Surface Water Comprehensive Plan were as follows:

- Develop a funding approach to implement the schedule of capital improvements and operations and maintenance activities provided by the City and in the Plan;
- Add a further implementation focus to the Plan; and
- Provide the City with a usable financial analysis.

The following tasks were performed in order to meet these objectives.

1. City surface water utility data was collected and reviewed. The information reviewed included:
    - Current budget;
    - Recent (historical) financial statements;
    - Most recent rate resolution;
    - Customer base information.
2. The existing surface water utility policy framework was discussed with the City Finance Director.
3. A 6-year revenue requirements model was developed to allow for the examination of a number of program levels of service. The model allows for the prioritization of capital improvements, discrete additions to operations costs due to added staff, discrete increases in the customer base to incorporate potential future annexations, and/or increased operations and maintenance.
4. Issue papers were drafted evaluating the following issues and recommending a course of action for the City:
    - Should the City impose a surface water capital facilities charge to recover the costs of growth from growth?
    - Should the City offer rate credits for those customers who construct on-site improvements of benefit to the City?

5. Ongoing monthly rates were calculated for several levels of service, assuming retention of the City's existing rate structure.

6. Meetings with City staff were conducted at key points in the study.

7. Findings were documented in this Plan.

EXISTING PROGRAM

The City charges a monthly rate of $5.40 per equivalent residential unit (ERU) for surface water drainage service. One ERU is equal to 2,500 square feet of impervious surface area. Single family and duplex residential are considered one ERU for rate purposes.

The City surface water utility customer base consists of 11,950 ERUs. The City is projected to reach full buildout of 17,700 ERUs in 2006, with remaining development to be primarily commercial. The City does not currently offer rate credits or adjustments for on-site mitigation, although it does provide rate relief for qualifying low-income senior and/or disabled customers.

The City does not impose surface water capital facilities charges. Capital facilities charges are one-time fees imposed at the time of development to recover an equitable share of capital investment incurred by a utility. The City would benefit very little from the implementation of these charges at this time. Much of the City's remaining growth has already been permitted and would therefore not be subject to the charge. Further, remaining development will construct a share of needed facilities as a condition of development.

FINANCIAL ANALYSIS

A summary of projected utility financial performance is shown in Table 18.1. The following assumptions are reflected in the analysis:

- The existing level of service will be provided for all program elements;
- Capital spending at the current level (approximately $310,000 per year) will be funded on a pay-as-you-go basis;
- Capital and operating costs will escalate at a general rate of 4% per year;
- An operating reserve minimum balance equal to thirty days of cash operating expenses will be maintained.

TABLE 18-1
PROJECTED REVENUE REQUIREMENT AND RATES: PAY-AS-YOU-GO CAPITAL FUNDING

	2000	2001	2002	2003	2004	2005
Sources of Funds						
Beginning Fund Balances						
Operating Fund	$ 267,907	$ 301,732	$ 327,163	$ 334,768	$ 322,601	$ 288,570
Capital Fund	0	0	0	0	0	0
subtotal	$ 267,907	$ 301,732	$ 327,163	$ 334,768	$ 322,601	$ 288,570
Min. Operating Fund Balance	*$ 43,149*	*$ 44,191*	*$ 45,959*	*$ 47,797*	*$ 49,709*	*$ 51,693*
Revenues						
Operations						
Service Charge Revenues	$ 767,316	$ 778,826	$ 790,508	$ 802,366	$ 814,401	$ 826,617
Other Income	$ 14,395	$ 16,087	$ 17,358	$ 17,738	$ 17,130	$ 15,429
Capital						
Loan Proceeds	0	0	0	0	0	0
subtotal	$ 781,711	$ 794,912	$ 790,508	$ 802,366	$ 814,401	$ 826,617
Uses of Funds						
Expenditures						
Operations						
Cash Operating Expenses	$ 434,586	$ 443,649	$ 461,395	$ 479,851	$ 499,045	$ 519,007
Non-CIP Capital Outlays	$ 3,300	$ 3,432	$ 3,569	$ 3,712	$ 3,861	$ 4,015
Capital						
Debt Service	-	-	-	-	-	-
Capital Construction	$ 310,000	$ 322,400	$ 335,296	$ 348,708	$ 362,656	$ 377,162
Additional D.S. Coverage	-	-	-	-	-	
subtotal	$ 747,886	$ 769,481	$ 800,261			
Ending Fund Balance	$ 301,732	$ 327,163	$ 334,768	$ 322,601	$ 288,570	$ 230,431
Resulting Monthly Rate per ERU	**$ 5.40**	**$ 5.40**	**$ 5.40**	**$ 5.40**	**$ 5.40**	**$ 5.40**
Annual % Increase Required		*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
Cumulative % Increase		*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*

As shown, rate revenues at the current rate are projected to meet the utility's operating and capital needs for the study period, assuming that no additional services are provided.

LEVEL OF SERVICE ANALYSIS

In order to evaluate the impacts of the additional operations and maintenance activities, as well as capital construction, contemplated in this Plan, the project team developed a level-of-service (LOS) analysis. The LOS analysis incorporated the additional projected costs of catch basin cleaning, detention facility maintenance, ditch enclosure, and capital construction, generating projected rate additions needed to fund those specific activities.

For example, funding an increase in catch basin cleaning to $250,000 per year, as recommended in the Plan, would require a rate increase of $0.50 per ERU by 2003. Funding the $4,970,000 citizen response capital improvement program (CIP) over twenty years would require a rate increase of $1.10 per ERU beginning in 2002. The following costs were assumed for the analysis:

Description	Cost	Basis
Catchbasin Cleaning	$250,000	Per year
Detention Facility Maintenance	$620,000	Per year
Ditch Enclosure Program		
At $155 per lineal foot	$1,600,000	Per year for 20 years
At $75 per lineal foot	$770,000	Per year for 20 years
Capital Improvement Program	$13,524,000	Total
Citizen Response CIP	$4,970,000	Total

The resulting "menu" of potential utility service additions and the accompanying rate increases required is provided below in Table 18-2. It is important to note that, for any given year, the rates shown are additive. For example, the addition of catch basin cleaning and detention facility maintenance in 2002 would require a rate increase of $0.40 + $2.70, or $3.10 per ERU per month. For capital, it is assumed that the citizen response CIP options would be in addition to the existing level of annual capital spending. It is conversely assumed that other CIP options would replace the existing level of annual capital spending. Table 18-2 already reflects these adjustments.

TABLE 18-2
RATE INCREASES BY PROGRAM ADDITION

Services Provided	2001	2002	2003	2004	2005
Base (Existing) Program	***$ 5.40***	***$ 5.40***	***$ 5.40***	***$ 5.40***	***$ 5.40***
Operating Additions					
Catchbasin Cleaning	$ -	$ 0.50	$ 0.50	$ 0.50	$ 0.50
Detention Facility Maintenance	$ 1.80	$ 2.70	$ 2.70	$ 2.70	$ 2.70
Ditch Encl. Program (@$155)	$ 10.30	$ 10.30	$ 10.30	$ 10.30	$ 10.30
Ditch Encl. Program (@$75)	$ 3.90	$ 4.50	$ 4.50	$ 4.50	$ 4.50
Capital Additions					
20-Year CIP	$ 0.45	$ 1.85	$ 1.85	$ 1.85	$ 1.85
20-Year Citizen Response CIP	$ -	$ 1.10	$ 1.10	$ 1.10	$ 1.10
10-Year CIP	$ 5.10	$ 6.35	$ 6.35	$ 6.35	$ 6.35
10-Year Citizen Response CIP	$ 1.35	$ 2.75	$ 2.75	$ 2.75	$ 2.75
6-Year CIP	$ 11.30	$ 12.35	$ 12.35	$ 12.35	$ 12.35
6-Year Citizen Response CIP	$ 3.65	$ 4.95	$ 4.95	$ 4.95	$ 4.95

The supporting technical analysis is included in Appendix F.

CHAPTER 19.
PROGRAMMATIC ELEMENTS OF STORMWATER MANAGEMENT

This chapter assesses Mukilteo's existing and proposed stormwater management program and evaluates it against regulatory requirements for such programs. Also included is an action plan for bringing the City's program into full compliance with requirements.

BACKGROUND

Puget Sound Water Quality Management Plan

The 1987 Puget Sound Water Quality Management Plan requires local governments in the Puget Sound region to implement stormwater management programs. All jurisdictions in the Puget Sound basin are required to adopt *basic* stormwater programs, and densely populated, urbanized areas (defined by the U.S. Bureau of the Census) are required to implement additional requirements for *comprehensive* stormwater programs. The goal for these programs, as stated in the management plan, is to

> "protect shellfish beds, fish habitat, and other resources; to prevent the contamination of sediments from urban runoff and combined sewer overflows; and to achieve standards for water and sediment quality by reducing and eventually eliminating harm from pollutant discharges from stormwater and combined sewer overflows throughout Puget Sound."

The Puget Sound Water Quality Management Plan established requirements for stormwater management programs and directed the Department of Ecology to develop minimum standards for controlling stormwater discharges. Ecology's minimum standards are contained in the *Stormwater Management Manual for the Puget Sound Basin*. The manual also contains design standards for best management practices (BMPs) that can be used to meet the minimum standards.

The *basic* stormwater program is prevention-oriented. Its minimum standards for development and redevelopment stress source control as a first priority in addressing stormwater quality. The main elements of the basic program are as follows:

- Ordinances containing minimum requirements for new development and redevelopment
- Operation and maintenance programs and ordinances
- A technical manual containing source control and treatment BMPs
- Education programs
- Growth management planning and interlocal coordination.

Comprehensive stormwater programs are both preventive and corrective and address runoff from new and existing industrial, commercial, and residential areas. Comprehensive stormwater programs consist of all of the basic program elements, plus the following:

- An implementation schedule
- A program to identify and rank significant water pollution sources
- A program to investigate and correct problem storm drains
- Inspection, compliance, and enforcement measures
- A water quality response program
- Adequate funding
- Local coordination agreements.

Ecology established a tiered schedule for implementing comprehensive stormwater programs. Ecology set a target date for program implementation for Tier 2 communities, which included Mukilteo, for June 1999.

National Pollutant Discharge Elimination System Phase II

The National Pollutant Discharge Elimination System (NPDES) was instituted by the U.S. EPA under the Clean Water Act amendments in 1972. In 1987, stormwater discharge became subject to NPDES permit coverage. In 1990, permit coverage was extended to cities with populations over 100,000; it applied to discharge from storm sewer systems serving these cities and to 11 categories of industrial activity, including construction activity involving 5 or more acres of disturbed area. NPDES regulation of these cities was called Phase I.

Municipal entities with populations below 100,000, including Mukilteo, were included in a Phase II category, and permit coverage was deferred pending EPA rule-making. Action on construction activities disturbing less than 5 acres was also deferred pending EPA rule-making. The final Phase II NPDES rules were published on December 8, 1999. Table 19-1 lists schedule milestones for Phase II implementation. Phase II requirements include the following minimum measures:

- Public education and outreach on stormwater impacts
- Public involvement and participation
- Detection and elimination of illicit discharge
- A construction site program
- A post-construction program for new development and significant redevelopment
- Pollution prevention and good housekeeping for municipal operations.

TABLE 19-1.
SCHEDULE MILESTONES FOR NPDES PHASE II IMPLEMENTATION

Milestone	Target Date
Final Phase II rule published	12/8/1999
EPA issues menu of recommended BMPs for regulated small storm sewer systems	10/2000
NPDES permitting authorities must modify their NPDES programs	12/2000-12/2001
EPA issues guidance on development of measurable goals for regulated small storm sewer systems	10/2001
NPDES permitting authorities issue general permits for Phase II storm sewer systems and construction disturbing 1 to 5 acres (small construction)	12/8/2002
Operators of Phase II storm sewer systems and small construction required to obtain NPDES permit coverage	3/10/2003
Full implementation of Phase II stormwater management programs	5 years after permit issuance (typical)

The Washington State Department of Ecology was granted NPDES permitting authority by EPA in 1993, and began to regulate Phase I entities and covered industrial activities. In 1999, Ecology initiated a review and update process for its stormwater manual, now called *Stormwater Management in Washington State*, to be completed in mid- to late 2000. When the update is completed, Ecology intends to require Phase II municipalities to adopt ordinances, minimum requirements, and BMPs equivalent to those contained in the manual.

As shown in Table 19-1, Ecology must revise its NPDES regulations to include Phase II no later than December 2001, and by December 8, 2002, issue general permits for small municipal storm sewer systems and construction activity disturbing 1 to 5 acres.

Resources

The following resources can be referred to for models of stormwater management ordinances and other assistance in preparing stormwater programs; additional information may be found on the EPA web site at www.epa.gov/owowwtr1/NPS/ordinance_old:

- *Stormwater Program Guidance Manual for the Puget Sound Basin* (Ecology, 1992) contains implementation guidance and model ordinances to assist local governments with stormwater programs.
- *Model Urban Runoff Program* (EPA, July 1998) was developed as part of a model program by a Phase II city with a grant from EPA and includes a model urban runoff ordinance.
- *Designing and Implementing an Effective Stormwater Management Program* (APWA, 2000) is a handbook used in the Stormwater Management Phase II Regulation NPDES workshop held on February 15, 2000, jointly

sponsored by EPA and the American Public Works Association. It includes an appendix describing a site visit to Redmond, Washington.

- *Guidance for Local Governments when Submitting Manuals and Associated Ordinances for Equivalency Review* (Ecology, 1994) helps local governments evaluate whether their stormwater programs meet Ecology requirements.
- *Guidance for Comprehensive Stormwater Programs Under the Puget Sound Water Quality Management Plan* (Ecology, 1997) also helps local governments evaluate whether their stormwater programs meet Ecology requirements.

CURRENT STATUS OF MUKILTEO'S STORMWATER PROGRAM

Mukilteo's current basic and comprehensive stormwater programs are documented in the City's Drainage Management Code (Chapter 13.12 MCC). The City's current regulations and programs address some of Ecology's requirements, but many elements are deficient and do not meet Ecology criteria:

- The biggest improvement needed for Mukilteo's basic stormwater program is an update of the stormwater code. The current Mukilteo City Code only contains a few of Ecology's minimum requirements. To meet Ecology's minimum standards, clarify the development process, and assure uniform application of standards, all of Ecology's minimum requirements for new development and redevelopment should be incorporated into a revised Drainage Management Code for Mukilteo.
- The Drainage Management Code does not adopt or reference a technical design manual.
- The City's program and ordinance for operations and maintenance need updating and documentation. The City probably is meeting Ecology requirements for inspection and maintenance, but compliance cannot be demonstrated because of inadequately documented schedules and procedures.
- Mukilteo has only conducted a very limited public education program.
- The City's comprehensive stormwater program lacks formal procedures for identifying, ranking, investigating, and correcting problem storm drains. Problem storm drains currently are addressed case-by-case as the City becomes aware of them.
- There is no coordinated management programs for shared watersheds. Several of the City's watersheds cross jurisdictional boundaries; the headwaters of Japanese Gulch, Smuggler's Gulch, and Big Gulch receive flow from Everett and Snohomish County Airport at Paine Field, and Hulk Creek and Picnic Point Creek flow from Mukilteo into Snohomish County at the mouth.

Mukilteo's stormwater programs meet Ecology requirements for integration of stormwater goals into the City's Comprehensive Plan. Table 19-2 summarizes Mukilteo's current compliance with key Ecology requirements for basic and comprehensive stormwater programs.

TABLE 19-2.
CITY COMPLIANCE WITH KEY ECOLOGY REQUIREMENTS

Activity	Mukilteo Status
Stormwater Management Ordinance	Mukilteo City Code requires revision to meet Ecology requirements for stormwater management ordinances.
Stormwater Technical Design Manual	The City needs to adopt a technical design manual.
Operation and Maintenance Program	The City's operation and maintenance program needs to be documented.
Operations and Maintenance Ordinance (for private facilities)	The Mukilteo code needs revision to meet Ecology requirements.
Public Education	A more active program is needed.
Growth Management Planning and Interlocal Coordination	The City's efforts for this activity meet Ecology's requirements
Identification and Ranking of Significant Pollutant Sources	Mukilteo does not have such a program.
Investigation and Corrective Actions of Problem Storm Drains	These actions currently are done case-by-case as City staff becomes aware of problems.
Water Quality Response Program	The City's program meets Ecology's requirements
Assurance of Adequate Funding	Mukilteo has a storm drainage utility and a funding plan, but funding has historically fallen short of stormwater program needs.
Local Coordination Agreements and Intergovernmental Coordination	The City needs to establish forums for coordinated management of shared watersheds.
Inspection, Compliance, and Enforcement Measures Targeted to Stormwater Quality	Mukilteo's program is equivalent to Ecology's requirements.

Equivalency Tables

Ecology is charged with reviewing local governments' progress in developing and implementing stormwater programs. This review focuses on development of the program rather than on short-term success in achieving water quality or effluent standards for stormwater discharges.

Two "equivalency tables" have been prepared to facilitate Ecology's review of Mukilteo's program. The tables, included at the end of this chapter, compare Ecology requirements to the current status of the City's basic and comprehensive programs, noting whether City programs or ordinances in place are equivalent to Ecology's minimum requirements. A prioritized list of recommended actions, based on this review, is provided in Table 19-3.

Table 19-4 evaluates the equivalency of overall program elements. It also serves as Mukilteo's stormwater program implementation schedule. Table 19-5 compares current Mukilteo laws and regulations to Ecology's minimum standards for stormwater ordinances. The minimum standards address the following issues:

- Erosion and sediment control
- Preservation of natural drainage systems
- Source control of pollution
- Runoff treatment BMPs
- Streambank erosion control
- Wetlands
- Water quality sensitive areas
- Off-site analysis and mitigation
- Basin planning
- Operation and maintenance
- Financial liability.

Ecology considers these minimum requirements to be the necessary core for any stormwater program. The conformance of a community's ordinances with these minimum standards is a crucial part of the agency's review and approval of a stormwater program.

RECOMMENDED ACTIONS

Table 19-3 summarizes a prioritized list of actions recommended to bring Mukilteo's stormwater program into compliance with Ecology requirements. These actions are described in detail in the following sections. Ecology's focus is on basic program elements first and comprehensive program elements second. Minimum requirements for new development and redevelopment are the agency's highest priority.

TABLE 19-3.
RECOMMENDED ACTIONS TO COMPLY WITH ECOLOGY REQUIREMENTS

Priority	Recommended Action
1	Adopt set of stormwater ordinances[a]
2	Develop and adopt a stormwater technical design manual
3	Develop an operations and maintenance manual
4	Enhance the public education program

[a]. A set of stormwater ordinances is likely to include a Stormwater Management Ordinance, Operations and Maintenance Ordinance, and possibly a Water Quality Ordinance.

Adopt Stormwater Ordinances

The highest priority action for Mukilteo is to revise the City Code that pertains to stormwater management so that it contains all of Ecology's minimum requirements for new development and redevelopment. This code should incorporate a technical manual for stormwater facility design and include the other elements identified in Table 19-4.

This change is likely to require two or three new stormwater ordinances: a stormwater management ordinance, an operations and maintenance ordinance, and possibly a water quality ordinance. Ecology requires ordinances or other codified regulations for stormwater management for new development and redevelopment, as well as for operations and maintenance. Water quality requirements can be included in the stormwater management ordinance or stand alone in a separate ordinance.

The easiest approach to revising the Mukilteo City Code is to use Ecology's model ordinances for stormwater management and maintenance and operations. We recommend using these ordinances as a starting point in revising Mukilteo's code. The model ordinances may require little modification. Alternately, the City could add Ecology requirements to its existing code or develop a brand new ordinance that contains Ecology requirements.

Develop and Adopt a Stormwater Design Manual

Mukilteo will need to adopt a Stormwater Design Manual as part of the Stormwater Management Ordinance. There are three general approaches to adopting a Stormwater Design Manual:

- Adopt an existing manual (Ecology's or another jurisdiction's that is equivalent to Ecology's).
- Develop a new manual.
- Prepare an addendum for an existing manual, and adopt the addendum and existing manual as Mukilteo's Stormwater Technical Manual.

The last approach—adopting an existing manual with a local addendum—has been the best approach for many communities. This allows the community to take advantage of technical standards previously developed by other jurisdictions in the Puget Sound region but tailor design standards and administrative procedures to local needs.

Operations and Maintenance Manual

The City's operation and maintenance program should be documented in a manual. This manual should include an inventory of City-maintained facilities, guidelines for special considerations for maintaining stormwater facilities near environmentally sensitive areas, and a description of the administration of the maintenance program. For each facility type, this manual should contain the following:

- Schedules for inspection and maintenance
- Location and content of facility and maintenance records

- Procedures for inspection and maintenance
- Inspection and maintenance checklists.

This manual would be useful as a training resource for new staff, and would help ensure consistency in inspection and maintenance procedures.

Enhance Mukilteo's Public Education Program

A more active public education is needed in Mukilteo to educate and inform the public about stormwater issues. Because of Mukilteo's budgetary constraints, low-cost public education activities should be emphasized, with the goal of reaching different audiences and addressing multiple aspects of stormwater issues. The Ecology guidebook *Stormwater Program Guidance Manual* (1992) contains many ideas for public education activities as well as the Public Information and Education section of Chapter 20.

NPDES Phase II

Mukilteo will be required to apply for NPDES Phase II permit coverage by March 10, 2003. The final permit terms may not be published until December 8, 2002. Guidance will be forthcoming from EPA and Ecology according to the timetable in Table 19-1. According to Ecology, adoption and implementation of BMPs in the *Stormwater Management in Washington State* manual, or their equivalent, will help Puget Sound municipalities fulfill NPDES Phase II requirements for construction controls and post-construction controls.

A brief review indicates that a number of the comprehensive requirements of the *Puget Sound Water Quality Management Plan* may overlap the Phase II minimum measures. A more detailed review is recommended for specifically identifying the extent of overlap or gap, with additional review when the Ecology's Phase II general permit is developed.

TABLE 19-4.
MUKILTEO STORMWATER PROGRAM EQUIVALENCY COMPARISON
AGAINST DEPARTMENT OF ECOLOGY BASIC AND COMPREHENSIVE PROGRAM REQUIREMENTS

Department of Ecology Requirement	Status of Mukilteo Stormwater Program	Equivalency Determination and Recommended Action	Anticipated Completion Date
Basic Stormwater Program Elements			
Stormwater Management Ordinance			
Adopt a Stormwater Management Ordinance that is equivalent to Ecology's. *(See Table 2 for comparison of required ordinance elements.)*	Mukilteo's current stormwater management code is contained Chapter 13.12 MCC, "Drainage Management." Table 2 compares current Mukilteo stormwater code elements with Ecology-required elements. Not all elements are adequately addressed in current city code.	NOT EQUIVALENT. Revise Mukilteo stormwater management code using the Ecology model stormwater management ordinance as a template.	July 2000
Stormwater Technical Manual			
Adopt and implement a stormwater technical manual that is equivalent to Ecology's *Stormwater Management Manual*. The Technical Manual must address the following: • Erosion and sediment control • Runoff control and control of pollution from urban land uses • Source control BMPs • Treatment BMPs • A BMP selection process equivalent to that in Ecology's Manual	Mukilteo's existing stormwater management code does not adopt a stormwater technical manual. The City uses a variety of technical resources, including the Ecology manual, to direct the selection and design of stormwater facilities and BMPs.	NOT EQUIVALENT A stormwater technical manual should be adopted as part of the stormwater management code revision described above. Options for stormwater manuals include: • Adopt the Ecology manual • Adopt another local jurisdiction's manual • Develop a new stormwater technical manual for Mukilteo • Adopt an existing technical manual and prepare an addendum that customizes that manual for local use.	July 2000 (possibly December 1999)

TABLE 19-4 (continued).
MUKILTEO STORMWATER PROGRAM EQUIVALENCY COMPARISON
AGAINST DEPARTMENT OF ECOLOGY BASIC AND COMPREHENSIVE PROGRAM REQUIREMENTS

Department of Ecology Requirement	Status of Mukilteo Stormwater Program	Equivalency Determination and Recommended Action	Anticipated Completion Date
Basic Stormwater Program Elements (continued)			
Operation and Maintenance Program			
Establish and maintain an operations and maintenance program that incorporates: • Maintenance schedules • Facility and maintenance records • Policies for desired methods; frequencies for inspecting and maintaining stormwater facilities • Employee training to prevent stormwater pollution from local government operations • Pollution prevention and good housekeeping controls for reducing or eliminating the discharge of pollutants from streets, roads, highways, municipal parking lots, maintenance and storage yards, and waste transfer stations.	Mukilteo's Operation and Maintenance Program includes street sweeping, mowing, vacuum or jet rodder truck cleanout of structures, detention/retention pond cleanout, and stormwater facility upgrade/repairs under the City's targeted drainage improvement program. • Maintenance Schedules: Street sweeping is done 4 times per year. Vactoring is done with rented equipment; approximately 25 percent of the City's facilities are cleaned each year. Mukilteo has recently began a program of cleaning out detention/retention ponds. Based on first year results, it appears that the City can clean out approximately seven or eight per year, resulting in a 10-year rotation for detention/retention pond cleanout. • Facility and Maintenance Records: Employee daily timesheets, maps on which completed work is plotted, and supervisor's tracking and knowledge of Mukilteo's stormwater system form the basis of Mukilteo's record-keeping system. Because the system is relatively small, this is a manageable approach to record-keeping. In the future, GIS mapping may be used to produce drainage maps and track maintenance activities.	PARTIALLY EQUIVALENT Mukilteo's Operations and Maintenance Program meets Ecology's minimum requirements for every element except the existence of formal policies for inspection and maintenance frequencies and methods. Program documentation would be useful for the City, particularly in training new staff and ensuring consistent standards.	July 2000

TABLE 19-4 (continued).
MUKILTEO STORMWATER PROGRAM EQUIVALENCY COMPARISON
AGAINST DEPARTMENT OF ECOLOGY BASIC AND COMPREHENSIVE PROGRAM REQUIREMENTS

Department of Ecology Requirement	Status of Mukilteo Stormwater Program	Equivalency Determination and Recommended Action	Anticipated Completion Date
Basic Stormwater Program Elements (continued)			
Operations and Maintenance Program (continued)			
	• Policies for Methods and Frequencies of Specific Facility Inspections and Maintenance: Mukilteo does not have formal policies describing approved inspection and maintenance methods and frequencies. • Employee Training: On-the-job training is the dominant training for operations and maintenance staff. They also attend seminars on relevant topics. • Pollution Prevention and Good Housekeeping Controls: These topics are emphasized in Mukilteo, particularly with regard to waste stream management.		

TABLE 19-4 (continued).
MUKILTEO STORMWATER PROGRAM EQUIVALENCY COMPARISON
AGAINST DEPARTMENT OF ECOLOGY BASIC AND COMPREHENSIVE PROGRAM REQUIREMENTS

Department of Ecology Requirement	Status of Mukilteo Stormwater Program	Equivalency Determination and Recommended Action	Anticipated Completion Date
Basic Stormwater Program Elements (continued)			
Operations and Maintenance Ordinance			
Adopt an ordinance, interlocal agreement or other enforceable mechanism establishing responsibility for operation and maintenance of new and existing private stormwater systems and facilities. This ordinance should include: • Provisions for a regular inspection program including right-of-entry provisions and/or dedicated easements for access to private property • Inspection procedures • Identification of parties responsible for operation and maintenance • Enforcement provisions • Procedures for appropriate disposal of decant water, solids, and other substances from stormwater facility maintenance.	Responsibility for cleaning and maintenance of privately-owned facilities is set forth in Chapter 13.12.085 MCC "Drainage Management." • Right-of-entry for inspections is provided (Item B). • Inspection procedures are not documented. • It is the owner's responsibility to clean and maintain privately owned storm drainage systems. • Enforcement provisions for improperly cleaned and maintained private facilities are described under Item C of Chapter 13.12.085 MCC. • Procedures for appropriate disposal of decant water solids are not described in Mukilteo's drainage code.	NOT EQUIVALENT Two required items pertaining to operation and maintenance of private stormwater facilities are missing from Mukilteo's city code: • Documentation of inspection procedures • Procedures for appropriate disposal of decant water solids. These items should be added to the revised stormwater management code recommended above. As another option, Mukilteo could move the operations and maintenance portions of its stormwater code into a separate operations and maintenance ordinance based on the Ecology model ordinance.	July 2000

TABLE 19-4 (continued).
MUKILTEO STORMWATER PROGRAM EQUIVALENCY COMPARISON
AGAINST DEPARTMENT OF ECOLOGY BASIC AND COMPREHENSIVE PROGRAM REQUIREMENTS

Department of Ecology Requirement	Status of Mukilteo Stormwater Program	Equivalency Determination and Recommended Action	Anticipated Completion Date
Basic Stormwater Program Elements (continued)			
Public Education (Basic and Comprehensive Program Element)			
Stormwater management programs will include ongoing efforts to educate residents, businesses, industries, and employees of the municipality about the impacts of stormwater discharges on water quality. These programs should include the public in developing, implementing and reviewing local stormwater programs. Sample activities include: • Education on proper use and disposal of pesticides, herbicides, and fertilizers • Activities to explain and promote proper management and disposal of used oil and toxic materials • Training of construction contractors and developers in preparing, installing and maintaining stormwater site plans and BMPs for construction activities • Efforts to explain the definition and impacts of illicit discharges and to promote their removal.	Mukilteo has conducted a limited public education program so far. This program has included storm drain stenciling.	NOT EQUIVALENT The Ecology Publication *Stormwater Program Guidance Manual* (1992) contains ideas for additional public education activities that Mukilteo could pursue in the future.	Ongoing

TABLE 19-4 (continued).
MUKILTEO STORMWATER PROGRAM EQUIVALENCY COMPARISON
AGAINST DEPARTMENT OF ECOLOGY BASIC AND COMPREHENSIVE PROGRAM REQUIREMENTS

Department of Ecology Requirement	Status of Mukilteo Stormwater Program	Equivalency Determination and Recommended Action	Anticipated Completion Date
Basic Stormwater Program Elements (continued)			
Growth Management Planning and Interlocal Coordination			
Incorporate the goals of local stormwater programs into a GMA Comprehensive Plan and stormwater management ordinances into development regulations. Neighboring jurisdictions will cooperate on stormwater, growth management and watershed or basin planning issues and concerns. • The countywide planning policy called for by GMA will address protection, preservation and enhancement of surface water, groundwater, and sediment quality. • Short plats and subdivisions are approved only with written findings that services, including stormwater management, are available. • The Land Use Element of the GMA comprehensive plan will address the protection of surface waters from stormwater runoff and protection of quantity and quality of groundwater used for public water supplies.	Mukilteo's Comprehensive Plan incorporates stormwater program goals in several places: • General Development Goal #9 (GD9) is "To protect and conserve open space and scenic resources, including the City's steep ravines and existing watercourses." • General Development Goal #7 (GD7) is "Preserve and enhance the City's natural amenities such as wooded areas, greenbelts, and view of the water and mountain ranges." • General Development Goal #6 (GD6) is "Provide cost-effective and efficient levels of public facilities and services consistent with City goals and policies." • The City's Comprehensive Land Use Map designates an open space corridor surrounding each of the major drainages in the City: Big Gulch Creek, North and South Chennault Creeks, 80th Street ravine, 84th Street ravine, and upper Picnic Point Creek (South Gulch). • General Land Use Policy #9 (LU9) states that "Wherever possible the City should strive to retain open space, stream and shoreline systems that are habitats for wildlife and fisheries which also contribute to resource-based industries."	PARTIALLY EQUIVALENT Mukilteo has not met Ecology's requirement for coordinated watershed analysis and management. Arrangements with neighboring jurisdictions should be made for Edgewater Creek, Japanese Gulch, Smuggler's Gulch, Big Gulch, Hulk Creek, and Picnic Point Creek.	July 2000

TABLE 19-4 (continued).
MUKILTEO STORMWATER PROGRAM EQUIVALENCY COMPARISON
AGAINST DEPARTMENT OF ECOLOGY BASIC AND COMPREHENSIVE PROGRAM REQUIREMENTS

Department of Ecology Requirement	Status of Mukilteo Stormwater Program	Equivalency Determination and Recommended Action	Anticipated Completion Date
Basic Stormwater Program Elements (continued)			
Growth Management Planning and Interlocal Coordination (continued)			
• The Capital Facilities Element will identify regional stormwater treatment facilities, including retention/detention facilities. Conveyances including natural drainage courses should be identified in the local comprehensive plan. • Jurisdictions sharing common watersheds and basins should cooperate in analyzing the effects and control of stormwater runoff and adopt coordinated and compatible stormwater management into local growth management regulatory actions implemented under the Growth Management Act.	• The Comprehensive Plan includes a Parks and Open Space element that directs the development of "land use regulations . . . which require preservation of the City's steep ravines" (LU13) • Land use policy #51 (LU51) calls for protection of "wetlands such as bogs, marshes, swamps, creeks, ravines and other natural surface water runoff and detention areas to mitigate and maintain their functional values." • LU53 states "Retain and enhance the existing water quality of the Sound and the various creeks and drainage areas within the City by adopting appropriate regulations." • The following Storm Drainage Utility Policies are included in the Utilities Element of the Plan: ➢ (UT13) Periodic updates of the Comprehensive Storm Drainage Plan should be undertaken as part of the annual Comprehensive Plan update. ➢ (UT14) Natural means for storm drainage conveyance should be used by developers wherever possible, including the protection of major wetland and drainage functions.		

TABLE 19-4 (continued).
MUKILTEO STORMWATER PROGRAM EQUIVALENCY COMPARISON
AGAINST DEPARTMENT OF ECOLOGY BASIC AND COMPREHENSIVE PROGRAM REQUIREMENTS

Department of Ecology Requirement	Status of Mukilteo Stormwater Program	Equivalency Determination and Recommended Action	Anticipated Completion Date
Basic Stormwater Program Elements (continued)			
Growth Management Planning and Interlocal Coordination (continued)			
	➢ (UT15) The City should regulate the storm drainage system throughout the City on both public and private property, and should encourage development practices which properly manage storm water runoff through the City's building, zoning, subdivision, environmental, and other codes and ordinances. ➢ (UT16) City approved storm water collection and disposal systems should be required for all development and construction projects within the City in accordance with the adopted Storm Drainage Plan and applicable codes and regulations. ➢ (UT17) Installation of appropriate storm drainage systems in conjunction with major street construction and reconstruction projects is required. ➢ (UT18) The City should identify and finance necessary public storm drainage capital improvements in accordance with the Comprehensive Storm Drainage Plan.		

TABLE 19-4 (continued).
MUKILTEO STORMWATER PROGRAM EQUIVALENCY COMPARISON
AGAINST DEPARTMENT OF ECOLOGY BASIC AND COMPREHENSIVE PROGRAM REQUIREMENTS

Department of Ecology Requirement	Status of Mukilteo Stormwater Program	Equivalency Determination and Recommended Action	Anticipated Completion Date
Basic Stormwater Program Elements (continued)			
Growth Management Planning and Interlocal Coordination (continued)			
	• Capital Facilities Policy #6 (CF6) directs development of "a Storm Drainage Plan to identify future needs, funding and locations. The City should consider impacts on the natural and manmade storm drainage system when reviewing new land use development projects." • The Capital Facilities Element contains storm water policies similar to those in the Utilities Element. Mukilteo has not initiated coordinated analyses of stormwater issues or stormwater-related regulations with neighboring jurisdictions.		

TABLE 19-4 (continued).
MUKILTEO STORMWATER PROGRAM EQUIVALENCY COMPARISON
AGAINST DEPARTMENT OF ECOLOGY BASIC AND COMPREHENSIVE PROGRAM REQUIREMENTS

Department of Ecology Requirement	Status of Mukilteo Stormwater Program	Equivalency Determination and Recommended Action	Anticipated Completion Date
Comprehensive Stormwater Program Elements			
Identification and Ranking of Significant Pollutant Sources			
Through an ongoing assessment program, identify and rank significant pollutant sources and determine their relationship to the drainage system and water bodies. These assessments will include: • Illicit discharges to stormwater systems • Erosion and sedimentation of natural water bodies • Deterioration of surface water, groundwater, or sediment quality, and habitat degradation caused by stormwater discharges. Problem stormwater drainage systems should be prioritized based on the magnitude of the problem, effects on existing or designated beneficial uses of surface or groundwater, and/or the degree of their contamination.	Identification of significant pollutant sources is done as part of the City's development review and inspection programs. Mukilteo does not have a formal program for ranking significant pollutant sources.	NOT EQUIVALENT Implement a program to identify and rank significant pollutant sources. Problems that are identified during development review, inspections, and complaint response should be prioritized.	July 2000

TABLE 19-4 (continued).
MUKILTEO STORMWATER PROGRAM EQUIVALENCY COMPARISON
AGAINST DEPARTMENT OF ECOLOGY BASIC AND COMPREHENSIVE PROGRAM REQUIREMENTS

Department of Ecology Requirement	Status of Mukilteo Stormwater Program	Equivalency Determination and Recommended Action	Anticipated Completion Date
Comprehensive Stormwater Program Elements (continued)			
Investigations and Corrective Actions of Problem Storm Drains			
Investigate and take corrective actions for problem storm drains. Investigative tools include collecting and analyzing water samples, surveying land uses, homes and businesses, and water and sediment tracing in storm drains. Corrective actions should focus mainly on the application of BMPs. Prepare a plan and schedule for implementing structural and non-structural treatment and source control measures for the highest priority areas.	Mukilteo investigates and corrects problem storm drain situations on a case-by-case basis. Problem storm drains are typically identified either by a complaint from a neighbor or by observation by City staff. Public Works staff conduct the investigation and work with the responsible party to correct the problem.	EQUIVALENT	No action required.
Water Quality Response Program			
Implement a water quality response program to investigate sources of pollutants, spills, fish kills, illegal hookups, dumping, and other water quality problems. These investigations should be used to support compliance/ enforcement efforts.	The City Public Works staff conduct Mukilteo's water quality response program. Incidents requiring response are identified through reports of spills by the responsible party or neighbor, notification from other agencies, and observation by City staff.	EQUIVALENT	No action required.

TABLE 19-4 (continued).
MUKILTEO STORMWATER PROGRAM EQUIVALENCY COMPARISON
AGAINST DEPARTMENT OF ECOLOGY BASIC AND COMPREHENSIVE PROGRAM REQUIREMENTS

Department of Ecology Requirement	Status of Mukilteo Stormwater Program	Equivalency Determination and Recommended Action	Anticipated Completion Date
Comprehensive Stormwater Program Elements (continued)			
Assurance of Adequate Funding			
Assure adequate local funding for the stormwater program through surface water utilities, sewer charges, fees, or other revenue-generating sources. Jurisdictions should prepare a fiscal analysis of funding needs for staff, equipment and capital facilities to implement the proposed Stormwater Management Program.	Mukilteo has a stormwater utility to finance storm water needs. The utility has prepared a Capital Facilities Plan that identifies stormwater facility needs and sets forth a plan for financing them.	EQUIVALENT	No action required.
Local Coordination Agreements/ Intergovernmental Coordination			
Complete local coordination arrangements such as interlocal agreements, joint programs, consistent standards, or regional boards or committees to assist in managing shared water bodies and drainage basins.	Mukilteo does not have local coordination arrangements to assist in managing the City's shared drainage basins.	NOT EQUIVALENT Arrangements with neighboring jurisdictions should be made for Edgewater Creek, Japanese Gulch, Smuggler's Gulch, Big Gulch, Hulk Creek, and Picnic Point Creek.	July 2000
Inspection, Compliance and Enforcement Measures			
Implement inspection, compliance, and enforcement measures to control pollutants in stormwater.	Enforcement actions are authorized under MCC Chapter 13.12.100. The City has the right to access privately-owned stormwater facilities. If deficiencies are found, owners are notified in writing and must correct the situation within 15 days. If the problem is not corrected, the City may file misdemeanor charges, seek a public nuisance ruling by council resolution, revoke the right to occupancy of property, or correct the situation at cost to the owner.	EQUIVALENT	No action required.

TABLE 19-4 (continued).
MUKILTEO STORMWATER PROGRAM EQUIVALENCY COMPARISON
AGAINST DEPARTMENT OF ECOLOGY BASIC AND COMPREHENSIVE PROGRAM REQUIREMENTS

Comprehensive Stormwater Program Elements (continued)			
Implementation Schedule			
Prepare an implementation schedule for the comprehensive stormwater program.	Mukilteo does not have an implementation schedule for its comprehensive stormwater program.	This table serves as Mukilteo's implementation schedule for the City's basic and comprehensive stormwater program.	July 1999

Sources: Department of Ecology requirements are derived from basic and comprehensive program elements found in *Guidance for Comprehensive Stormwater Programs Under the Puget Sound Water Quality Management Plan* (Ecology, 1997). Other reference material used to complete this table includes Ecology equivalency review criteria in *Guidance for Local Governments When Submitting Manuals and Associated Ordinances for Equivalency Review* (Ecology, 1994) and *Stormwater Program Guidance Manual* (Ecology, 1992)

TABLE 19-5.
MUKILTEO STORMWATER CITY CODE EQUIVALENCY COMPARISON
AGAINST DEPARTMENT OF ECOLOGY REQUIREMENTS FOR STORMWATER MANAGEMENT ORDINANCES

Ecology Stormwater Management Ordinance Component	Current Mukilteo Code	Equivalency Determination
Small Parcel[a] Minimum Requirements for New Development and Redevelopment		
• Construction Access Route • Stabilization of Denuded Areas • Protection of Adjacent Properties • Maintenance • Other BMPs (discretionary)	Mukilteo's "Standard Drainage Plan" is available, with prior authorization from the city engineer, for projects with development coverage between 1,000 and 5,000 square feet of impervious surface. This boilerplate drainage plan focuses on drainage control and authorizes two alternative approaches: an enclosed, underground detention system that discharges to an acceptable outfall location, or an infiltration trench. If the "Standard Drainage Plan" is determined by the city engineer to be inappropriate for a specific project of this size, a full drainage plan is required. Projects with development coverage of less than 1,000 square feet of impervious surface do not require drainage review. Mukilteo's "Standard Drainage Plan" does not include any of Ecology's small parcel erosion and sediment control requirements. They are required in the grading, building, right-of-way, or demolition permit process.	PARTIALLY EQUIVALENT Mukilteo should codify Ecology-equivalent erosion and sediment control requirements, such as to its Standard Drainage Plan.

a. The Washington State Department of Ecology defines "small parcels" as detached single-family residences and duplexes, creation or addition of less than 5,000 square feet of impervious surface area, and land disturbing activities of less than 1 acre.

TABLE 19-5 (continued).
MUKILTEO STORMWATER CITY CODE EQUIVALENCY COMPARISON
AGAINST DEPARTMENT OF ECOLOGY REQUIREMENTS FOR STORMWATER MANAGEMENT ORDINANCES

Ecology Stormwater Management Ordinance Component	Current Mukilteo Code	Equivalency Determination
Large Parcel Minimum Requirements for New Development and Redevelopment		
1. Erosion and Sediment Control		
Ecology's erosion and sedimentation controls for large parcels are as follows: • Stabilize exposed and unworked soils. • Delineate clearing and easement limits. • Protect adjacent properties from sediment deposition. • Construct sediment-trapping facilities before major land-disturbing activities begin. • Construct cut-and-fill slopes in a manner that will minimize erosion. • Control off-site erosion. • Stabilize temporary conveyance channels and outlets. • Protect storm drain inlets from excess sedimentation. • Use special construction practices for underground utility construction to minimize erosion and sedimentation. • Provide construction access routes that minimize off-site transport of sediment. • Remove temporary BMPs following construction and stabilization of site. • Dispose of the discharge from dewatering in a sediment pond or trap. • Control other potential stormwater pollutants. • Maintain BMPs. • Provide assurance of financial liability.	Mukilteo's Drainage Management code includes a short reference to erosion and sediment control (Chapter 13.12 MCC under Drainage Plan – Contents, Item A.3), which requires drainage plans to address "proposed measures for controlling runoff, maintaining water quality and controlling erosion during construction." Erosion and sediment control is also addressed in the following paragraphs from Mukilteo's "Grading and "Excavation" code (Chapter 15.16.160 MCC): A. Slopes. The faces of cut and fill slopes shall be prepared and maintained to control against erosion. This control may consist of effective planting. The protection for the slopes shall be installed as soon as practicable and prior to calling for final approval. Where cut slopes are not subject to erosion due to the erosion-resistant character of the materials, such protection may be omitted. B. Other Devices. Where necessary, check dams, cribbing, riprap or other devices or methods shall be employed to control erosion and provide safety.	NOT EQUIVALENT Mukilteo's Drainage Management code should be revised to include all the erosion and sediment control elements required by Ecology (listed in the column at far left).

TABLE 19-5 (continued).
MUKILTEO STORMWATER CITY CODE EQUIVALENCY COMPARISON
AGAINST DEPARTMENT OF ECOLOGY REQUIREMENTS FOR STORMWATER MANAGEMENT ORDINANCES

Ecology Stormwater Management Ordinance Component	Current Mukilteo Code	Equivalency Determination
Large Parcel Minimum Requirements for New Development and Redevelopment (continued)		
2. Preservation of Natural Drainage Systems		
Natural drainage patterns shall be maintained and discharges from the site shall occur at the natural location.	Addressed in Mukilteo City Code, ("Drainage Management," Chapter 13.12.050 Item A, MCC)	EQUIVALENT No action needed.
3. Source Control of Pollution		
All projects should use source control BMPs to the greatest extent possible.	The issue of source control of pollution is not addressed in existing Mukilteo City Code.	NOT EQUIVALENT Source control requirements should be added to a revised "Drainage Management" City code chapter.
4. Runoff Treatment BMPs		
All projects are required to use runoff treatment BMPs.	Runoff treatment BMPs are not required in existing Mukilteo city code.	NOT EQUIVALENT The requirement for runoff treatment BMPs should be added to a revised "Drainage Management" City code chapter.

TABLE 19-5 (continued).
MUKILTEO STORMWATER CITY CODE EQUIVALENCY COMPARISON
AGAINST DEPARTMENT OF ECOLOGY REQUIREMENTS FOR STORMWATER MANAGEMENT ORDINANCES

Ecology Stormwater Management Ordinance Component	Current Mukilteo Code	Equivalency Determination
Large Parcel Minimum Requirements for New Development and Redevelopment (continued)		
5. Streambank Erosion Control		
For the 2-year, 24-hour design storm, Ecology's requirement for streambank erosion control at individual development sites limits the post-development peak rate of runoff to 50 percent of the existing condition rate. For the 10- and 100-year 24-hour design storms, post-development peak runoff may not exceed the existing conditions rate.	Item B, under Mukilteo City Code Chapter 13.12.050 states that "the peak discharge from the subject property due to the design storm may not be increased due to the proposed development." The City's adopted codes and written policies do not specify acceptable methodologies for hydrologic analyses including determining the design storm and predicting flows.	NOT EQUIVALENT Mukilteo can either adopt Ecology's requirements, develop flow control requirements for Mukilteo that are technically equivalent to Ecology's, or adopt another local jurisdiction's flow control strategies that are equivalent to Ecology's requirements. King County has developed a strategy that Ecology has recognized as superior to its own strategy.
6. Wetlands		
Requirements are established for maintaining existing hydrologic characteristics and good water quality for stormwater discharges into wetlands.	Mukilteo's stormwater code does not address wetlands. The Site Sensitive Areas Code (MCC 17.52B) contains specific wetland definition and protection requirements.	EQUIVALENT Incorporate reference to wetland protection requirements in Drainage Management code.
7. Water Quality Sensitive Areas		
Extra protection for designated areas is required.	Mukilteo's stormwater code does not address water quality sensitive areas.	NOT EQUIVALENT Incorporate requirements for water quality sensitive areas into revised "Drainage Management" City code chapter.

TABLE 19-5 (continued).
MUKILTEO STORMWATER CITY CODE EQUIVALENCY COMPARISON
AGAINST DEPARTMENT OF ECOLOGY REQUIREMENTS FOR STORMWATER MANAGEMENT ORDINANCES

Ecology Stormwater Management Ordinance Component	Current Mukilteo Code	Equivalency Determination
Large Parcel Minimum Requirements for New Development and Redevelopment (continued)		
8. Off-site Analysis and Mitigation		
Analysis and mitigation must be provided for potential water quality impacts at least one-fourth of a mile downstream from the project.	Mukilteo's stormwater code does not address off-site analysis and mitigation.	NOT EQIVALENT Incorporate requirements for addressing off-site analysis and mitigation into revised "Drainage Management" City code chapter.
9. Basin Planning		
Adopted basin plans can be substituted for minimum requirements if watershed protection is at least equivalent to that provided by Ecology's minimum requirements.	Mukilteo's stormwater code does not address basin planning.	NOT EQUIVALENT Incorporate provisions for allowing adopted basin plans to dictate stormwater-related requirements into revised "Drainage Management" City code chapter.
10. Operation and Maintenance		
Responsibility and schedules for O&M are defined.	Responsibility for cleaning and maintenance of privately owned stormwater facilities is specified in Chapter 13.12.085 MCC. This section does not specify maintenance schedules or procedures however.	NOT EQUIVALENT Update maintenance provisions in Mukilteo City Code to be equivalent to Ecology's requirements.

TABLE 19-5 (continued).
MUKILTEO STORMWATER CITY CODE EQUIVALENCY COMPARISON
AGAINST DEPARTMENT OF ECOLOGY REQUIREMENTS FOR STORMWATER MANAGEMENT ORDINANCES

Ecology Stormwater Management Ordinance Component	Current Mukilteo Code	Equivalency Determination
Large Parcel Minimum Requirements for New Development and Redevelopment (continued)		
11. Financial Liability		
Developers are to be required to provide financial backup to ensure compliance.	Chapter 13.12.080 MCC requires applicants constructing retention/detention and/or other drainage treatment/abatement facilities serving areas larger than 1 acre to post performance bonds. This section also requires the applicant to post a maintenance bond following satisfactory completion of the facilities.	EQUIVALENT
Thresholds and Definitions of New Development, Redevelopment, Land Disturbing Activities, and Existing Conditions That Are Substantially Equivalent to Ecology's		
New Development		
(Definition) Land disturbing activities, structural development, including construction, installation or expansion of a building or other structure; creation of impervious surfaces; Class IV – general forest practices that are conversions from timber land to other uses; and subdivision and short subdivision of land as defined in RCW 58.17.020. *(Threshold)* Creation or addition of 5,000 square feet or more of new impervious surface. If associated land-disturbing activities are 1 acre or greater, then Minimum Requirements #1 through #11 must be complied with. If land disturbing activities are less than 1 acre, then Minimum Requirements #2 through #11, and the Small Parcel Minimum Requirements must be complied with (this includes preparation of a Stormwater Site Plan).	Mukilteo does not have a definition for "new development." Mukilteo's threshold for triggering drainage review is the following: • Projects that require the following permits/approvals: ➢ Right-of-way permit ➢ Building permit ➢ Grading permit ➢ Subdivision approval ➢ Short subdivision approval ➢ Conditional use permits ➢ Substantial development permit • Projects that add more than 1,000 square feet of impervious surface.	EQUIVALENT Mukilteo's usage of thresholds for new development is equivalent to Ecology's requirements.

TABLE 19-5 (continued).
MUKILTEO STORMWATER CITY CODE EQUIVALENCY COMPARISON
AGAINST DEPARTMENT OF ECOLOGY REQUIREMENTS FOR STORMWATER MANAGEMENT ORDINANCES

Ecology Stormwater Management Ordinance Component	Current Mukilteo Code	Equivalency Determination
Thresholds and Definitions of New Development, Redevelopment, Land Disturbing Activities, and Existing Conditions That Are Substantially Equivalent to Ecology's (continued)		
Redevelopment		
(Definition) On an already developed site, the creation or addition of impervious surfaces, structural development including construction, installation or expansion of a building or other structure, and/or replacement of impervious surface that is not part of a routine maintenance activity; and land disturbing activities associated with structural or impervious redevelopment. *(Thresholds)* For redevelopment of 5,000 square feet or greater – the portion of the site that is being redeveloped must comply with Minimum Requirements #1 through #11 and source control BMPs shall be applied to the entire site. Redevelopment projects on the following sites with high likelihood of water quality concerns must also have a Stormwater Site Plan prepared that includes a schedule for implementing the Minimum Requirements on the entire site. • Existing sites greater than 1 acre in size with 50 percent or more impervious surface • Sites that discharge to a receiving water that has a documented water quality problem • Sites where the need for additional stormwater control measures have been identified through a basin plan, the watershed ranking process, or Growth Management Act planning.	Redevelopment is not defined in Mukilteo's City Code. Thresholds for redevelopment are not discussed in Mukilteo's current stormwater management program. The only triggering mechanism for drainage review identified in Mukilteo's code is the need for permits listed above in the discussion of new development.	NOT EQUIVALENT A definition and thresholds for drainage review for redevelopment activities should be established in a stormwater management ordinance.

TABLE 19-5 (continued).
MUKILTEO STORMWATER CITY CODE EQUIVALENCY COMPARISON
AGAINST DEPARTMENT OF ECOLOGY REQUIREMENTS FOR STORMWATER MANAGEMENT ORDINANCES

Ecology Stormwater Management Ordinance Component	Current Mukilteo Code	Equivalency Determination
Thresholds and Definitions of New Development, Redevelopment, Land Disturbing Activities, and Existing Conditions That Are Substantially Equivalent to Ecology's (continued)		
Land Disturbing Activities		
(Definition) Any activity that results in a change in the existing soil cover (both vegetative and nonvegetative) and/or the existing soil topography. Land disturbing activities include, but are not limited to demolition, construction, clearing, grading, filling and excavation.	Mukilteo does not currently have a definition or thresholds for land disturbing activities.	NOT EQUIVALENT A definition and thresholds for land disturbing activities should be established in a stormwater management ordinance.
Existing Site Conditions		
(Definition) (a) For developed sites with stormwater facilities that have been constructed to meet the standards in the Minimum Requirements, the existing conditions on the site. (b) For developed sites that do not have stormwater facilities that meet the Minimum Requirements, the conditions that existed prior to local government adoption of a stormwater management program. (c) For all sites in Water Quality Sensitive Areas as identified under Minimum Requirement #7, undisturbed forest, for the purposes of calculating runoff characteristics. (d) For all undeveloped sites outside of water quality sensitive areas, the existing conditions on the site.	Mukilteo does not currently have a definition for existing site conditions	NOT EQUIVALENT Include a definition for existing site conditions that is similar to Ecology's in Stormwater Management Ordinance.

TABLE 19-5 (continued).
MUKILTEO STORMWATER CITY CODE EQUIVALENCY COMPARISON
AGAINST DEPARTMENT OF ECOLOGY REQUIREMENTS FOR STORMWATER MANAGEMENT ORDINANCES

Ecology Stormwater Management Ordinance Component	Current Mukilteo Code	Equivalency Determination
Other Required Elements		
The ordinance must provide for effective treatment of the design storm	Mukilteo has not formally adopted methodologies for treatment of the design storm, however the City typically uses the Ecology manual. Occasionally, other technical resources are used when deemed appropriate by City staff.	NOT EQUIVALENT Develop and/or adopt a technical manual that contains methodologies for effective treatment of the design storm.
The ordinance must promote the use of infiltration, with appropriate precautions, as the first consideration in stormwater management	Mukilteo City Code does not encourage the use of infiltration as the city soils, documented in MCC 17.52, are inappropriate for infiltration facilities due to steep slopes and lack of infiltration capacity.	PARTIALLY EQUIVALENT Document in stormwater management ordinance the insufficiency of infiltration approaches for stormwater control.
The ordinance must promote the protection of stream channels, fish, shellfish, and other aquatic habit and wetlands	These issues are not specifically addressed in Mukilteo's stormwater code.	NOT EQUIVALENT Include language calling out these needs in a revised stormwater management ordinance.
The ordinance must contain a variance process	Chapter 13.12.040 MCC, Item B states that "The requirements of this section may be modified at the discretion of the city engineer in special cases." This chapter does not describe the process for requesting and receiving a variance however.	NOT EQUIVALENT The City Code should be revised to contain a variance process, including application requirements and criteria for evaluating variance requests.
The ordinance must contain provisions for local enforcement of these stormwater controls	Chapter 13.12.100 MCC describes enforcement. This enforcement process authorizes the City to gain access to private stormwater facilities, order corrections to facilities when necessary, pursue civil misdemeanor charges against the owner, and make corrections to facilities at the expense of the owner is the owner is not responsive to City requests.	EQUIVALENT During revision of the City's overall stormwater management code, this section should be evaluated and updated as appropriate.
The ordinance must adopt a Technical Manual or refer to one as guidance. This technical manual may actually contain the minimum requirements or implement the minimum requirements specified in the ordinance	Mukilteo's stormwater code does not adopt or refer to a technical manual.	NOT EQUIVALENT Revised stormwater code should adopt a technical design manual or refer to one as guidance. (See Table 1 for a more detailed discussion of options for technical manuals.)

CHAPTER 20.
NONSTRUCTURAL MEASURES

Frequently the first suggested response to water quality and quantity issues is to construct some facility or system to correct the problem. A more economical approach is to prevent the problem from occurring by instituting a program of nonstructural actions.

The City of Mukilteo has a unique environment with respect to surface water. Due to the topography of the land, the main surface water conveyance mechanisms are the ravines and streams that discharge into Puget Sound. The City's natural drainage system, ravines, streams, and wetlands should be preserved for continued use as part of the citywide drainage system, as well as providing habitat. Once the surface water riparian environments, such as forested streamside corridors, are altered or destroyed, it is difficult or impossible to replace the lost hydrologic and hydraulic benefits. The riparian environments are vital for the prevention of flood damage and for the protection of water quality and fish and wildlife habitat. Protection of existing riparian environments is a citywide concern and relies primarily on land use and regulatory measures as discussed in this section.

The nonstructural alternatives were divided into the following categories: administration, finance, maintenance and operations, program monitoring, public involvement and education, regulatory/enforcement, and waste control. These alternatives are explained in more detail in the following sections. The alternatives are described on individual action sheets.

ADMINISTRATION

The administration category provides nonstructural alternatives that directly involve City employees and City policy. An important aspect of surface water management is an educated staff. Training and workshop sessions are necessary to keep the employees educated on current issues and recent legislation regarding surface water.

Also included in the administration category is an emergency complaint response system, which can be very useful in tracking repetitive situations.

AD-1 Increased Inspection and Plan Review
AD-2 Staff Workshops
AD-3 Emergency Complaint Response

ACTION CATEGORY:	*ADMINISTRATION*
NONPOINT SOURCE:	*Construction*
AD - 1	***INCREASED INSPECTION AND PLAN REVIEW***
PROBLEM / ISSUE:	Failure to comply with drainage and surface water requirements during construction Negative impacts that can occur during construction and related activities: • Increased flow volumes and velocities • Erosion and sedimentation • Hazardous substance spills
PROPOSED SOURCE CONTROL ACTION:	Inspection and plan review: • Provide additional inspector training on water quality issues as well as regulations and procedures for inspectors and plan reviewers (update training annually). • Revise City building and site inspection procedures, incorporating inspections covering new Department of Ecology minimum technical requirements for stormwater. • Add capability for increasing the number of drainage and surface water inspections.
BENEFITS:	Increases compliance with construction regulations through increased contractor understanding of drainage and surface water issues and improved inspection and enforcement. Increases staff authority and response to violations in construction requirements
COSTS:	Inspector and training (annual).................... $40,000 - $50,000 ***Interval:*** Ongoing

ACTION CATEGORY:	***ADMINISTRATION***
NONPOINT SOURCE:	*All Sources*
AD - 2	***STAFF WORKSHOPS***
PROBLEM / ISSUE:	Lack of communication amongst the various City positions regarding surface water issues City staff who are uninformed about nonpoint source management issues
PROPOSED SOURCE CONTROL ACTION:	Design and conduct workshops as a forum for maintenance, inspection, and code enforcement staff to share knowledge of basin problems and solutions. Focus on surface water nonpoint source management issues • Safety • Ditch and swale maintenance • Hazardous spill cleanup and response • Public relations
BENEFITS:	Increases understanding among City staff with respect to nonpoint source issues. Coupled with the opportunity for information exchange, may result in increased effectiveness of implementation.
COSTS:	Initial startup .... $10,000 ***Interval:*** One time Annually per workshop cycle .... $5,000 ***Interval:*** Ongoing

ACTION CATEGORY:	*ADMINISTRATION*
NONPOINT SOURCE:	*Hazardous Substance Spills*
AD - 3	***EMERGENCY COMPLAINT RESPONSE***
PROBLEM / ISSUE:	Degradation of water quality due to accidental or intentional spillage of hazardous substances into surface water systems
PROPOSED SOURCE CONTROL ACTION:	Emergency Complaint Response • Develop a network of agency and interlocal contacts to respond to spills in waters • Continue to coordinate with Snohomish County and local fire district.
BENEFITS:	Reduces loading of toxic substances to creek and rivers, thereby improving water quality and aquatic habitat Increases public understanding and awareness of water quality issues Improves response and implementation of appropriate actions following a spill Increases City knowledge of spill occurrence, type, impacts, and magnitude, thereby facilitating appropriate response actions (e.g., education, clean-up, enforcement)
COSTS:	Staff.. $5,000 ***Interval:*** One time set-up Answering service (annual) .... $1,000 ***Interval:*** Ongoing response

FINANCIAL INCENTIVES FOR RESOURCE PROTECTION

High property taxes on properties with sensitive surface water features, such as stream corridors and wetlands, can encourage landowners to recover costs through maximum development of their land. One way to address this problem is to provide incentives, such as current use taxation, and to encourage the donation of conservation easements. Current use taxation was established under RCW 84.34, and allows a major portion of property taxes to be deferred if land is maintained in open space uses.

Using a conservation easement, a landowner may permanently donate some or all of the development rights to a parcel of land to a governmental agency or private charity. This donation permanently reduces the market value of the donated property, resulting in reduced property taxes for the owner. Donation can also be used for a one-time federal income tax deduction (26 CFR Parts 1, 20, 25 and 602). Incentives such as these can work very well in protecting sensitive areas and creating a cooperative attitude with concerned property owners.

FN-1 Financial Incentives

ACTION CATEGORY:	***FINANCE***
NONPOINT SOURCE:	*Land Development*
FN - 1	***FINANCIAL INCENTIVES***
PROBLEM / ISSUE:	Negative impacts associated with loss of wetlands and riparian corridors.
PROPOSED SOURCE CONTROL ACTION:	Provide financial incentives to property owners, businesses, developers and industries to take actions over and above those required by environmental regulations to protect water quality through riparian zone restoration, tree planting, and other water quality enhancement measures. Provide property tax relief to landowners with wetlands on their properties so that those properties are not taxed for highest and best use. Allow for increased density on portions of upland areas in exchange for protecting wetlands and wetland buffers, creeks, and creek buffers. Support actions of regional land trusts to protect areas through conservation easements. Encourage open space taxation and assessment.
BENEFITS:	Provides incentives and rewards for protecting riparian corridors and wetland areas. Increases voluntary compliance with regulations that will improve water quality.
COSTS:	Cost will depend on scale of program ***Interval:*** Ongoing

MAINTENANCE AND OPERATION

A program for maintaining the conveyance and storage capacity of natural drainageways or channels, constructed culverts and ditches, and detention/retention basins can reduce or prevent flood damages. This involves the following measures:

- Developing and implementing an inspection and maintenance plan for all drainageways; inspections of catch basins, drainage channels, detention facilities, and flow control structures
- Maintenance operations to clean catch basins, remove channel debris, clear culvert obstructions, remove sediment from detention facilities, plant vegetation to control channel erosion, remove intrusive vegetation to increase channel conveyance capacity, and remove trash
- Adopting stream dumping regulations and informing residents about the regulations and how to report violations
- Developing an erosion protection program for areas susceptible to streambank erosion or head cutting.

Implementation begins by creating and maintaining a complete drainage inventory. All drainage channels, stormwater control facilities, pipe networks, and natural channels should be inventoried and mapped. Based on the inventoried facilities, a maintenance plan can be developed. The plan should outline scheduled maintenance for each facility, clearly define who is responsible, outline reports to be used for inspection documentation, and detail what can and cannot be removed.

Implementation should also include the adoption of regulations to prohibit dumping debris in streams, or other floodplain areas. Public outreach programs (e.g., mailings and stream clean-up days) should be conducted to inform affected residents and explain how to report violations. "NO DUMPING" signs should be posted near problem areas.

MO-1 Ditch & Swale System Management
MO-2 Drainage System Standards
MO-3 Drainage Structure Cleaning
MO-4 Storm Response Standards
MO-5 Detention Basin Maintenance
MO-6 Roadside Stream Indicators

ACTION CATEGORY:	***MAINTENANCE & OPERATION***
NONPOINT SOURCE:	*Land Development*
MO - 1	***DITCH & SWALE SYSTEM MANAGEMENT***
PROBLEM / ISSUE:	Flooding, erosion, and sedimentation of ditches and swales caused by improper or inadequate ditch maintenance, increased runoff from development, and dumping of debris/waste into ditches/swales.
PROPOSED SOURCE CONTROL ACTION:	Routine removal of blockages to flow in ditches/swales and restoration of inverts. Review City policies and practices (coordinate with Snohomish County) to ensure maintenance includes the following: • A ditch/pipe inventory to identify ditches that can be converted to swales or swale/pipe systems • Performance standards for ditch and swale maintenance, including post-storm response (coordinate with MO - 2) • Ditch improvement plan
BENEFITS:	Reduces sediment and other contaminant loading through improved ditch/swale biofiltration, thereby improving downstream water quality. Establishes a systematic methodology to correct and prevent drainage problems. Reduces potential for localized flooding by eliminating blocked flow paths.
COSTS:	Inventory .... $30,000 ***Interval:*** One time Develop standards .... $5,000 ***Interval:*** One time Increased ditch/swale maintenance (annual)........$10,000 ***Interval:*** Ongoing

ACTION CATEGORY:	***MAINTENANCE & OPERATION***
NONPOINT SOURCE:	*Land Development*
MO - 2	***DRAINAGE SYSTEM STANDARDS***
PROBLEM / ISSUE:	Flooding caused by sedimentation and blockage of catchbasins and culverts Negative impacts of sediments and contaminant loading
PROPOSED SOURCE CONTROL ACTION:	Review and utilize Snohomish County maintenance standards for catchbasins, culverts, ditches, and detention facilities Incorporate Department of Ecology Operation and Maintenance Standards required under the Basin Stormwater Program.
BENEFITS:	Prevents failure of catchbasins and culverts Protects water quality by preventing sediment and other contaminant loading from improperly maintained systems Reduces the potential for flooding by preventing blocked flow paths
COSTS:	Develop standards .... $5,000 ***Interval:*** One time

ACTION CATEGORY:	*MAINTENANCE & OPERATION*
NONPOINT SOURCE:	*Land Development*
MO - 3	***DRAINAGE STRUCTURE CLEANING***
PROBLEM / ISSUE:	Flooding caused by sedimentation and blockage of catchbasins and culverts Negative impacts of sediments from land use washoff
PROPOSED SOURCE CONTROL ACTION:	Regular removal of sediments from catchbasins: • Initially, clean catch basins on an annual cycle • Clean catchbasins in flood-prone areas, or areas subject to higher sedimentation rates Remove sediments from underground detention tanks once a year. Inspect and, if necessary, clean storm systems, vaults, tanks, and culverts on a routine basis.
BENEFITS:	Reduces contaminant load and nutrient load, thereby improving water quality
COSTS:	Sediment removal operations (per day) .... $1,500 ***Interval:*** Catchbasins annually in the fall Dump fees per year (depending on location) .... $2,000 ***Interval:*** Annual Inspection .... $1,000 ***Interval:*** Annual

ACTION CATEGORY:	*MAINTENANCE & OPERATION*
NONPOINT SOURCE:	*Land Development*
MO - 4	***STORM RESPONSE STANDARDS***
PROBLEM / ISSUE:	Water quality degradation from oil, grease, or erosion Negative impacts of petroleum products and sediments from land use washoff
PROPOSED SOURCE CONTROL ACTION:	Develop and implement a plan for response during and following storms: • Inventory City oil/water separators • Identify critical storm events for oil/water separator cleaning • Following storms, remove oil/grease from key oil/water separators and inspect erosion-prone segments of ditches and creeks for damage • Cleaning should occur within 24 hours after storm events to prevent resuspension and emulsification of oils
BENEFITS:	Prevents resuspension and emulsification of oils and greases Provides immediate correction of small-scale, storm-related erosion Enhances and maintains water quality
COSTS:	Drainage system inventory .... $5,000 ***Interval:*** One time inventory Plan development .... $5,000 ***Interval:*** One time development Oil/grease removal per separator .... $1,000 - $3,000 ***Interval:*** Ongoing inspection and cleaning Cleaning per structure .... $1,000 - $2,000 ***Interval:*** Ongoing inspection and cleaning

ACTION CATEGORY:	***MAINTENANCE & OPERATION***
NONPOINT SOURCE:	*Land Development*
MO - 5	***DETENTION BASIN MAINTENANCE***
PROBLEM / ISSUE:	Flooding caused by sedimentation and blockage of detention facilities Negative impacts of sediments from land use washoff
PROPOSED SOURCE CONTROL ACTION:	Review existing detention-facility maintenance policies to ensure that the following are included: • Mow annually or remove vegetation at the end of the growing season • Remove clippings and vegetative wastes • Remove sediment on a once per 10-year cycle (or as needed) If revised policies for private detention facilities are needed, meet with owner to identify issues associated with maintenance and identify appropriate avenues for City involvement
BENEFITS:	Removes sediments, vegetation, and thus, phosphorus, thereby enhancing water quality Reduces total phosphorus loading for areas draining to retention/detention (R/D) facilities with additional reductions through modifications to R/D facilities
COSTS:	Dumping fees per pond .... $500 - $1,000 ***Interval:*** Maintain annually Pond maintenance per pond .... $500 - $2,000 ***Interval:*** Maintain annually

ACTION CATEGORY:	*MAINTENANCE & OPERATION*
NONPOINT SOURCE:	*Land Development*
MO - 6	***ROADSIDE STREAM INDICATORS***
PROBLEM / ISSUE:	Portions of creeks and waterways in roadside ditches may be degraded by applications of herbicide or vegetation removal during routine maintenance.
PROPOSED SOURCE CONTROL ACTION:	Work with maintenance crews to develop an appropriate sign, pavement marking, or other indicator to be placed at the beginning and ending of stream sections which have been routed along roadsides. Coordinate with maintenance crews to prevent application of pesticides or removal of vegetation along these stream sections.
BENEFITS:	Enhances and maintains water quality to support beneficial uses of the water. Protects the physical and biological integrity of wetlands, stream corridors, and fish and wildlife habitat.
COSTS:	Crew time (per sign) .... $500 ***Interval:*** Ongoing

PROGRAM MONITORING

In order to improve the City's surface water system, the initial conditions must be established as a comparative scale. The program monitoring strategies are an important part of determining point source pollutant loading, illicit connections to the storm drain system, and evaluating the methodology of monitoring.

On-site septic system inventory would provide important information to Mukilteo, which has numerous streams that could be affected by failing septic tanks. An inventory may already exist as part of the wastewater management system. Where possible, these residences should be connected to the City's sewer system in order to decrease the risk associated with individual septic systems.

M-1 Stream Walks
M-2 Drainage System Survey
M-3 Monitoring Strategies
M-4 On-site System Inventory

ACTION CATEGORY:	***PROGRAM MONITORING***
NONPOINT SOURCE:	*All Sources*
M - 1	***STREAM WALKS***
PROBLEM / ISSUE:	Negative impacts of oils, greases, pathogens, sediments, and other pollutants from land use washoff Erosion caused by increased channel velocities and volumes
PROPOSED SOURCE CONTROL ACTION:	Conduct stream walks to identify potential sites of pollutant loading, violation of regulations, and sites for stream enhancement projects. Solicit property owners along the creeks to participate in the surveys as a means of providing ongoing public education and watershed ownership.
BENEFITS:	Encourages local residents to participate in protection of water quality Identifies existing problem areas Provides an opportunity for public education and stewardship of the watershed Provides incentive to comply with regulations
COSTS:	Staff time / start up .... $1,000 ***Interval:*** Ongoing Stream walk sessions (per day costs) .... $500 ***Interval:*** Ongoing

ACTION CATEGORY:	*PROGRAM MONITORING*
NONPOINT SOURCE:	*Waste Disposal*
M - 2	***DRAINAGE SYSTEM SURVEY***
PROBLEM / ISSUE:	Illicit connections to the City's stormwater system can contribute to wastes in creeks or groundwater.
PROPOSED SOURCE CONTROL ACTION:	Conduct periodic drainage system surveys throughout the City to detect illegal connections.
BENEFITS:	Reduces loading of toxic substances to creeks, thereby improving water quality and aquatic habitat. Provides information on extent of problem Increases City authority to enforce control measures
COSTS:	Initial survey (coordinate with MO - 1) .... $10,000 ***Interval:*** One time inventory Semi-annual update .... $5,000 ***Interval:*** Semi-annual

ACTION CATEGORY:	*PROGRAM MONITORING*
NONPOINT SOURCE:	*All Sources*
M - 3	***MONITORING STRATEGIES***
PROBLEM / ISSUE:	Need to evaluate the effectiveness of management measures Negative impacts of land use runoff, agricultural practices, on-site waste disposal, and other watershed activities
PROPOSED SOURCE CONTROL ACTION:	Prepare and implement a citywide monitoring strategy to track the effectiveness of management measures. Coordinate with Department of Ecology's ambient water quality monitoring program.
BENEFITS:	Monitors/tracks the effectiveness of management measures Critical to the responsible use of financial resources in the watershed
COSTS:	Depends on extent of monitoring ***Interval:*** Ongoing

ACTION CATEGORY:	*PROGRAM MONITORING*
NONPOINT SOURCE:	*Waste Disposal*
M - 4	***ON-SITE SYSTEM INVENTORY***
PROBLEM / ISSUE:	Failing septic systems provide potential for hydraulic connection between surface waters and discharge from system. This may result in increased loading of nutrients and pathogens to groundwater and surface water.
PROPOSED SOURCE CONTROL ACTION:	On-site system inventory, to include: • Compile a list of property owners with on-site waste disposal systems. • Identify systems of concern with respect to proximity to surface waters and soil condition.
BENEFITS:	Reduces loading of nutrients, microbial pathogens, and toxic substances to creeks, thereby improving water quality and aquatic habitat Reduces occurrence of system failures through improved operation and maintenance, inspection, and enforcement Increases owner knowledge of system operation and maintenance and ways to improve treatment effectiveness Enhances owner understanding of water quality issues and the need for septic system maintenance
COSTS:	Inventory .... $10,000 ***Interval:*** One time study Inspection and enforcement (annual)................$10,000 ***Interval:*** Ongoing

REGULATORY / ENFORCEMENT

In a natural landscape, water reaches streams by varied and diverse paths. Some water may infiltrate to groundwater aquifers or may flow underground to the stream as interflow. The remainder of the surface runoff is slowed by vegetation or low gradients. Site development, by removing natural land cover and paving the surface, increases the volume and rate of runoff and decreases the time for water to reach the stream system. The cumulative effect of widespread development is that streams reach higher peak flows more quickly than before development, the total volume of runoff is increased, and the duration of flood events is increased, as is the frequency of their occurrence. This results in greater flooding, erosion, and aquatic habitat damage.

The objective of land use management, as part of an overall surface water management program, is two-fold. The first part is preventing land development or certain land use activities from adversely affecting the hydrologic and hydraulic characteristics of the drainage system. Preventing the filling of wetlands, which act as flow regulators to streams, is an example. The second part is preventing structures from being built in areas in natural drainage courses. To be effective, land use management measures should be supported at all levels of government, have an effective enforcement program, and be consistent throughout the basin.

Zoning codes can be used to prevent development or densities that could significantly affect the drainage system or water quality in a negative manner. The zoning code could be amended to require low-density development in sensitive drainage basins to minimize the impact of development. The zoning code could also be amended to concentrate development in areas where facilities can be economically provided without harming the environment.

Performance standards can also be used to minimize the negative impact of development. A Stormwater Management Ordinance is a performance-oriented ordinance, containing minimum performance and construction standards for developments. These ensure that all developments are constructed to minimize the impact on the environment and drainage facilities.

RE-1 Increased Enforcement
RE-2 Steep Slope Restrictions
(Mukilteo recently formalized these in their Site Sensitive Areas Ordinance)
RE-3 Clearing and Grading Ordinance
(Mukilteo is in the process of upgrading these requirements)
RE-4 Stormwater Management Ordinance

ACTION CATEGORY:	***REGULATORY / ENFORCEMENT***
NONPOINT SOURCE:	*Construction*
RE - 1	***INCREASED ENFORCEMENT***
PROBLEM / ISSUE:	Shortage of inspectors to investigate and cite drainage and water quality violations. Negative impacts from construction and related activities: • Increases flow volumes and velocities • Increases erosion and sedimentation • Hazardous substance spills
PROPOSED SOURCE CONTROL ACTION:	Amend regulations to increase enforcement authority • Ensure penalties for drainage and water quality violations provide for compensation commensurate with damages • Provide funding for additional staff person to carry out enforcement of regulations; enforcer's role is to cite violators • Coordinate with AD - 1 (Increased inspection and plan review)
BENEFITS:	Increases compliance with regulations through increased awareness of penalties and improved inspection/enforcement Increases staff authority & response to violations of construction water quality requirements
COSTS:	Depends on training and extent of amendments (existing authority) ***Interval:*** Provide changes as needed

ACTION CATEGORY:	***REGULATORY / ENFORCEMENT***
NONPOINT SOURCE:	*Land Development*
RE - 2	***STEEP SLOPE RESTRICTIONS***
PROBLEM / ISSUE:	Flooding and erosion of steep slopes caused by increased runoff from development • Increases runoff volumes • Concentrated flows • Increases erosion and reduces stability of the slopes
PROPOSED SOURCE CONTROL ACTION:	Increased building/development standards • Require a building setback from all steep slopes • Require a drainage plan for all construction • Require on-site detention • Require dispersion of runoff or piping to bottom of slope • Require additional engineering studies to ensure stability of structure and adequacy of drainage plan
BENEFITS:	Less stormwater is generated and more is intercepted naturally Structures and hillsides are more stable
COSTS:	Staff (annual) .... $5,000 ***Interval:*** As needed

ACTION CATEGORY:	***REGULATORY / ENFORCEMENT***
NONPOINT SOURCE:	*Construction*
RE - 3	***CLEARING AND GRADING ORDINANCE***
PROBLEM / ISSUE:	Negative impacts from excess clearing and grading, especially the vegetation in stream corridors: • Increases flow volumes and velocities • Increases erosion and sedimentation • Decreases water quality
PROPOSED SOURCE CONTROL ACTION:	Adopt a clearing and grading ordinance that includes the following: • Control the amount and location of clearing and grading on individual parcels • Minimize or eliminate the clearing of native vegetation in stream corridors and steep slopes
BENEFITS:	Storm flood peak are minimized and flooding is less likely to occur Maintains high water quality and reduces the amount of stream erosion Adopting buffers in steep slope areas helps to stabilize the slopes and limit future slides
COSTS:	Depends on extent of existing regulations ***Interval:*** Provide changes as needed

ACTION CATEGORY:	*REGULATORY / ENFORCEMENT*
NONPOINT SOURCE:	*Land Development*
RE - 4	***STORMWATER MANAGEMENT ORDINANCE***
PROBLEM / ISSUE:	Negative impacts from construction and related activities • Increase flow volumes and velocities, therefore increase the frequency and magnitude of floods • Erosion and sedimentation • Decrease water quality
PROPOSED SOURCE CONTROL ACTION:	Adopt a stormwater management ordinance that includes measures to mitigate development impacts such as requiring on-site detention/retention to reduce floods to at most the level that existed before development. Require developers to not increase the flood peaks associated with flows ranging from a 2-year storm event to a 100-year storm event
BENEFITS:	Reduces the affect of development on surface water using mitigation methods such as detention/retention: • Reduces increased flow volumes and velocities caused by development • Reduces the affect of development on erosion and sedimentation • Reduces the impact to water quality
COSTS:	Depends on the extent of existing regulations ***Interval:*** Provide changes as needed

WASTE CONTROL

Improper disposal of hazardous and toxic substances directly affects water quality and wildlife habitat. In the past, it was common practice to dump household waste such as motor oil over the side of a hill or in the brush. In order to prevent such actions now, it is important to provide proper disposal facilities for hazardous and toxic substances, for both private residents and businesses. Disposal of household chemicals and motor oil should be convenient and accessible to everyone throughout the City. This means there must be multiple locations or a mobile unit that consistently serves specific locations.

These waste disposal alternatives should be combined with public education in order to achieve high success. For example, a pamphlet could be created that describes the negative affects of improper disposal of household waste, then lists the locations of designated disposal sites so the public can use it as a reference.

WC-1 Oil Recycling Program
WC-2 Household Hazardous Waste Disposal Facility
WC-3 Organic Waste Disposal / Composting
WC-4 Vactor Waste Disposal
WC-5 Small Waste Generator Survey
WC-6 Deterrence of Illegal Waste Disposal

ACTION CATEGORY:	*WASTE CONTROL*
NONPOINT SOURCE:	*Waste Disposal*
WC - 1	***OIL RECYCLING PROGRAM***
PROBLEM / ISSUE:	Improper disposal of used motor oil can contribute toxic substances to nearby creeks
PROPOSED SOURCE CONTROL ACTION:	Increase availability of recycling centers throughout watershed and arrange for collection and maintenance Advertise location and promote use Coordinate with Snohomish County and/or surrounding cities
BENEFITS:	Reduces loading of toxic substances to creeks, thereby improving water quality and aquatic habitat Increases public understanding and awareness of water quality issues Reduces incidence of improper waste disposal practices due to ignorance
COSTS:	Staff time, per year .... $2,000 ***Interval:*** Ongoing

ACTION CATEGORY:	*WASTE CONTROL*
NONPOINT SOURCE:	*Waste Disposal*
WC - 2	***HOUSEHOLD HAZARDOUS WASTE DISPOSAL FACILITY***
PROBLEM / ISSUE:	Improper chemical storage and waste disposal can contribute toxic substances to nearby creeks and streams.
PROPOSED SOURCE CONTROL ACTION:	Develop a facility for drop-off of household hazardous wastes and continue local "round up" events Provide a mobile collection van to routinely visit designated areas within the City Coordinate with Snohomish County and adjacent cities
BENEFITS:	Reduces loading of toxic substances to creeks, thereby improving water quality and aquatic habitat Increases public understanding and awareness of water quality issues Reduces incidence of improper waste disposal practices due to ignorance
COSTS:	Equipment (van) .... Depends on coordination efforts ***Interval:*** One time Staff time, per year .... Depends on coordination efforts ***Interval:*** Ongoing Dumping fees .... Depends on coordination efforts ***Interval:*** Ongoing

ACTION CATEGORY:	*WASTE CONTROL*
NONPOINT SOURCE:	*Waste Disposal*
WC - 3	***ORGANIC WASTE DISPOSAL / COMPOSTING***
PROBLEM / ISSUE:	Improper disposal of yard wastes, organic debris, and leaves in creeks, ditches, ravines, or wetlands creates nutrient loading problems
PROPOSED SOURCE CONTROL ACTION:	Investigate innovative waste reduction techniques to reduce the amount of organic wastes generated (i.e., mulching mowers). Utilize existing haulers to remove waste to permitted composting sites Encourage the use of curbside pickup of yard debris Educate the public about backyard composting through distribution of brochures and presentations by master recyclers/composters. Establish a composting demonstration site in the City. Publicize it and hold workshops on composting there.
BENEFITS:	Reduces external loading, thereby improving water quality and aquatic habitat Provides for re-use of grass, leaves, and vegetation waste from maintenance operations Protects natural stormwater conveyance and storage systems Increases neighborhood involvement and education about water quality management
COSTS:	Program development .... $8,000 ***Interval:*** One time Staff time, per year .... $1,000 ***Interval:*** Composting annually thereafter (April - September)

ACTION CATEGORY:	*WASTE CONTROL*
NONPOINT SOURCE:	*Waste Disposal*
WC - 4	***VACTOR WASTE DISPOSAL***
PROBLEM / ISSUE:	Improper disposal of vactor waste can pollute surface waters
PROPOSED SOURCE CONTROL ACTION:	Work with Ecology to develop an appropriately scaled treatment and disposal system for vactor waste that meets emerging regulations, such as a decant/treatment station Educate the handlers about responsible waste handling
BENEFITS:	Protects surface water resources from potential hazardous pollutants
COSTS:	Decant/treatment station .... $10,000 to $50,000 ***Interval:*** One-time Proper disposal practices.........Depends on coordination efforts ***Interval:*** Ongoing

ACTION CATEGORY:	*WASTE CONTROL*
NONPOINT SOURCE:	*Waste Disposal*
WC - 5	***SMALL WASTE GENERATOR SURVEY***
PROBLEM / ISSUE:	Improper disposal of hazardous wastes can pollute surface and groundwater Small hazardous waste generators are not well regulated
PROPOSED SOURCE CONTROL ACTION:	Investigate potential waste generators through a door-to-door survey. Medical facilities, photo laboratories, dry-cleaners, funeral parlors, and service stations should be included in the survey. Coordinate with the local Health Department and the Department of Ecology to establish guidelines for each business. Educate the proprietors about responsible waste handling
BENEFITS:	Protects surface water and groundwater resources from potential hazardous materials. Increase public awareness about water quality management.
COSTS:	Survey .... $10,000 ***Interval:*** Every four years

ACTION CATEGORY:	*WASTE CONTROL*
NONPOINT SOURCE:	*Waste Disposal*
WC - 6	***DETERRENCE OF ILLEGAL WASTE DISPOSAL***
PROBLEM / ISSUE:	Illegal waste disposal can contribute toxic substances to nearby streams
PROPOSED SOURCE CONTROL ACTION:	Meet with Department of Ecology and adjacent communities to coordinate efforts to develop and implement a plan to prevent illegal waste disposal.
BENEFITS:	Reduces loadings of toxic substances to streams, thereby improving water quality and aquatic habitat. Increases public understanding and awareness of water quality issues. Reduces incidence of improper waste disposal practices due to ignorance. Increases City authority to enforce control measure
COSTS:	Plan development .... $5,000 ***Interval:*** One time Program implementation .... $1,000 ***Interval:*** Ongoing

PUBLIC EDUCATION

Past actions of City residents have had significant effects on habitat and water quality within all the ravines, streams, and wetlands of Mukilteo. Many harmful activities, such as filling of natural drainage courses, removal of streamside vegetation, or disposal of used oil and household chemicals into storm drains, occur because residents do not understand the consequences of their actions. Reporting of illegal activities by both citizens and City staff may be hindered because of unfamiliarity with procedures for reporting such problems and the past lack of enforcement of existing regulations.

A surface water education program for Mukilteo residents and City staff to improve public knowledge of and participation in solutions to surface-water-related problems would help to reduce these problems. The program could provide information on topics such as the following:

- Stream and riparian ecology and citizens' roles in protecting the environment
- Reduction of pollution from non-point sources
- Code requirements and the rationale behind them
- Best management practices for surface water control.

An excellent reference for public education guidance is the *Stormwater Program Guidance Manual for the Puget Sound Basin* published by the Department of Ecology (1992). There is an entire chapter devoted to public education that includes appendices. The chapter provides valuable information such as developing a plan and getting the message out.

Public awareness is a critical aspect of environmental protection and citizen participation. Peer pressure can be very effective in preventing many problems, and a better educated public can also develop into an effective interest group for solving or preventing surface water problems.

PIE-1 Voluntary Ditch Maintenance
PIE-2 BMP Brochure & Manual for Residents and Proprietors
PIE-3 Annual Creek Clean-up Days
PIE-4 Citizen Advocate Training
PIE-5 Questionnaire
(Mukilteo recently completed – see end of Chapter 3)
PIE-6 Contractor Training / Certification
PIE-7 Catchbasin Stenciling
PIE-8 Resource List

ACTION CATEGORY:	***PUBLIC INVOLVEMENT & EDUCATION***
NONPOINT SOURCE:	*Land Development*
PIE - 1	***VOLUNTARY DITCH MAINTENANCE***
PROBLEM / ISSUE:	Degradation of portions of creeks and tributaries in roadside ditches
PROPOSED SOURCE CONTROL ACTION:	Institute voluntary ditch maintenance programs, which include preparation of informational materials and training workshops that address minimum maintenance requirements, safety precautions, and maintenance that will still be required of jurisdictional maintenance staff. Form an Adopt-A-Ditch program
BENEFITS:	Prevents destruction of ditch and swale vegetation required for biofiltration Reduces sediment and other contaminant loading through biofiltration, thereby improving downstream water quality Reduces loading of toxic substances to creeks, thereby improving water quality and aquatic habitat Increases public understanding and awareness of water quality issues
COSTS:	Startup cost .... $5,000 ***Interval:*** One time Staff time .... $1,000 ***Interval:*** Inspect & maintain annually during dry months

ACTION CATEGORY:	***PUBLIC INVOLVEMENT & EDUCATION***
NONPOINT SOURCE:	*Land Development*
PIE - 2	***BMP BROCHURE & MANUAL FOR RESIDENTS AND PROPRIETORS***
PROBLEM / ISSUE:	Lack of information among City residents and proprietors about best management practices (BMPs) and City resources, which often results in water quality degradation.
PROPOSED SOURCE CONTROL ACTION:	Develop brochures, newsletters, and newspaper articles in conjunction with Snohomish County and neighboring cities, and distribute them at regular intervals throughout the year to watershed residents and businesses. Watershed Water Quality Hotline .... Weekly or Monthly Composting and Yard Waste Handling .... Spring Fertilizing Practices and Pesticide Use .... Spring Voluntary Ditch Maintenance Program....................... Spring Ditch Maintenance .... Fall Ditch Safety .... Winter Boat Maintenance.. Spring and Fall Automobile Operation/Oil Recycling/Washing .... Quarterly Proper Pet Waste Disposal .... Quarterly Waterfowl Feeding .... Quarterly Hazardous Household Waste Disposal .... Semi-Annually Construction/Remodeling/Painting .... Semi-Annually Sensitive Area Protection .... Semi-Annually Stream-Side Household Guideline .... Annually Develop a general BMP reference manual and distribute to each resident as a practical guide on the responsibilities of watershed residents for watershed quality (coordinate with Snohomish County Surface Water Management and PC Conservation District).
BENEFITS:	Identifies resources for information and assistance associated with watershed protection Increases public understanding of what they can do to help water quality in the watershed
COSTS:	Initial development of manual.............................. $20,000 ***Interval:*** One time Printing .... $1,000 ***Interval:*** Ongoing Article update .... $1,000 ***Interval:*** Annual

ACTION CATEGORY:	***PUBLIC INVOLVEMENT & EDUCATION***
NONPOINT SOURCE:	*All Sources*
PIE - 3	***ANNUAL CREEK CLEAN-UP DAYS***
PROBLEM / ISSUE:	Organic debris and garbage in creeks and ditches impedes drainage and increases contaminant loading to surface waters.
PROPOSED SOURCE CONTROL ACTION:	Organize volunteer groups and/or high school students to remove debris and provide general clean-up of the watershed streams on an annual basis. Coordinate efforts with regional and local political figures to broaden awareness among different sectors of the watershed residents. Coordinate efforts with Adopt-A-Stream program and Department of Fish and Wildlife.
BENEFITS:	Reduces pollutant loading from the watershed, thereby improving water quality Provides opportunity to expand the public advocacy group by combining education and "hands-on" experience
COSTS:	Dumping fees .... \$2,000 - \$5,000 ***Interval:*** Seasonal Staff time to set up (~40 hours) .... \$2,000 ***Interval:*** Review & update annually Staff time/clean-up day (per day) .... \$1,500 ***Interval:*** Annual clean-up occurring June through September

ACTION CATEGORY:	***PUBLIC INVOLVEMENT & EDUCATION***
NONPOINT SOURCE:	*All Sources*
PIE - 4	***CITIZEN ADVOCATE TRAINING***
PROBLEM / ISSUE:	A corps of volunteers may be used to supply a representative for each basin in the watershed to address ongoing water quality issues
PROPOSED SOURCE CONTROL ACTION:	Provide a three-day training for a small group of individuals and/or teachers on water quality issues for each drainage basin and the role of citizen advocacy in the ongoing stewardship of the basins. Topics and activities should include the following: • Field trips to examine losses associated with unmanaged watershed development • Fish habitat protection or restoration • Overview of government processes • Coordinate with Adopt-A-Stream Foundation efforts
BENEFITS:	Provide watershed residents with a trained understanding of water quality issues
COSTS:	Staff time to develop class .... $10,000 ***Interval:*** One time Staff time to lead class .... $5,000 ***Interval:*** Ongoing

ACTION CATEGORY:	*PUBLIC INVOLVEMENT & EDUCATION*
NONPOINT SOURCE:	*All Sources*
PIE - 5	***QUESTIONNAIRE***
PROBLEM / ISSUE:	Need to evaluate the effectiveness of management measures Negative impacts of land use runoff, on-site waste disposal, and other watershed activities.
PROPOSED SOURCE CONTROL ACTION:	Prepare and circulate a questionnaire to track trends in public awareness and public involvement in watershed water quality protection. Distribute to watershed residents on a two- to five-year basis
BENEFITS:	Provides public understanding of watershed issues and encourages changes in behavior to positively impact watershed water quality
COSTS:	Develop questionnaire .... $3,000 ***Interval:*** One time Distribute and analyze results (per event) .... $10,000 ***Interval:*** Every two to five years

ACTION CATEGORY:	*PUBLIC INVOLVEMENT & EDUCATION*
NONPOINT SOURCE:	*Hazardous Substance Spills*
PIE - 6	***CONTRACTOR TRAINING / CERTIFICATION***
PROBLEM / ISSUE:	Negative impacts from construction and related activities • Increase flow volumes and velocities • Erosion and sedimentation • Hazardous substance spills
PROPOSED SOURCE CONTROL ACTION:	Contractor training and certification • Provide a mechanism for ensuring that qualified contractors, developers, and engineers are involved in projects that impact surface water quantity and/or quality. • Teach contractors/developers to use the Department of Ecology's *Stormwater Management Manual* so that projects have minimal impact on water quantity and quality. • Coordinate with Snohomish County and Department of Ecology
BENEFITS:	Increases compliance with construction regulations through increased contractor understanding of drainage and surface water issues and through improved inspection/enforcement.
COSTS:	Inspector time (per class) .... $1,000 ***Interval:*** Ongoing

ACTION CATEGORY:	***PUBLIC INVOLVEMENT & EDUCATION***
NONPOINT SOURCE:	*Hazardous Substance Spills*
PIE - 7	***CATCHBASIN STENCILING***
PROBLEM / ISSUE:	Degradation of water quality due to accidental or intentional spillage of hazardous substances into surface water systems such as catchbasins
PROPOSED SOURCE CONTROL ACTION:	Stencil catchbasins with: DRAINS TO STREAM DUMP NO POLLUTANTS
BENEFITS:	Reduces loading of toxic substances to streams, thereby improving water quality and aquatic habitat Increase public understanding and awareness of water quality issues
COSTS:	Staff time (annual) (stenciling by volunteers) .... $1,500 ***Interval:*** Ongoing (April - October) Materials, per year .... $500 ***Interval:*** Ongoing

ACTION CATEGORY:	***PUBLIC INVOLVEMENT & EDUCATION***
NONPOINT SOURCE:	*All Sources*
PIE - 8	***Resource List***
Stormwater Program Guidance Manual for the Puget Sound Basin Volume 2 (1992)	This manual is an essential resource and should be the first place to look for public education guidance. The 64-page section on public education provides an excellent reference for basic information on setting up and implementing a successful public education program. There is also over 100 pages of appendix that includes numerous public education program examples. Also included with most of the program examples is a contact name.
Clean Water, Streams and Fish: A Holistic View of Watersheds	Washington State Office of Environmental Education has produced a curriculum looking at all aspects of water quality and fish life. This resource provides a comprehensive curriculum of lessons and activities on salmon, water quality, stream ecology and environmental impacts by humans. Available for both elementary and secondary levels. Curriculum is $18. Contact: Office of Environmental Education; 2800 NE 200th; Seattle, WA 98155. Phone: (206) 365-3893.
Storm Drain Marking Video	A video that shows children marking storm drains. The video has a musical theme and an upbeat style. 2 1/2 minutes. Distributed by: B.C. Teachers Federation, Lesson Aids Service; 2235 Burrard Street; Vancouver, BC B6J 3H9. Phone: (604) 731-8121.
Give Water a Hand Program	Give Water a Hand is national watershed education program designed to involve young people in local environmental service projects. The Washington State contact is Jerry Newman at Washington State University. Phone: (509) 335-2800. For more information go to the following website: http://www.uwex.edu/erc/index.html
Adopt Your Watershed Program	EPA is leading an "Adopt Your Watershed" campaign to encourage stewardship of the nation's water resources. ***There is an existing program in Mukilteo called Big Gulch Watershed Keepers who "conduct a citizen watch, participate in land use policy and environmental education, and work to protect the Northwest way of life." The contact for this group is John Jacobson. Phone: (425) 363-2346.
Adopt-a-Stream Program	The Adopt-a-Stream Foundation is an environmental education and habitat restoration organization, whose goal is to assist people in becoming actively involved in stream enhancement and environmental education. *Adopting a Stream: A Northwest Handbook* by Steven Yates is an informative handbook that is complete with fun activities, for monitoring streams and wetlands. *The Stream Keepers Field Guide* is another good resource for citizens. Phone for Snohomish County Adopt-a-Stream: (425) 316-8592.

ACTION CATEGORY:	*PUBLIC INVOLVEMENT & EDUCATION*
NONPOINT SOURCE:	*All Sources*
PIE - 8	***Resource List***
Institutional Aspects of Urban Runoff Management: A Guide for Program Development and Implementation (1997)	Published by the Watershed Management Institute, Inc., this manual presents a comprehensive review of the institutional frameworks of successful urban runoff management programs. It was developed to assist individuals responsible for developing and implementing urban erosion, sediment control, and stormwater management programs. The book includes summaries of 32 successful state, regional, county, and municipal urban runoff programs. These include information about the programs legal and institutional framework, goals, performance standards, design criteria, staffing, budget, inspection and compliance processes, and public education efforts. Contact: Eric Livingston (850) 926-5310. Order form available at: http://www.epa.gov/OWOW/NPS/education/manual.html
Teaching Ecology in Urban Environments (1995)	This resource discusses ecological and environmental education in urban environments by means of field trips to city parks, airports, nuclear power plants, water treatment plants, sewage treatment plants, incinerators, foundries, and forests. Author: Joseph Fail, Jr.
Landscaping for Wildlife in the Pacific Northwest (1999)	This informative resource provides a guide for selecting, arranging, and maintaining plants and other landscape elements that fulfill wildlife needs. It is written for homeowners, property owners, professional wildlife managers, landscape architects, and garden designers. Author: Russell Link who is a wildlife biologist with the Washington Department of Fish and Wildlife. (It is available through the Washington Department of Fish and Wildlife or most bookstores.)
EPA Office of Water: Nonpoint Source Pointers (Factsheets)	EPA created a series of factsheets designed to help the public increase their understanding and management of nonpoint source pollution in their community. The factsheets are available at the following website: http://www.epa.gov/OWOW/NPS/facts/
An Inventory of Environmental Education Programs for Youth in the Central Puget Sound Region (2000)	This directory, compiled by the Puget Sound Regional Council, provides a central resource for identification of a wide range of environmental programs available to youth in the Puget Sound region. Contact the Puget Sound Regional Council Information Center, Phone: (206) 464-7532. The publications list is also available at the following website: http://www.infoctr@psrc.org/datapubs/pubs/index.htm

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APPENDIX A.

OUTFALL INVENTORY INFORMATION

The following table summarizes the culvert information gathered during two field visits to the City of Mukilteo. Selene Fisher and Cindy Callan performed the first visit on September 8, 1999 and Sherman Klaus and Cindy Callan did the second on September 9, 1999.

A total of 32 culverts and one concrete channel containing discharge from an unmarked building were inventoried. The shore was inaccessible along the U.S. Department of Defense property on the north shore between the ferry terminal and Japanese Gulch, therefore, no culvert information was gathered for that portion of the City. Information was gathered by walking along the beach at low tide, photographing each culvert and measuring the diameter with a tape measure (no GPS equipment was used). With the aid of topographic maps locations of stream outfall culverts were more accurate to determine than the track drainage culverts that had no distinguishing features. Most of the topography along the Mukilteo shoreline is dense trees with railroad tracks along most of the west, which made it difficult to determine exact locations of some of the dry or abandoned culverts. The approximate location of the non-distinct culverts was determined as a relative distance from a known position.

The culverts were numbered from north to south and correspond to photos taken during the field visits. Approximate locations are described in the spreadsheet and hand drawn on a large map that will eventually be digitized. Invert elevations were approximated from evidence of high tide such as barnacles and algae.

TABLE A-1
OUTFALL INVENTORY FOR CITY OF MUKILTEO

Culvert #	Size	Type	Approx. Invert	Approx. Location	Comments
1	--	--	--	North shore; just west of U.S. Dept. of Defense property	Concrete channel with discharge water from building; not a fish issue
2	24"	RCP	-2'	North of Park Ave.	Outfall of Brewery Creek. 2/3 full of sand and protrudes from the beach. The creek travels underground to 2nd Ave., possible fish passage.
3	18"	RCP	5'	West of 4th St.	Plugged
4	18"	RCP	3'	West of 5th St.	Track drainage
5	24"	RCP	6'	West of 8th St.	Track drainage
6	36"	RCP	0'	West of 11th St.	Outfall of Goat Trail Ravine. 1/3 blocked by huge rocks. Possible fish passage.
7	36"	RCP	5'	West of 13th St.	Track drainage
8	36"	RCP	3'	West of 16th Pl.	Track drainage
9a	24"	RCP	4'	West of Clover Ln.	Additional stream outfall (see culvert #10), elevation prevents fish passage
9b	24"	RCP	4'	West of Clover Ln.	Additional stream outfall (see culvert #10), elevation prevents fish passage
10	36"	RCP	5'	West of Clover Ln.	Main stream outfall, elevation prevents fish passage
11	18"	RCP	6'	West of 75th St. SW	Track drainage
12	36"	RCP	4'	West of 76th St. SW	Outfall of Unnamed Ravine, elevation and distance from high tide prevents fish passage
13	18"	RCP	0'	North of houses along shoreline	Could be outfall to small stream? May be fish passable depending on characteristics of flow through outfall.
14	48"	RCP	0'	In the middle of the houses along the shoreline	Outfall of Naketa Beach ravine. Not fish passable
15	32"	RCP	0'	West of 84th St. SW	Could be outfall to small stream? May be fish passable.
16	18"	RCP	4'	West of 85th Pl. SW	Could be outfall to small stream? Not fish passable.
17	24"	RCP	0'	West of 90th Pl. SW	Drains detention pond that receives water from Smuggler's Gulch ravine, may be fish passable.

TABLE A-1
OUTFALL INVENTORY FOR CITY OF MUKILTEO

Culvert #	Size	Type	Approx. Invert	Approx. Location	Comments
18	24"	RCP	0'	West of 90th Pl. SW	Drains detention pond that receives water from Smuggler's Gulch ravine, may be fish passable.
19	27"	RCP	2'	Southwest of 92nd St. SW	Could be outfall to small stream?
20	24"	CMP	5'	West of 93rd Pl. SW	Abandoned? Track drainage.
21	60"	CMP	0'	West of 96th St. SW, near treatment plant	Outfall of Big Gulch Ravine, appears to be fish passable.
22	30"	RCP	10'	1200' south of Big Gulch Outfall	Outfall of storm water drainage along Marine View Dr., no fish issue
23	18"	RCP	5'	West of Webster Way	Abandoned? Track drainage.
24	36"	CMP	0'	West of Canyon Dr.	Outfall of detention pond, no fish issue
25	24'	RCP	1'	West of Chennault Beach Dr.	Outfall of Upper Chennault Creek, may be fish passable
26	24"	CMP	5'	500' south of Upper Chennault Cr.	Track drainage
27a	42"	CMP	2'	Southwest of Harbour Heights Parkway	Outfall 1 of 2 of Lower Chennault Creek, may be fish passable (depending on flows)
27b	42"	CMP	2'	Southwest of Harbour Heights Parkway	Outfall 2 of 2 of Lower Chennault Creek, may be fish passable (depending on flows)
28	24"	CMP	5'	500' south of Lower Chennault Cr.	Abandoned? Track drainage.
29	18"	RCP	5'	West of St. Andrews Dr.	Drains hillside
30	24"	RCP	3'	On southern boundary of City limits	Outfall of Hulk Creek, may be fish passable

APPENDIX B.

DETENTION POND INVENTORY

TABLE B-1
DETENTION POND INVENTORY

No	Id	Owner	Plat	Lot/Tract	Address	Comments	Type	Maint
1	P280409XX	Private			8216 49th Ave W	Not working	Pipe	
2					46th Pl W			
3					88th St / 53rd	Daffron		
4			Elliot Pointe			Weir (not working)	Pond	
5			Filbert Estates		80th			
6			Halverson Estates					
7					5232 88th St Sw			
8			Mariner Heights		73rd / 48th Ave		Pipe	
9			Mukilteo Estates		88th			
10					Mukilteo Elem. School 70th		Pond	
11					Mukilteo Water Dist. 44th / 84th			
12					8505 Naketa Beach			
13			Island Vista		Clover Court		Pipe	
14			Olympic View Heights #2					
15			Olympic View Heights #3					
16	P280404XX	Private	Randolph Sp		8th Drive		Pond	•
17	280409XX	City?	Sunnyside Park		Washington		Pipe	
18	280416XX	City	Trophy Hillcrest	LOT 6	9000 50th Pl W		Pond	1998
19			Puget Sound Hills	LOT 1				
20			Puget Sound Hills	-	71st Pl Sw @ 48th Ave W			
21		Private	Vierthaler Sp		15th Pl @ Sr525			
22		City?	Westwood Lane					
23		City	Whisperwood West		8920 46th Pl W		Pond	1998
24		City?	Windsong Vista Ii					
25		City?	Windsong Vista Iii					
26	28041601	City	Mohalo	LOT 52	9539 57th Ave W		Vault	
27	28041602	City	Matiko	LOT 23	9558 55th Ave W		Vault	
28					501 Clover Lane	??		
29					91st & 49th Ave			
30	P280416XX	Private			84xx Mukilteo Speedway	Taco bell	Pipe	
31		City?			Clover Lane		Pipe	
32		Private?			48th South Of 84th		Pond	

TABLE B-1
DETENTION POND INVENTORY

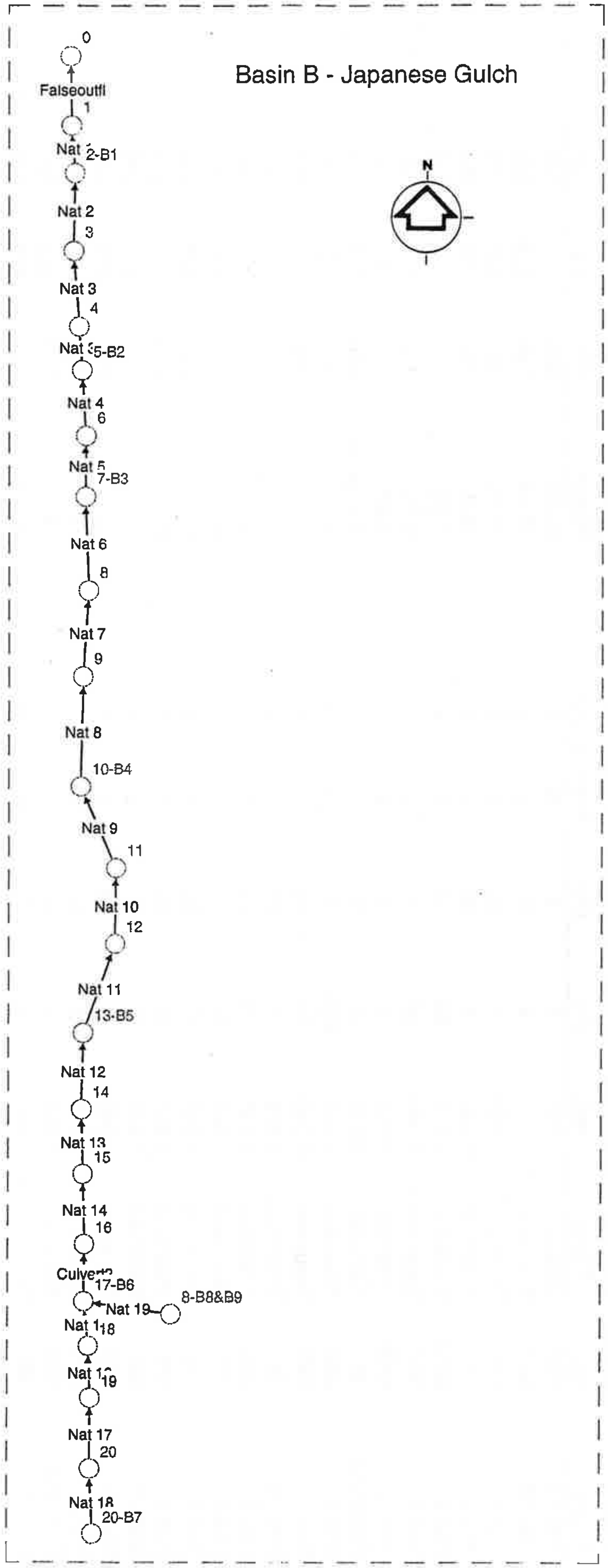
No	Id	Owner	Plat	Lot/Tract	Address	Comments	Type	Maint
33		Private			10801 H P Blvd	Kamiak high school	Pond	
34		Private			5000 H P Blvd	H p middle school	Pond	
35		City	Harbour Lane		10624 53rd Ave W	Esmt in back of lots	Pond	1998
36		City			59th Ave W @ Canyon Drive		Pond	
37		City			107th Pl Sw @ Chennault Bch Dr			
38		City	Harbour Pointe Secxx Divxx		116th St	@ Awd pump station	Pond	
39		City	Harbour Pointe Secxx Divxx		Clearview @ 116th St		Pond	
40		City	Harbour Pointe Secxx Divxx		6100 128th St Sw		Vault	
41		City?	Bayview Estates		46th Ave W North Of 84th			
42		City?	Harbour Pointe Sector 13		11600 H P Blvd	Big lake	Pond	
43		Private?	Harbour Pointe Sector 16		Golf Course	Golf course weirs	Ponds	
44		Private?	Harbour Pointe Sector 15		Harbour Reach Dr @ Harbour Pointe Blvd Sw	Pond "m"	Pond	
45		City	Harbour Pointe Sector 7				Pond	
46		Private	Harbour Pointe Sector 20			Boeing	Ponds	
47		City			4900 H P Blvd Sw	In street	Pipe	
48		City			5100 H P Blvd Sw	In street	Pipe	
49		City			12300 H P Blvd Sw	In street	Pipe	
50		Private			3701 South Road		Pond	
51		Private			11900 Cyrus Way	H p shopping center	Pond	
52		Private			11700 Mukilteo Speedway	H p shopping center	Pond	
53		Private			11500 Cyrus Way		Pond	
54		City	Harbour Pointe Sec 9 Divxx		10900 53rd Pl W	Tatoosh wetlands	Pond	
55		City	Harbour Pointe Sec 9 Divxx		10800 53rd Pl W	Tatoosh wetlands	Pond	
56		Private	Harbour Heights		12700 49th Ave W	In street	Pipe	
57		Private	Harbour Heights	Tract 504	13100 Harbour Hts Dr		Pond	
58		Private	Harbour Heights		4200 130th Pl Sw		Pond	

TABLE B-1
DETENTION POND INVENTORY

No	Id	Owner	Plat	Lot/Tract	Address	Comments	Type	Maint
Additional facilities from 1993 Report								
59			Waterford Park		127th St SW	2 det/open spaces	Pond	
60			Waterford Park		127th St SW	2 det/open spaces	Pond	
61			Possession Bay Highlands		Harbour Heights Drive	2 det/open spaces	Pond	
62			Possession Bay Highlands		Harbour Heights Drive	2 det/open spaces	Pond	
63			One Club House Lane		End Of Double Eagle Drive	47,000 cf	Vault	
64			Waterford Park		53rd Place SW	17,000 cf	Vault	
65			Waterford Park		126th Street SW	16,000 cf	Vault	
66			Harbour Point Blvd			173' of 57" x 38" CMPA, 212' of 30" CMP	Pipe	
67			Harbour Point Blvd			155' of 30" CMP	Pipe	
68			Harbour Point Blvd			145' of 60" CMP	Pipe	
69			Waterford Park		55th Place W	124' of 84" CMP	Pipe	

APPENDIX C.

STORMWATER INVENTORY DATA FROM XP-SWMM MODELS


Basin B - Japanese Gulch
N
0
Falseoutfl
1
Nat
2-B1
Nat 2
3
Nat 3
4
Nat
5-B2
Nat 4
6
Nat 5
7-B3
Nat 6
8
Nat 7
9
Nat 8
10-B4
Nat 9
11
Nat 10
12
Nat 11
13-B5
Nat 12
14
Nat 13
15
Nat 14
16
Culve
17-B6
Nat 19
8-B8&B9
Nat 1
18
Nat
19
Nat 17
20
Nat 18
20-B7

Modeled Drainage System Inventory

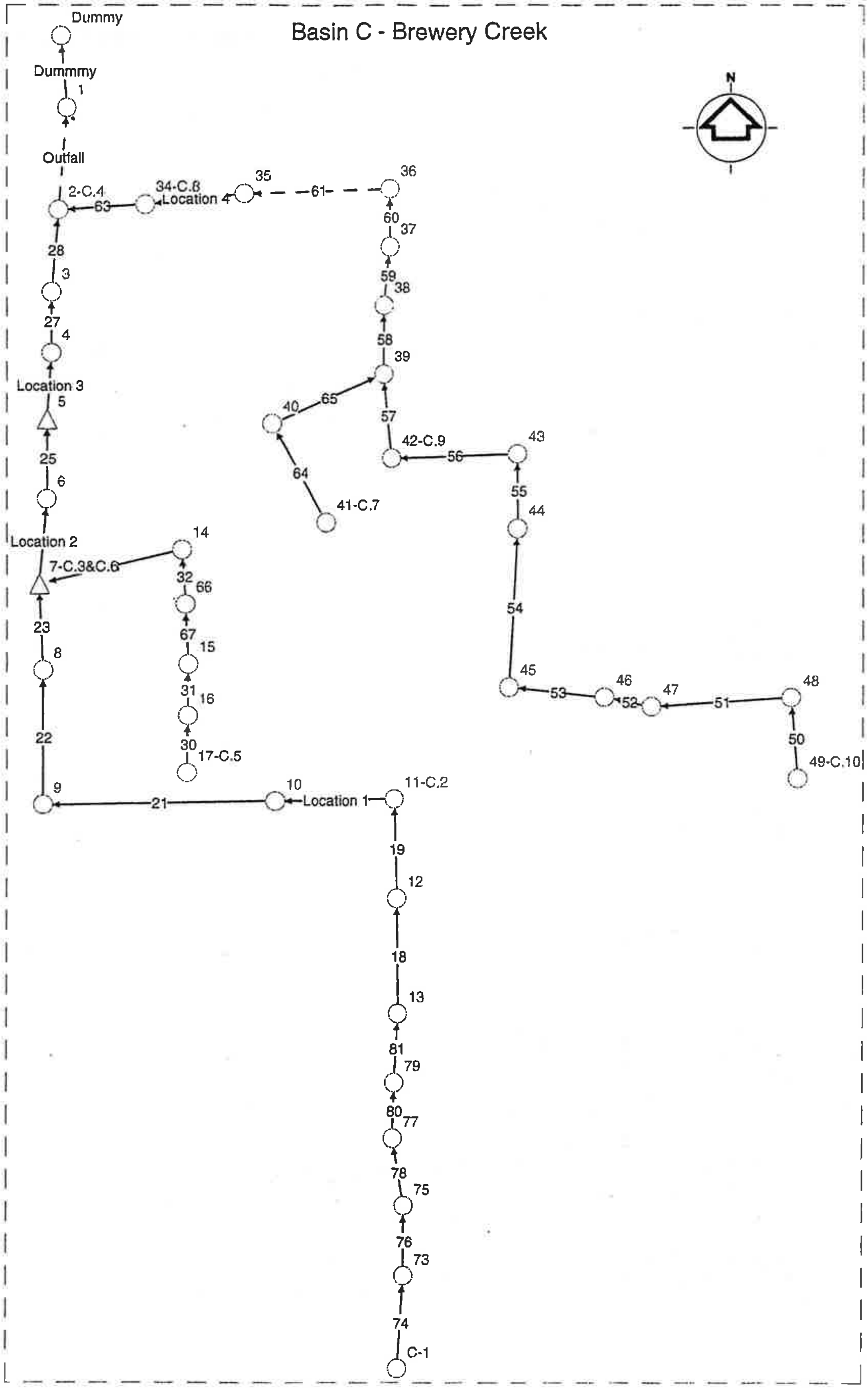
BASIN B

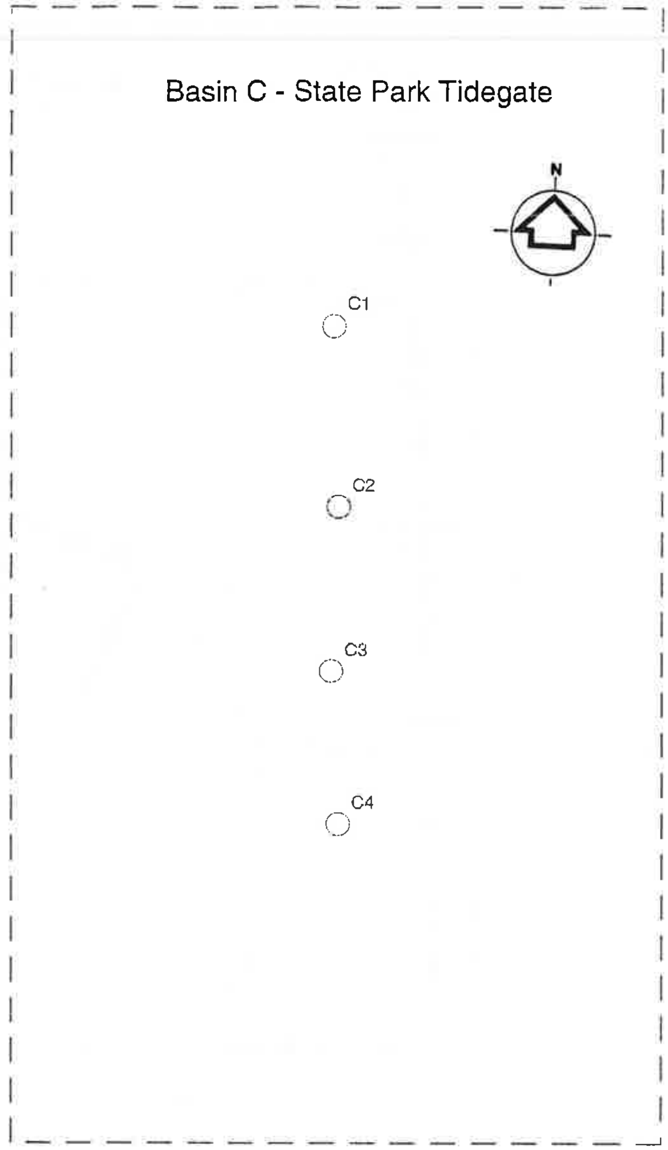
REACH INVENTORY

Reach Name	Length (ft)	Conduit Class	Manning Coef.	Max Width (ft)	Depth or Diameter (ft)	Trapezoid Side Slopes	
Nat 15	800	Trapezoid	0.045	5	5	20	20
Nat 12	800	Trapezoid	0.045	5	10	2	2
Nat 9	1000	Trapezoid	0.045	5	20	2	5
Nat 6	760	Trapezoid	0.045	5	20	2	2
Nat 4	1000	Trapezoid	0.045	50	10	5	5
Nat 2	550	Trapezoid	0.045	20	4	12.5	12.5
Nat 19	1000	Trapezoid	0.045	2	5	2	2
Falseoutfl	50	Circular	0.014	6	6		
Nat 1	300	Trapezoid	0.045	100	6	14	14
Nat 3	250	Trapezoid	0.045	10	20	5	5
Nat 3a	50	Trapezoid	0.045	5	20	5	5
Nat 5	550	Trapezoid	0.045	10	10	5	5
Nat 8	1000	Trapezoid	0.045	5	20	5	5
Nat 7	600	Trapezoid	0.045	5	20	2	2
Nat 11	680	Trapezoid	0.014	5	10	3	3
Nat 10	800	Trapezoid	0.045	5	10	2	2
Nat 14	600	Trapezoid	0.045	5	10	4	4
Nat 13	1000	Trapezoid	0.045	5	10	5	5
Culvert2	300	Circular	0.014	5	5		
Nat 18	700	Trapezoid	0.045	5	5	10	10
Nat 17	1000	Trapezoid	0.045	5	5	10	20
Nat 16	1000	Trapezoid	0.045	5	5	20	20

NODE INVENTORY

Node Name	Ground Elev. (ft)	Crown Elev. (ft)	Invert Elev. (ft)
20-B7	570	567	562
17-B6	540	525	520
13-B5	428	418	408
10-B4	314	314	294
7-B3	150	150	130
5-B2	112	112	92
2-B1	28	24	18
8-B8&B9	556	541	536
0	25	22	16
1	30	23.5	17.5
3	70	70	50
4	110	110	90
6	118	108	98
8	230	230	210
9	254	254	234
11	376	376	356
12	412	402	392
14	456	446	436
15	510	500	490
16	520	520	510
18	566	561	556
19	578	563	558
20	570	565	560


Basin C - Brewery Creek
N
Dummy
Dummmy
1
Outfall
2-C.4
63
34-C.8
Location 4
35
61
36
60
37
59
38
58
39
28
3
27
4
Location 3
5
40
65
57
42-C.9
56
43
25
6
64
41-C.7
55
44
Location 2
14
7-C.3&C.6
32
66
23
67
15
8
54
45
53
46
52
47
51
48
31
16
22
30
17-C.5
50
49-C.10
9
21
10
Location 1
11-C.2
19
12
18
13
81
79
80
77
78
75
76
73
74
C-1


Basin C - State Park Tidegate
N
C1
C2
C3
C4

Modeled Drainage System Inventory

BASIN C

REACH INVENTORY

Reach Name	Length (ft)	Conduit Class	Manning Coef.	Max Width (ft)	Depth or Diameter (ft)	Trapezoid Side Slopes	
18	300	Trapezoid	0.100	6	28	4.2	3
19	200	Trapezoid	0.100	6	28	4.2	3
Location 1	130	Circular	0.014	2	2		
21	1000	Trapezoid	0.100	6	10	6	3
22	1000	Trapezoid	0.100	6	30	4	1.33
23	700	Trapezoid	0.100	6	20	2	3
Location 2	200	Circular	0.014	2	2		
25	500	Trapezoid	0.100	6	24	2.5	2.5
Location 3	120	Circular	0.014	2	2		
27	100	Trapezoid	0.100	6	10	5	5
28	230	Circular	0.014	2	2		
30	400	Circular	0.014	1	1		
31	400	Trapezoid	0.045	5	4	2	2
32	800	Circular	0.014	1	1		
33	360	Circular	0.014	1	1		
50	100	Circular	0.014	1.5	1.5		
51	200	Trapezoid	0.045	5	4	2	2
53	300	Circular	0.014	1	1		
54	240	Trapezoid	0.045	5	4	2	2
55	150	Circular	0.014	2	2		
56	380	Circular	0.014	2	2		
57	440	Circular	0.014	2	2		
58	160	Trapezoid	0.045	6	3	3	3
59	150	Circular	0.014	1.5	1.5		
60	100	Trapezoid	0.045	6	4	2	2
63	300	Trapezoid	0.045	6	4	2	2
64	400	Circular	0.014	2	2		
65	280	Circular	0.014	2	2		
67	800	Circular	0.014	1	1		
74	500	Trapezoid	0.100	6	4	11.2	11.2
76	500	Trapezoid	0.100	6	4	11.2	11.2
78	400	Trapezoid	0.100	6	4	11.2	11.2
80	260	Trapezoid	0.100	6	28	4.2	3
81	300	Trapezoid	0.100	6	28	4.2	3
Dummmy	50	Circular	0.011	4	4		
Pipe	600	Circular	0.014	2	2		

NODE INVENTORY

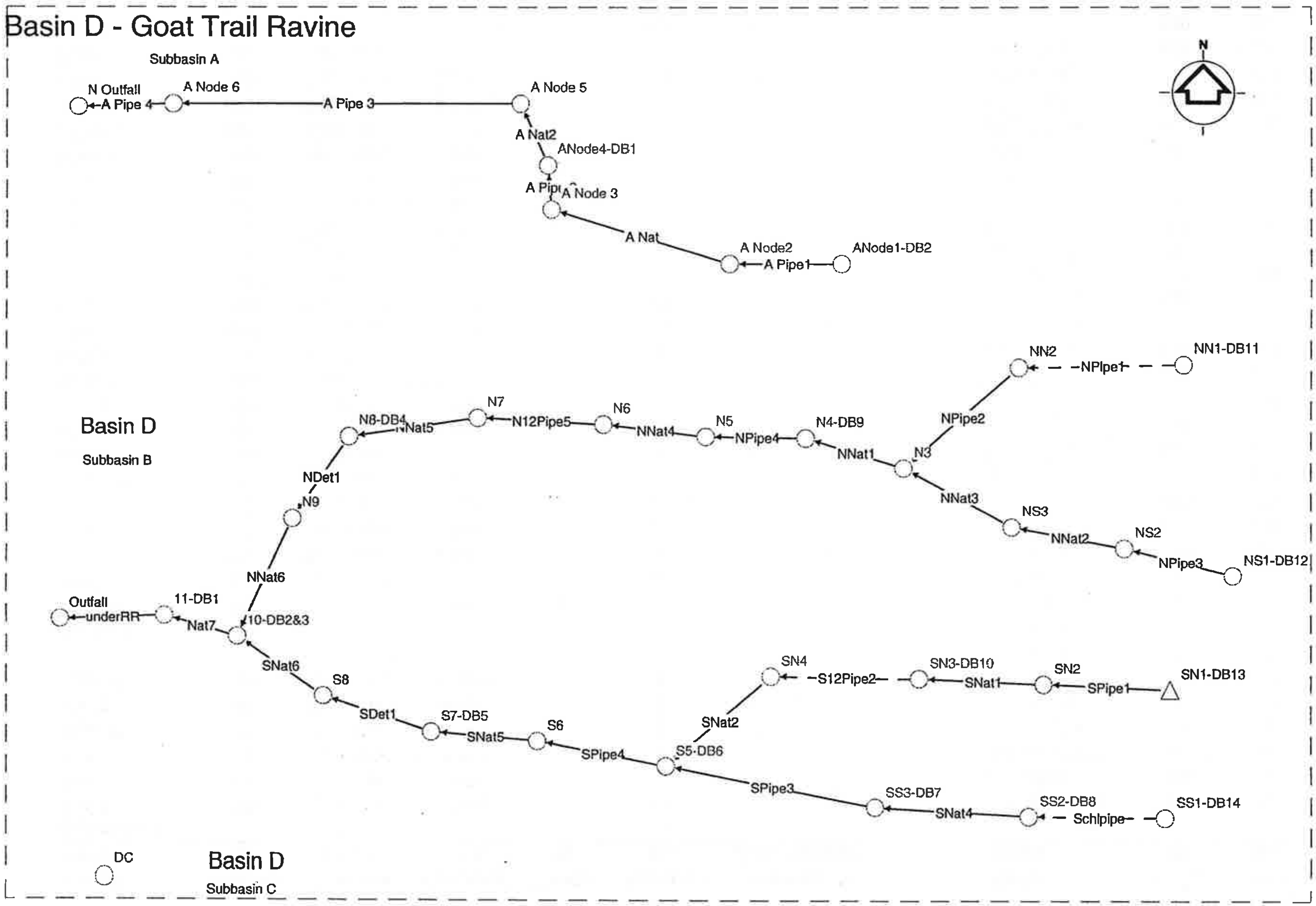
Node Name	Ground Elev. (ft)	Crown Elev. (ft)	Invert Elev. (ft)
1	20	20	0
2-C.4	21	21	1
3	50	50	40
4	50	50	40
5	101	78	54
6	102	102	78
7-C.3&C.6	135	120	100
8	190	190	160
9	240	240	210
10	360	360	350
11-C.2	388	388	360
12	400	400	372
13	417	417	389
14	117	116	115
15	220	220	216
16	248	248	244
17-C.5	338	335	334
34-C.8	22	22	16.1
35	23	23	16.1
36	25	25	20
37	38	38	34
38	58	58	55
39	60	60	57
40	70	69	67
41-C.7	98	97	95
42-C.9	90	84	82
43	87	85	83
44	93	93	89
45	111	111	107
46	115	115	110
47	147	147	142
48	166	166	162
49-C.10	178	176	174
66	169	167	166
C-1	468	468	464
73	455	455	451

Modeled Drainage System Inventory

BASIN C

REACH INVENTORY							
Reach Name	Length (ft)	Conduit Class	Manning Coef.	Max Width (ft)	Depth or Diameter (ft)	Trapezoid Side Slopes	
Outflguttr	600	Trapezoid	0.014	1	1	1	1
Pipe-52	340	Circular	0.014	1.25	1.25		
ditch-52	340	Trapezoid	0.014	1	1	1	1
Pipe-61	100	Circular	0.014	1.5	1.5		
ditch-61	100	Trapezoid	0.014	1	1	1	1
Pipe-62	200	Circular	0.014	2	2		
ditch-62	200	Trapezoid	0.014	1	1	1	1

NODE INVENTORY			
Node Name	Ground Elev. (ft)	Crown Elev. (ft)	Invert Elev. (ft)
75	439	439	435
77	450	450	422
79	435	435	407
Dummy	5	4	0


Basin D - Goat Trail Ravine
Subbasin A
N
N Outfall
A Pipe 4
A Node 6
A Pipe 3
A Node 5
A Nat2
ANode4-DB1
A Node 3
A Nat
A Node2
A Pipe1
ANode1-DB2
Basin D
Subbasin B
NN2
NPipe1
NN1-DB11
NPipe2
N3
NNat1
N4-DB9
NPipe4
N5
NNat4
N6
N12Pipe5
N7
NNat5
N8-DB4
NDet1
N9
NNat6
NNat3
NS3
NNat2
NS2
NPipe3
NS1-DB12
Outfall
underRR
11-DB1
Nat7
10-DB2&3
SNat6
S8
SDet1
S7-DB5
SNat5
S6
SPipe4
S5-DB6
SNat2
SN4
S12Pipe2
SN3-DB10
SNat1
SN2
SPipe1
SN1-DB13
SPipe3
SS3-DB7
SNat4
SS2-DB8
Schlpipe
SS1-DB14
DC
Basin D
Subbasin C

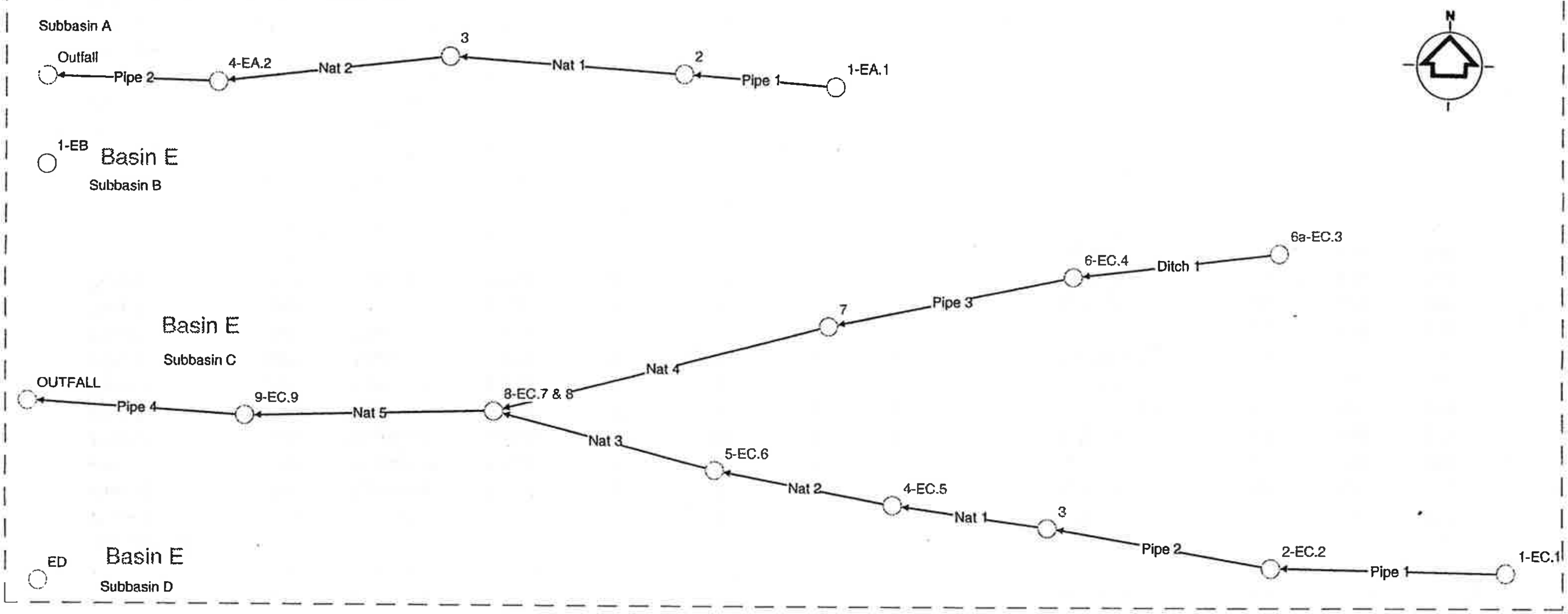
Modeled Drainage System Inventory

BASIN D

REACH INVENTORY							
Reach Name	Length (ft)	Conduit Class	Manning Coef.	Max Width (ft)	Depth or Diameter (ft)	Trapezoid Side Slopes	
Subbasin A							
Pipe1	100	Circular	0.014	1.5	1.5		
Nat	400	Trapezoid	0.030	3	4	3	3
Pipe 4	60	Circular	0.014	2	2		
Pipe 2	60	Circular	0.014	1	1		
Nat2	90	Trapezoid	0.030	2	2	1	1
Pipe 3	420	Trapezoid	0.030	2	3	1	1
Subbasin B							
underRR	30	Circular	0.014	2	2		
Nat7	450	Trapezoid	0.035	5	20	5	5
NNat6	570	Trapezoid	0.035	5	20	4	4
NDet1	300	Trapezoid	0.035	30	20	1	1
NNat5	315	Trapezoid	0.035	6	11	3	3
N12Pipe5	100	Circular	0.014	1	1		
NNat4	450	Trapezoid	0.035	5	14	3	3
NPipe4	80	Circular	0.014	1	1		
NNat1	300	Natural	0.250	91	10		
NNat2	225	Trapezoid	0.035	5	11	3	3
NPipe3	70	Circular	0.014	2	2		
SNat6	450	Trapezoid	0.035	5	20	4	4
SNat5	900	Trapezoid	0.035	5	10	3	3
SPipe4	76	Circular	0.014	2	2		
SNat2	1125	Trapezoid	0.030	5	4	4	4
SNat1	1125	Trapezoid	0.025	4	4	3	3
SPipe1	50	Circular	0.014	2	2		
SPipe3	40	Circular	0.014	1	1		
SNat4	450	Trapezoid	0.035	5	10	4	4
NPipe2	450	Circular	0.014	1	1		
NNat3	255	Trapezoid	0.035	5	13	4	4
SDet1	450	Trapezoid	0.030	75	20	1.5	1.5
Pipe 1	115.5	Circular	0.014	1	1		
Crb/Gutter	115.5	Trapezoid	0.015	0.5	0.5	1	1
Pipe 2	150	Circular	0.014	1	1		
Crbgutter	150	Trapezoid	0.025	2	1	1	1
School	1425	Circular	0.014	1	1		
Crb	1425	Trapezoid	0.015	0.5	0.5	1	1

NODE INVENTORY			
Node Name	Ground Elev. (ft)	Crown Elev. (ft)	Invert Elev. (ft)
ANode1-DB2	180	164	162
A Node2	180	152	148
ANode4-DB1	106	106	104
N Outfall	15	8	0
A Node 3	110	110	106
A Node 5	105	105	102
A Node 6	15	10	7
Outfall	10	7	5
11-DB1	50	35	6
10-DB2&3	100	80	60
N9	218	200	180
N8-DB4	250	229	209
N7	340	340	329
N6	345	344	330
N5	378	372	358
N4-DB9	375	375	360
NN2	417	417	408
NN1-DB11	421	421	411
NS2	415	405	394
NS1-DB12	415	397	395
S7-DB5	230	180	160
S6	298	298	288
S5-DB6	325	296	292
SN4	394	394	389
SN3-DB10	397	397	392
SN2	460	454	450
SN1-DB13	460	456	454
SS3-DB7	310	304	294
SS2-DB8	377	377	366
SS1-DB14	425	425	420
N3	390	390	377
NS3	400	391	378
S8	230	178	158

Basin E - Unnamed Ravine

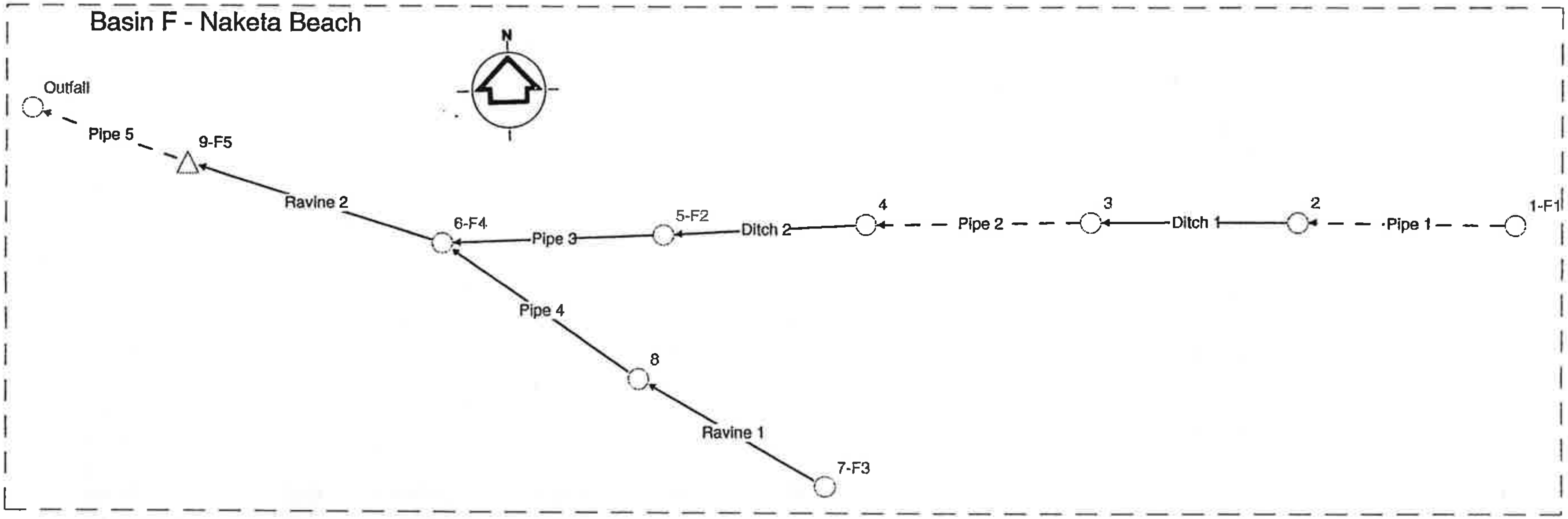


Modeled Drainage System Inventory

BASIN E

REACH INVENTORY							
Reach Name	Length (ft)	Conduit Class	Manning Coef.	Max Width (ft)	Depth or Diameter (ft)	Trapezoid Side Slopes	
Subbasin A							
Pipe 1	65	Circular	0.014	1.25	1.25		
Nat 1	375	Trapezoid	0.030	10	6	5	5
Nat 2	525	Trapezoid	0.100	5	6	3	3
Pipe 2	50	Circular	0.014	3	3		
Subbasin C							
Pipe 1	180	Circular	0.014	2	2		
Pipe 2	60	Circular	0.014	3	3		
Nat 1	750	Trapezoid	0.030	5	6	3	3
Nat 3	750	Trapezoid	0.030	5	10	3	3
Nat 5	945	Trapezoid	0.030	5	4	3	3
Pipe 4	50	Circular	0.014	3	3		
Nat 4	1095	Trapezoid	0.030	5	10	3	3
Pipe 3	60	Circular	0.014	2	2		
Nat 2	450	Trapezoid	0.030	5	10	3	3
Ditch 1	960	Trapezoid	0.045	2	2	1	1

NODE INVENTORY			
Node Name	Ground Elev. (ft)	Crown Elev. (ft)	Invert Elev. (ft)
1-EA.1	328	325	324
2	328	324	318
3	306	306	300
4-EA.2	20	20	5.5
Outfall	20	8	5
1-EC.1	443	437	435
2-EC.2	440	435	432
3	440	439	433
5-EC.6	390	244	234
8-EC.7 & 8	350	122	112
9-EC.9	20	9	5
OUTFALL	20	7	4
7	460	430	420
6-EC.4	430	426	424
4-EC.5	400	370	360
6a-EC.3	440	438	436


Basin F - Naketa Beach
N
Outfall
Pipe 5
9-F5
Ravine 2
6-F4
Pipe 3
5-F2
Ditch 2
4
Pipe 2
3
Ditch 1
2
Pipe 1
1-F1
Pipe 4
8
Ravine 1
7-F3

Modeled Drainage System Inventory

BASIN F

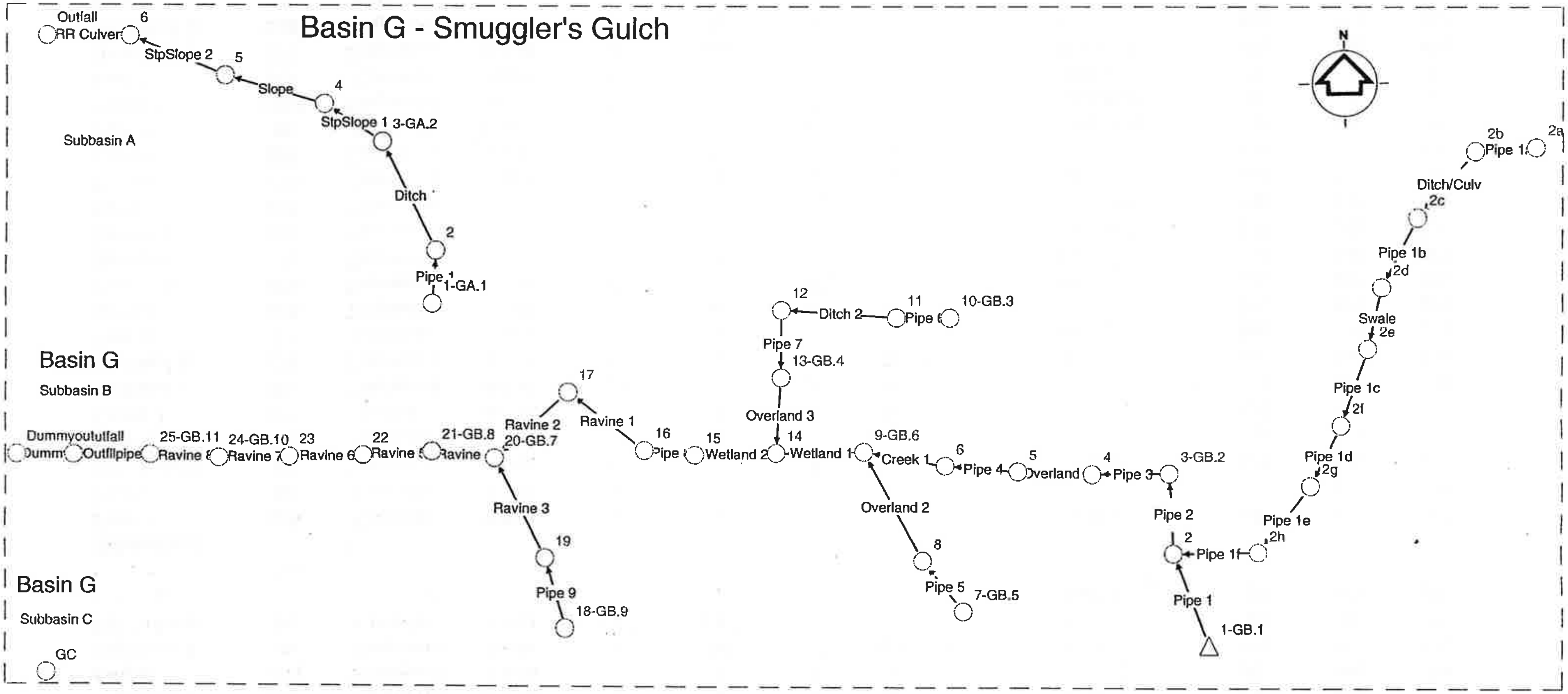
REACH INVENTORY

Reach Name	Length (ft)	Conduit Class	Manning Coef.	Max Width (ft)	Depth or Diameter (ft)	Trapezoid Side Slopes	
Ditch 1	300	Trapezoid	0.030	3	4	1	1
Ditch 2	330	Trapezoid	0.030	3	4	1	1
Pipe 3	60	Circular	0.014	2	2		
Ravine 2	1600	Trapezoid	0.100	5	6	3	3
Ravine 1	600	Trapezoid	0.100	5	6	3	3
Pipe 4	60	Circular	0.014	2	2		
Pipe 1	375	Circular	0.014	1	1		
Crb/gttr1	375	Trapezoid	0.014	1	1	1	1
Pipe 2	330	Circular	0.014	1	1		
Crb/gttr2	330	Trapezoid	0.014	1	1	1	1
Greg	300	Closd Cnd	0.014	6	6		

NODE INVENTORY

Node Name	Ground Elev. (ft)	Crown Elev. (ft)	Invert Elev. (ft)
1-F1	449	449	444
2	436	436	432
3	425	425	420
4	420	420	416
5-F2	386	381	377
6-F4	386	381	375
9-F5	20	7	1
7-F3	410	410	404
8	390	386	380
Outfall	20	7	0

Basin G - Smuggler's Gulch



Modeled Drainage System Inventory

BASIN G

REACH INVENTORY

Reach Name	Length (ft)	Conduit Class	Manning Coef.	Max Width (ft)	Depth or Diameter (ft)	Trapezoid Side Slopes	
Subbasin A							
Pipe 1	30	Circular	0.014	1	1		
Ditch	450	Trapezoid	0.045	4	2	1	1
StpSlope 1	150	Trapezoid	0.030	10	1	10	10
Slope	600	Trapezoid	0.045	5	2	4	4
StpSlope 2	225	Trapezoid	0.045	5	10	0.5	0.5
RR Culvert	50	Circular	0.014	2.67	2.67		
Subbasin B							
Pipe 1	225	Circular	0.014	1	1		
Pipe 3	45	Circular	0.014	2	2		
Overland 1	90	Trapezoid	0.030	5	1	5	5
Pipe 4	50	Circular	0.014	2	2		
Creek 1	795	Trapezoid	0.045	5	2	3	2
Wetland 1	300	Trapezoid	0.045	10	1	10	10
Wetland 2	270	Trapezoid	0.045	10	1	10	10
Pipe 8	50	Circular	0.014	2	2		
Ravine 1	675	Trapezoid	0.100	5	6	6	6
Ravine 2	600	Trapezoid	0.100	10	4	15	15
Ravine 4	150	Trapezoid	0.100	5	8	4	4
Ravine 5	780	Trapezoid	0.100	5	10	2	2
Ravine 6	285	Trapezoid	0.100	5	10	4.5	4.5
Ravine 7	270	Trapezoid	0.100	10	6	4	4
Ravine 8	825	Trapezoid	0.100	5	6	7	3
Pipe 6	50	Circular	0.014	1	1		
Ditch 2	1065	Trapezoid	0.030	5	1	5	5
Pipe 7	345	Circular	0.014	1	1		
Overland 3	270	Trapezoid	0.030	10	0.5	5	5
Overland 2	225	Trapezoid	0.030	5	1	5	5
Pipe 9	50	Circular	0.014	1	1		
Ravine 3	450	Trapezoid	0.100	5	6	10	10
Dummy	10	Trapezoid	0.010	15	10	10	10
Pipe 1b	150	Circular	0.014	1	1		
Swale	175	Trapezoid	0.035	1.25	2	1	1
Pipe 1c	200	Circular	0.024	1.5	1.5		

NODE INVENTORY

Node Name	Ground Elev. (ft)	Crown Elev. (ft)	Invert Elev. (ft)
1-GA.1	344	342	341
2	342	342	340
3-GA.2	322	322	320
4	262	262	260
5	160	160	150
6	30	30	1
Outfall	20	2.67	0
1-GB.1	466	464	463
2	455	455	452
3-GB.2	449	449	446
4	448	447	445
5	422	422	420
6	420	420	418
9-GB.6	396	396	394
14	395	394	393
15	394	394	392
16	410	397	391
17	370	368	362
20-GB.7	350	348	340
21-GB.8	330	330	320
22	140	130	120
23	110	100	90
24-GB.10	100	90	84
25-GB.11	20	7	1
Outfall	20	10	0
10-GB.3	456	455	454
11	454	453	452
12	404	403	402
13-GB.4	400	399	398
7-GB.5	399	399	397
8	397	397	395
18-GB.9	372	369	368
19	370	364	358

Modeled Drainage System Inventory

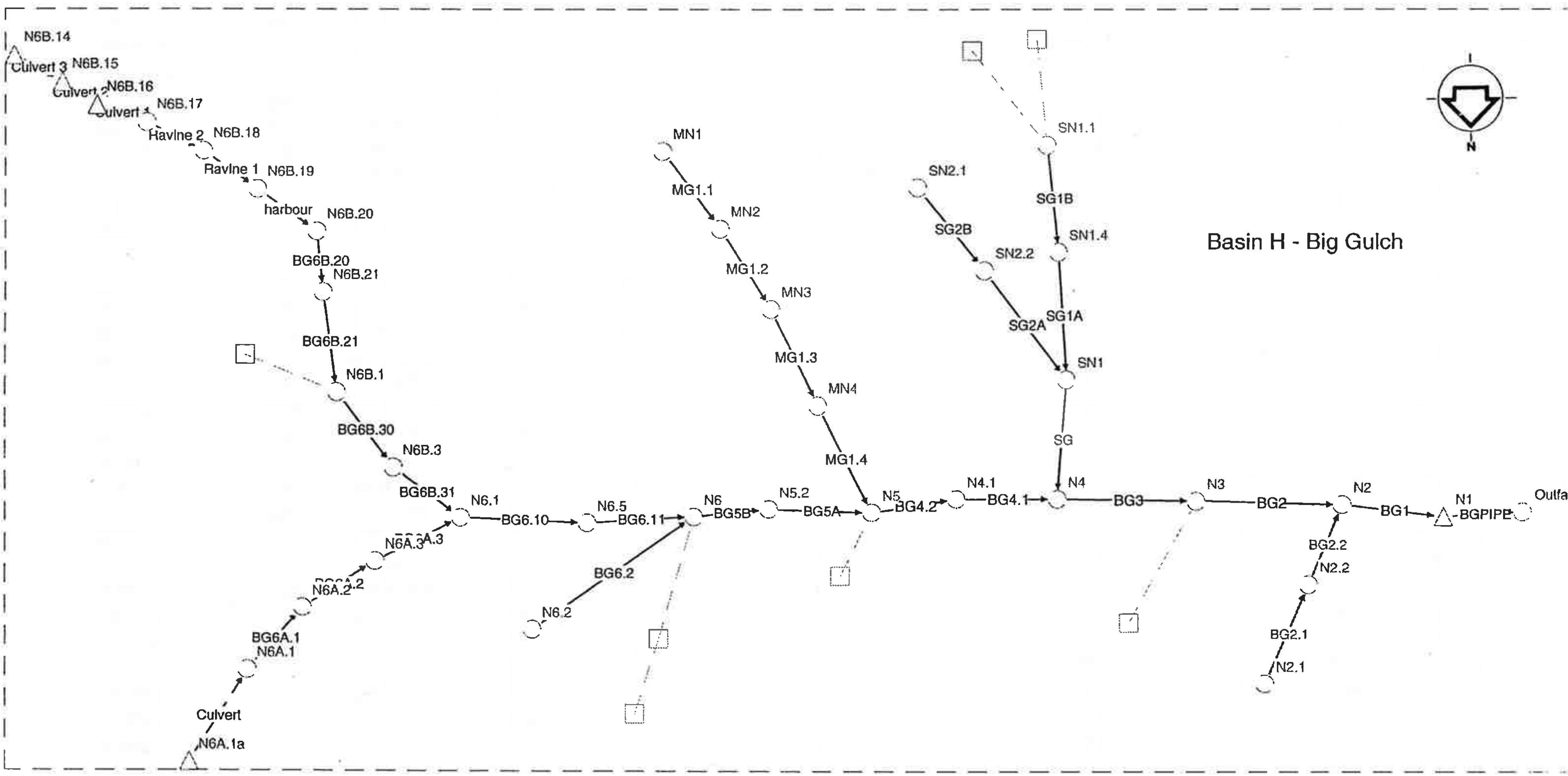
BASIN G

REACH INVENTORY

Reach Name	Length (ft)	Conduit Class	Manning Coef.	Max Width (ft)	Depth or Diameter (ft)	Trapezoid Side Slopes	
Pipe 1d	500	Circular	0.024	1.5	1.5		
Pipe 1e	250	Circular	0.024	1.5	1.5		
Pipe 1f	180	Circular	0.024	1.5	1.5		
91	50	Circular	0.014	1	1		
Pipe 2a	375	Circular	0.014	1	1		
Pipe2guttr	375	Trapezoid	0.014	5	1	5	5
outfall-a	50	Circular	0.014	2	2		
outfall-b	50	Circular	0.014	2	2		

NODE INVENTORY

Node Name	Ground Elev. (ft)	Crown Elev. (ft)	Invert Elev. (ft)
Dummyout	20	10	0
2a	559	557	556
2b	558	556	555
2c	548	547	546
2d	544	541	539
2e	537	536	534
2f	534	532	530
2g	505	505	503
2h	480	476	474

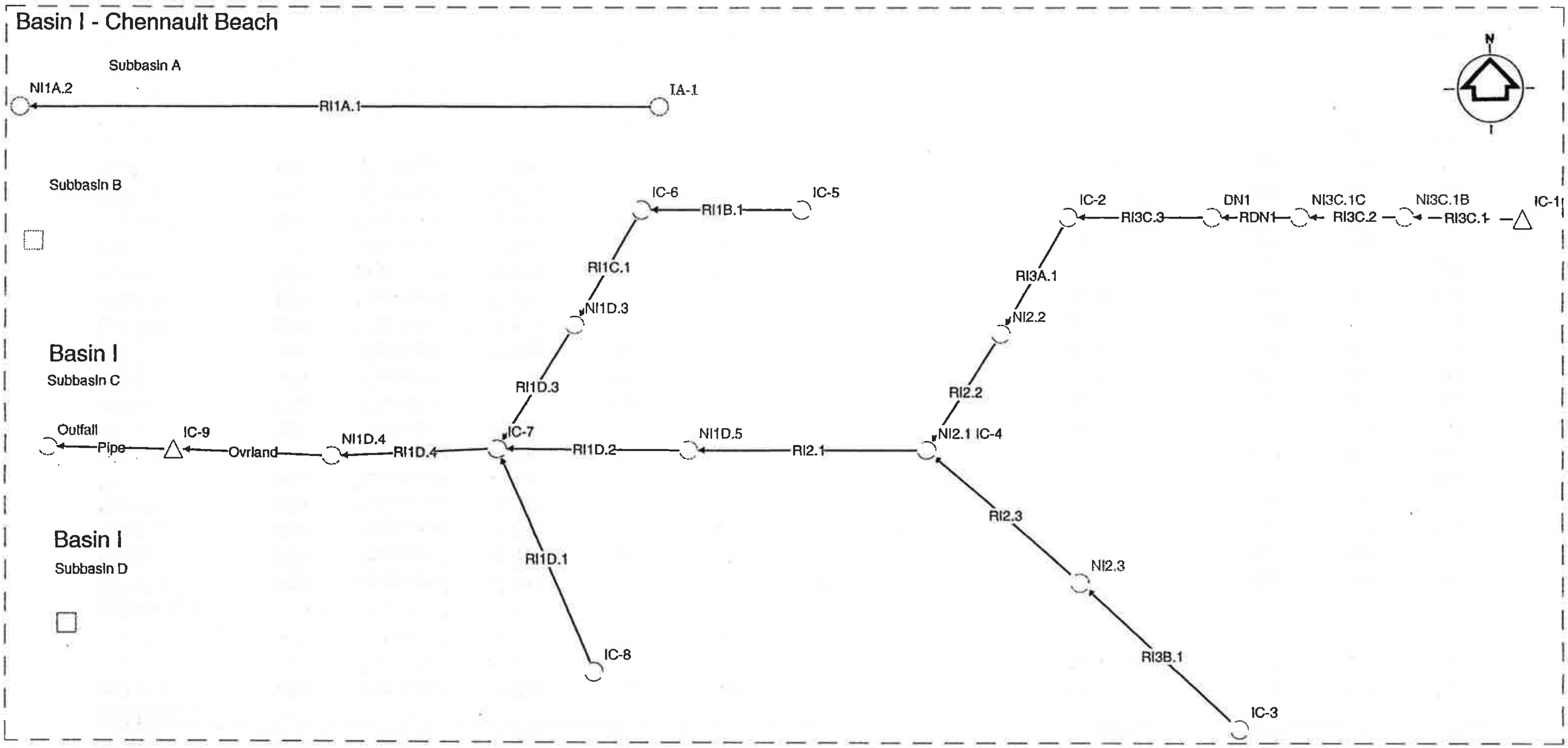

Basin H - Big Gulch
N
N6B.14
Culvert 3
N6B.15
Culvert 2
N6B.16
Culvert 1
N6B.17
Ravine 2
N6B.18
Ravine 1
N6B.19
harbour
N6B.20
BG6B.20
N6B.21
BG6B.21
N6B.1
BG6B.30
N6B.3
BG6B.31
N6.1
N6A.3
N6A.2
BG6A.1
N6A.1
Culvert
N6A.1a
BG6.10
N6.5
BG6.11
BG6.2
N6.2
N6
BG5B
N5.2
BG5A
N5
BG4.2
N4.1
BG4.1
N4
BG3
N3
BG2
N2
BG1
N1
BGPIPE
Outfa
BG2.2
N2.2
BG2.1
N2.1
MN1
MG1.1
MN2
MG1.2
MN3
MG1.3
MN4
MG1.4
SN2.1
SG2B
SN2.2
SG2A
SN1.1
SG1B
SN1.4
SG1A
SN1
SG

Modeled Drainage System Inventory

BASIN H - Big Gulch

REACH INVENTORY							
Reach Name	Length (ft)	Conduit Class	Manning Coef.	Max Width (ft)	Depth or Diameter (ft)	Trapezoid Side Slopes	
BG6B.20	750	Trapezoid	0.035	5	13	1.79	2.08
BG6B.21	750	Trapezoid	0.035	5	13	1.79	2.08
BG6B.30	575	Trapezoid	0.050	5	20	1.82	1.63
BG6B.31	575	Trapezoid	0.050	5	20	1.82	1.63
BG6A.1	750	Trapezoid	0.035	5	28	2.82	2.59
BG6A.2	700	Trapezoid	0.035	5	3	3	3
BG6A.3	670	Trapezoid	0.035	5	28	2.82	2.59
BG6.10	725	Trapezoid	0.050	5	21	3.64	4
BG6.11	725	Trapezoid	0.050	5	21	3.64	4
BG6.2	600	Trapezoid	0.035	5	6	8.33	8.33
BG5B	690	Trapezoid	0.050	5	20	2.78	2.38
BG5A	700	Trapezoid	0.050	5	20	2.78	2.38
BG4.2	650	Natural	0.040	120.87	29		
BG4.1	650	Natural	0.050	120.87	29		
SG1B	550	Trapezoid	0.050	5	21	2.27	2.5
SG1A	550	Trapezoid	0.050	5	21	2.27	2.5
SG2B	1000	Trapezoid	0.050	5	22	2.63	2
SG2A	1000	Trapezoid	0.050	5	20	2.63	2
SG	600	Trapezoid	0.050	5	21	2.27	2.5
BG3	970	Natural	0.04	120.87	29		
BG2	700	Natural	0.04	120.87	29		
BG2.1	600	Natural	0.04	33.8	10		
BG2.2	570	Trapezoid	0.04	5	10	1	1
BG1	720	Natural	0.04	16.78	6		
MG1.1	825	Trapezoid	0.035	5	14	3.13	4.17
MG1.2	825	Trapezoid	0.035	5	14	3.13	4.17
MG1.3	825	Trapezoid	0.035	5	14	3.13	4.17
MG1.4	825	Trapezoid	0.035	5	14	3.13	4.17
Ravine 2	660	Trapezoid	0.045	5	3	2	2
Ravine 1	770	Trapezoid	0.045	5	3	2	2
harbour	140	Circular	0.014	4	4		
CMP-60	1000	Closd Cnd	0.014	8.9	8.9		
Wetland25	1000	Closd Cnd	0.014	5.6	5.6		
Wetland24	1000	Closd Cnd	0.014	6	6		
B10 Pond	1000	Closd Cnd	0.014	6.8	6.8		
Clvrtspdwy	1000	Closd Cnd	0.014	26	26		

NODE INVENTORY			
Node Name	Ground Elev. (ft)	Crown Elev. (ft)	Invert Elev. (ft)
N6B.1	391	391	371
N6B.20	473	473	460
N6B.21	431	431	418
N6B.3	339	334	314
N6.1	335	333	305
N6A.1	516	498	470
N6A.2	426	426	398
N6A.3	376	374	346
N6.5	300	291	270
N6	263	255	234
N6.2	241	241	235
N5.2	233	224	204
N5	197	197	168
N4.1	169	169	140
N4	117	117	88
SN1.1	373	373	352
SN1.4	281	281	260
SN1	233	233	212
SN2.1	472	472	450
SN2.2	316	316	294
N3	75	75	46
N2	55	55	26
N2.1	270	270	260
N2.2	202	202	192
N1	18.9	18.9	10
Outfall	18.9	18.9	8
MN1	498	498	484
MN2	472	460	446
MN3	392	384	370
MN4	287	282	268
N6B.14	532	532	526
N6B.15	529	529	523
N6B.16	515	515	508
N6B.17	518	515	508
N6B.18	490	483	480
N6B.19	473	466	462
N6A.1a	484	484	458


Basin I - Chennault Beach
Subbasin A
NI1A.2
RI1A.1
IA-1
N
Subbasin B
IC-6
RI1B.1
IC-5
IC-2
RI3C.3
DN1
RDN1
NI3C.1C
RI3C.2
NI3C.1B
RI3C.1
IC-1
RI1C.1
NI1D.3
RI3A.1
NI2.2
Basin I
Subbasin C
RI1D.3
RI2.2
Outfall
Pipe
IC-9
Ovrland
NI1D.4
RI1D.4
IC-7
RI1D.2
NI1D.5
RI2.1
NI2.1 IC-4
RI2.3
NI2.3
Basin I
Subbasin D
RI1D.1
RI3B.1
IC-8
IC-3

Modeled Drainage System Inventory

BASIN I

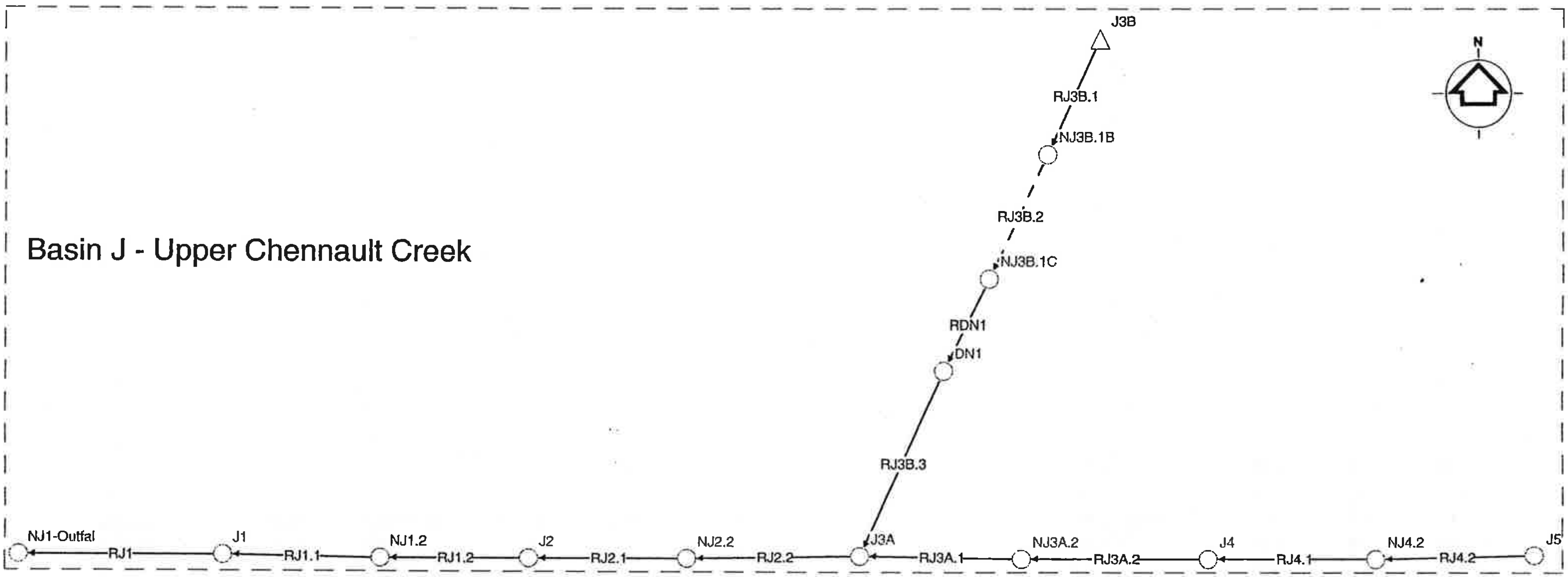
REACH INVENTORY

Reach Name	Length (ft)	Conduit Class	Manning Coef.	Max Width (ft)	Depth or Diameter (ft)	Trapezoid Side Slopes	
Subbasin A							
RI1A.1	120	Circular	0.012	1.5	1.5		
Subbasin C							
RI3A.1	700	Trapezoid	0.040	2	1.75	20	0.5
RI2.2	700	Trapezoid	0.040	2	2	20	20
RI3B.1	400	Trapezoid	0.040	5	2.67	20	20
RI2.3	700	Trapezoid	0.040	5	2	2.5	2
RI2.1	550	Trapezoid	0.040	2	2	5	5
RI1D.2	600	Trapezoid	0.040	2	10	2.5	5
RI1D.4	50	Circular	0.014	3	3		
RI1D.1	750	Circular	0.014	2.5	2.5		
RI1B.1	350	Circular	0.014	1.5	1.5		
RI1C.1	90	Circular	0.014	2	2		
RI1D.3	600	Circular	0.014	2.5	2.5		
RI3C.3	700	Trapezoid	0.040	5	1.75	3.33	20
RDN1	300	Trapezoid	0.040	5	1.75	3.33	20
Pipe	50	Circular	0.014	2	2		
Ovrland	300	Trapezoid	0.100	5	10	1	1
RI3C.1A	100	Circular	0.014	1	1		
RI3C.1B	110	Circular	0.014	1	1		

NODE INVENTORY

Node Name	Ground Elev. (ft)	Crown Elev. (ft)	Invert Elev. (ft)
IA-1	117	112	110
NI1A.2	112	107	105
IC-1	364	363	360
IC-2	254	254	252
NI2.2	200	197	195
NI2.1 IC-4	180	180	178
IC-3	240	240	237
NI2.3	218	211	208
NI1D.5	158	158	148
IC-7	127	123	113
NI1D.4	125	123	113
IC-8	125	122	119
IC-5	125	118	116
IC-6	124	117	115
NI1D.3	122	117	115
NI3C.1B	364	358	351
NI3C.1C	364	357	351
DN1	331	326	324
Outfall	20	6.5	4.5
IC-9	20	15.5	5.5

Basin J - Upper Chennault Creek



Modeled Drainage System Inventory

BASIN J

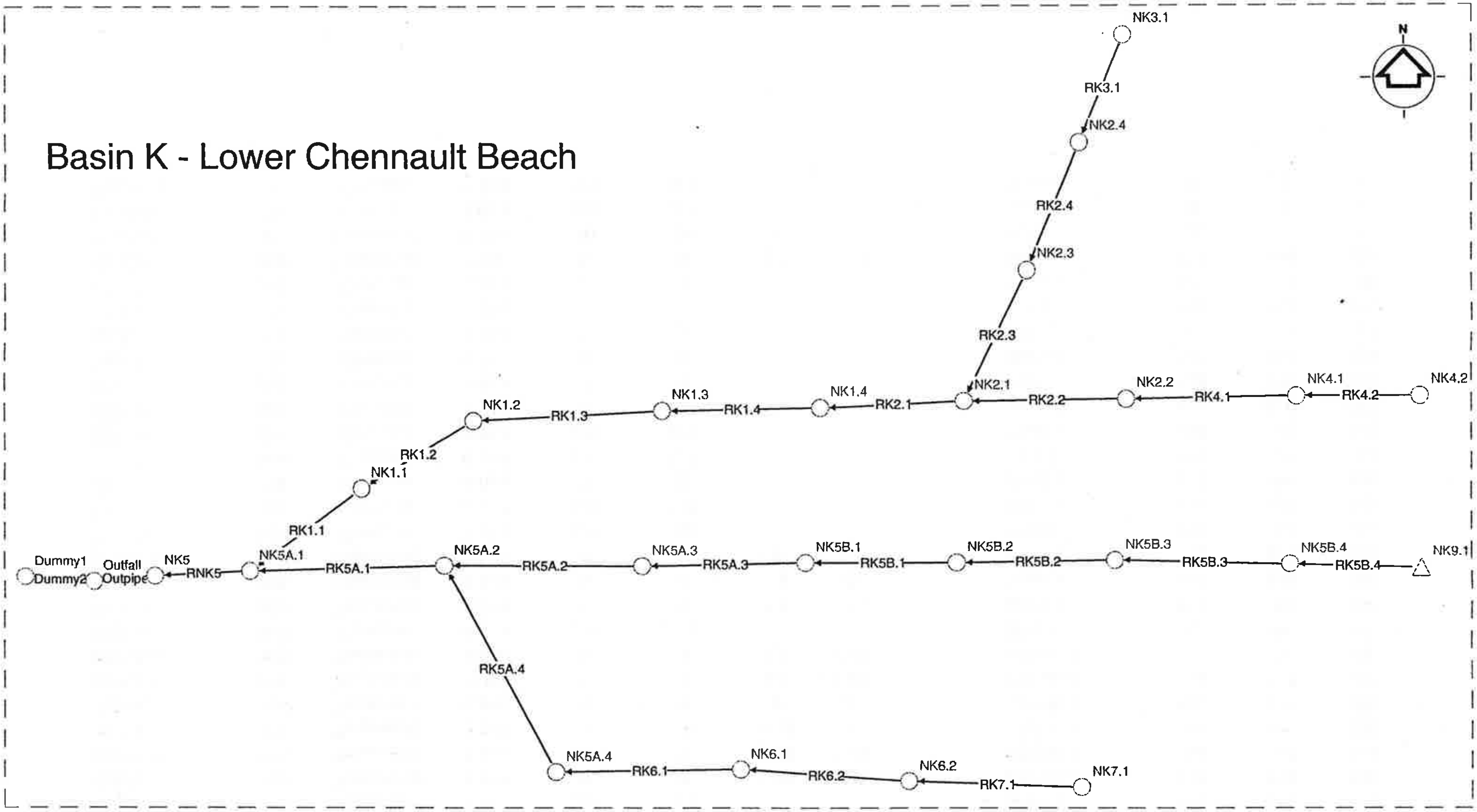
REACH INVENTORY

Reach Name	Length (ft)	Conduit Class	Manning Coef.	Max Width (ft)	Depth or Diameter (ft)	Trapezoid Side Slopes	
RJ4.2	625	Trapezoid	0.040	5	8	3.33	3.33
RJ4.1	625	Trapezoid	0.040	5	9	2.5	3.33
RJ3A.2	800	Trapezoid	0.040	5	9	2.5	4.17
RJ3A.1	800	Trapezoid	0.040	5	9	3.33	3.33
RJ2.2	750	Trapezoid	0.040	5	9	3.33	7.5
RJ2.1	750	Trapezoid	0.04	5	9	2.5	2.5
RJ1.2	750	Trapezoid	0.040	5	9	3.33	1.5
RJ1.1	750	Trapezoid	0.040	5	4	2	2.5
RJ3B.1	40	Circular	0.014	1.5	1.5		
RJ1	50	Circular	0.014	2	2		
RJ3B.3	500	Circular	0.014	1.5	1.5		
RDN1	200	Circular	0.014	1.5	1.5		

NODE INVENTORY

Node Name	Ground Elev. (ft)	Crown Elev. (ft)	Invert Elev. (ft)
NJ4.3	480	480	472
NJ4.2	464	463	454
NJ4.1	432	431	422
NJ3A.2	372	371	362
NJ3A.1	312	311	302
NJ2.2	246	245	236
NJ2.1	194	193	184
NJ1.2	110	109	100
NJ1.1	18	18	0
NJ3B.1	422	419	417
NJ3B.1B	423	417	415
NJ1-Outfal	14	12	0
NJ3B.1C	423	417	415
DN1	391	384	383

Basin K - Lower Chennault Beach



Modeled Drainage System Inventory

BASIN K

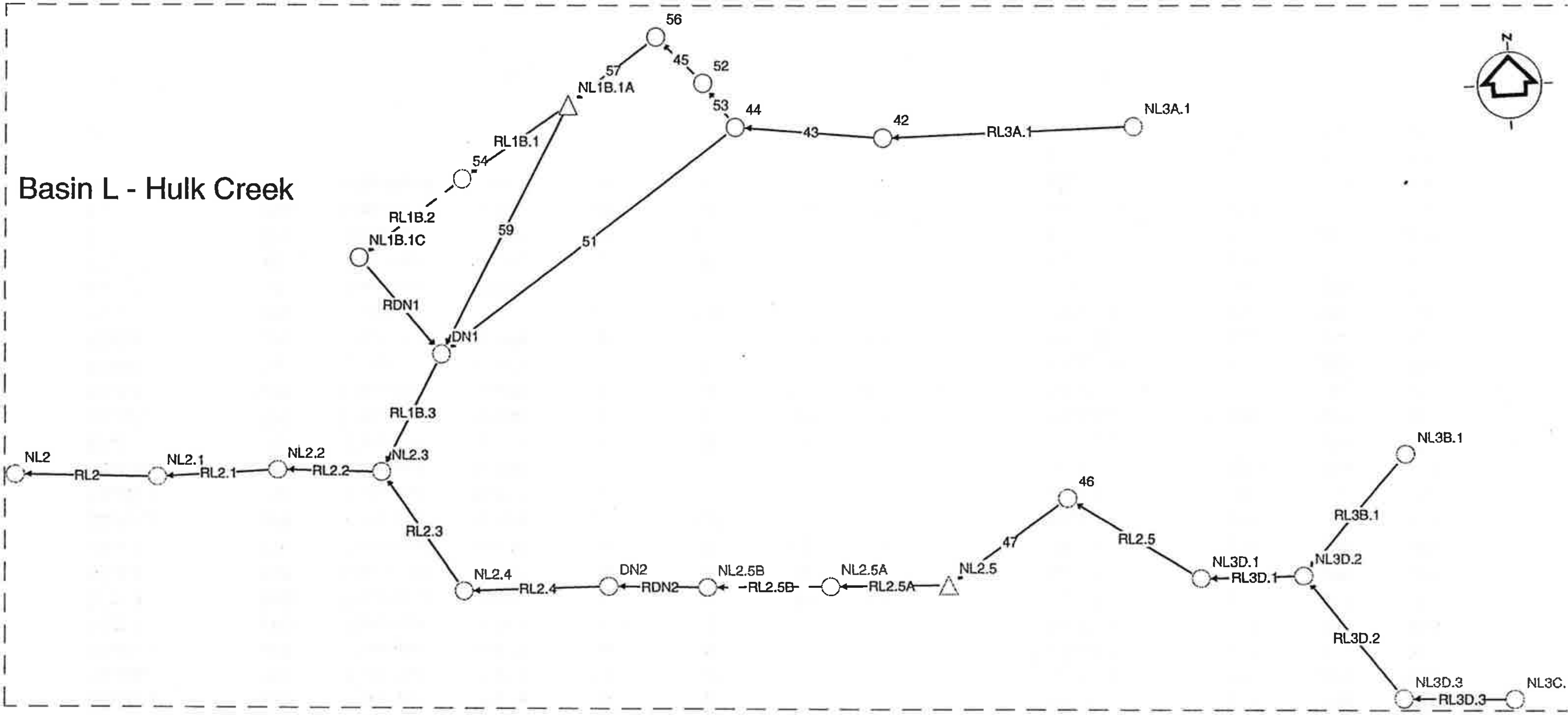
REACH INVENTORY

Reach Name	Length (ft)	Conduit Class	Manning Coef.	Max Width (ft)	Depth or Diameter (ft)	Trapezoid Side Slopes	
RK5B.4	250	Circular	0.014	2.5	2.5		
RK5B.3	120	Trapezoid	0.040	5	9	3.33	1.25
RK5B.2	875	Trapezoid	0.040	5	9	3.33	3.33
RK5B.1	875	Trapezoid	0.040	5	9	3.33	2
RK5A.3	875	Trapezoid	0.040	5	9	2	2
RK5A.2	875	Trapezoid	0.04	5	9	2.5	1.67
RK5A.1	800	Trapezoid	0.040	5	9	2.5	3.33
RK7.1	200	Circular	0.014	1.5	1.5		
RK6.2	950	Trapezoid	0.040	5	9	7.5	3.33
RK6.1	925	Trapezoid	0.040	5	9	1.5	15
RK5A.4	300	Trapezoid	0.040	5	9	1.67	2
RK4.2	550	Circular	0.014	1.5	1.5		
RK4.1	800	Circular	0.014	1.5	1.5		
RK2.2	700	Circular	0.014	2	2		
RK2.1	500	Circular	0.014	2.5	2.5		
RK1.4	650	Circular	0.014	2.5	2.5		
RK1.3	600	Circular	0.014	3	3		
RK1.2	400	Circular	0.014	3	3		
RK1.1	110	Circular	0.014	3	3		
RK3.1	400	Circular	0.014	1	1		
RK2.4	140	Circular	0.014	1	1		
RK2.3	350	Circular	0.014	1	1		
RNK5	200	Trapezoid	0.04	5	9	2.5	3.33
Dummy2	40	Trapezoid	0.014	10	10	3	3
Outfall1	50	Circular	0.014	3.5	3.5		
Outfall2	50	Circular	0.014	3.5	3.5		

NODE INVENTORY

Node Name	Ground Elev. (ft)	Crown Elev. (ft)	Invert Elev. (ft)
NK9.1	488	481	478
NK5B.4	480	479	470
NK5B.3	454	453	444
NK5B.2	408	407	398
NK5B.1	260	259	250
NK5A.3	174	173	164
NK5A.2	92	91	82
NK5A.1	27	26	17
NK7.1	311	308	306
NK6.2	300	299	290
NK6.1	212	211	202
NK5A.4	164	163	154
NK4.2	451	446	445
NK4.1	413	410	408
NK2.2	339	335	333
NK2.1	260	255	253
NK1.4	212	210	207
NK1.3	158	152	149
NK1.2	140	134	131
NK1.1	50	44.3	41.3
NK3.1	400	394	393
NK2.4	347	331	330
NK2.3	312	304	303
NK5	26	12	3
Outfall	16	12	2
Dummy1	12	12	2

Basin L - Hulk Creek



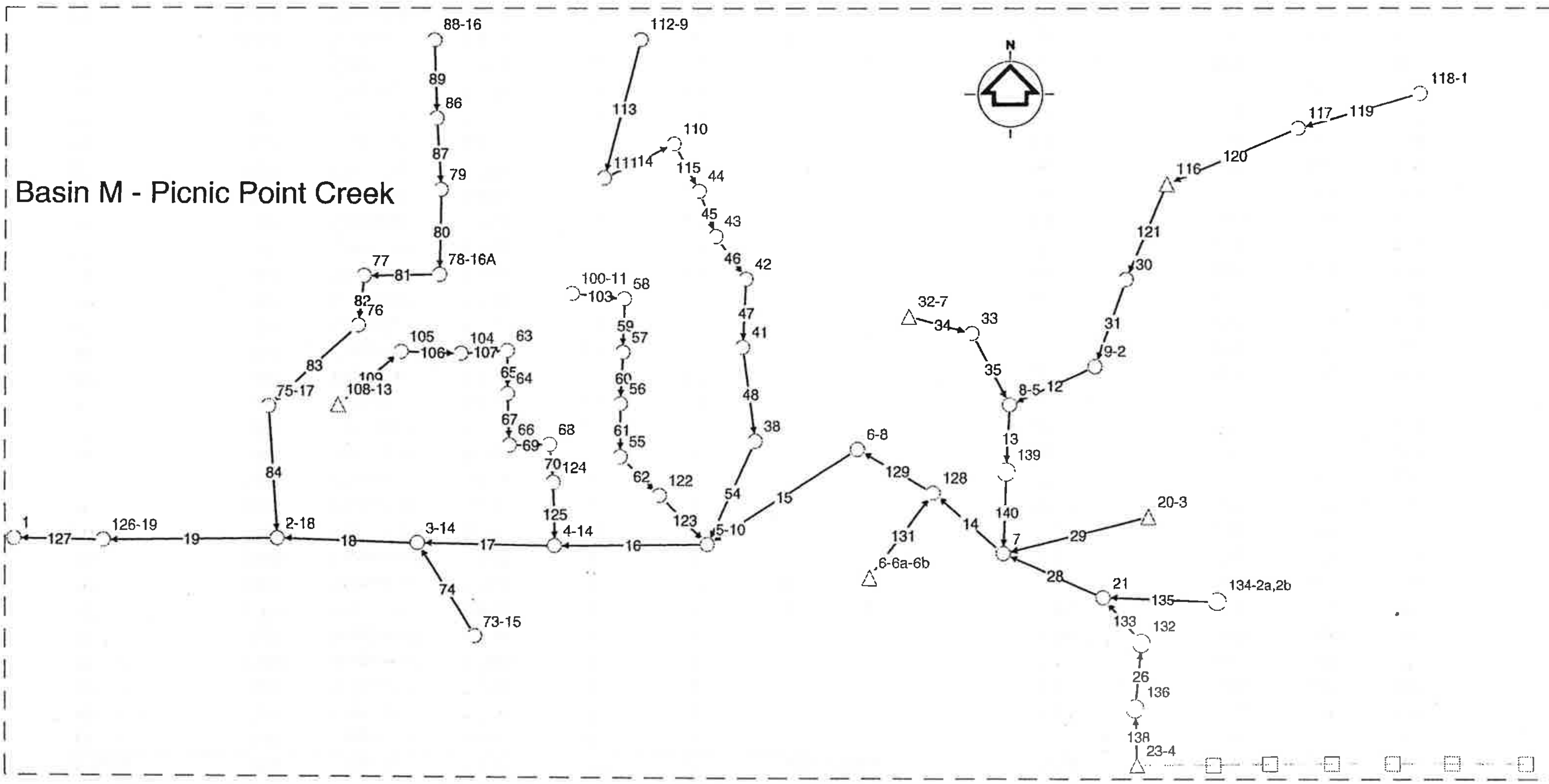
Modeled Drainage System Inventory

BASIN L

REACH INVENTORY							
Reach Name	Length (ft)	Conduit Class	Manning Coef.	Max Width (ft)	Depth or Diameter (ft)	Trapezoid Side Slopes	
RL3D.3	800	Circular	0.014	1.5	1.5		
RL3D.2	130	Circular	0.014	2	2		
RL3B.1	500	Circular	0.014	1.5	1.5		
RL3D.1	300	Circular	0.014	2	2		
RL2.5	150	Circular	0.014	2	2		
RL2.3	900	Trapezoid	0.04	5	9	10	8.75
RL2.2	640	Trapezoid	0.040	5	9	5	5
RL2.1	570	Trapezoid	0.040	5	9	3.21	3.33
RL3A.1	389	Circular	0.014	1.5	1.5		
RL1B.1	79	Circular	0.014	1	1		
RL2.5A	50	Circular	0.010	1	1		
RL2	70	Circular	0.014	2	2		
RL1B.3	600	Trapezoid	0.040	5	5	10	15
RL2.4	300	Trapezoid	0.040	5	9	7.5	5.45
RDN1	33	Circular	0.040	1	1		
RDN2	100	Trapezoid	0.040	5	9	7.5	5.45
43	160	Circular	0.014	1.5	1.5		
45	33	Circular	0.014	1	1		
47	50	Circular	0.014	2	2		
51	297	Circular	0.014	1.5	1.5		
57	100	Trapezoid	0.04	20	3	10	10
59	40	Trapezoid	0.014	10	1	3	3

NODE INVENTORY			
Node Name	Ground Elev. (ft)	Crown Elev. (ft)	Invert Elev. (ft)
NL3C.1	403	392	.390
NL3D.3	311	309	307
NL3D.2	316	308	306
NL3B.1	366	363	361
NL3D.1	309	302	300
NL2.5	288	277	275
NL2.4	270	269	260
NL2.3	203	202	193
NL2.2	183	182	173
NL2.1	45	34	25
NL3A.1	309	304	302
NL1B.1A	260	260	256
NL2.5A	289	276	271
NL2	17	5	3
NL1B.1C	260	255	250
NL2.5B	289	284	271
DN1	255	255	250
DN2	284	280	271
42	296	293	291
44	279	276	268
46	290	283	281
52	279	273	268
54	260	255	250
56	273	272	268

Basin M - Picnic Point Creek



Modeled Drainage System Inventory

BASIN M

REACH INVENTORY							
Reach Name	Length (ft)	Conduit Class	Manning Coef.	Max Width (ft)	Depth or Diameter (ft)	Trapezoid Side Slopes	
12	600	Trapezoid	0.035	3	4	3	3
13	715	Trapezoid	0.035	3	4	3	3
14	300	Trapezoid	0.035	4	5	4	4
15	1800	Trapezoid	0.035	4	5	4	4
16	700	Trapezoid	0.014	4	5	4	4
17	2700	Trapezoid	0.035	4	5	4	4
18	1350	Trapezoid	0.035	4	5	10	10
19	1500	Trapezoid	0.035	3	5	4	4
26	180	Circular	0.014	1.5	1.5		
28	600	Trapezoid	0.035	4	5	3	3
29	350	Circular	0.024	2	2		
31	150	Trapezoid	0.035	3	4	2	2
34	150	Circular	0.014	1.5	1.5		
35	150	Circular	0.014	1.5	1.5		
45	200	Circular	0.014	1.5	1.5		
46	220	Circular	0.014	1.5	1.5		
47	190	Circular	0.014	1.5	1.5		
48	100	Circular	0.014	1.5	1.5		
54	620	Circular	0.014	1.5	1.5		
59	180	Circular	0.014	1.5	1.5		
60	170	Circular	0.014	1.5	1.5		
61	80	Circular	0.014	1.5	1.5		
62	180	Circular	0.014	1.5	1.5		
65	200	Circular	0.014	1.5	1.5		
67	90	Circular	0.014	1.5	1.5		
69	110	Circular	0.014	1.5	1.5		
70	80	Circular	0.014	1.5	1.5		
74	3600	Trapezoid	0.035	4	4	8	8
80	311.5	Circular	0.014	1.25	1.25		
81	210	Circular	0.014	1.25	1.25		
82	55	Circular	0.014	1.5	1.5		
83	299.5	Circular	0.014	4	4		
84	1600	Trapezoid	0.035	2	4	2	2
87	130	Circular	0.014	1.25	1.25		
89	500	Circular	0.014	1	1		
103	120	Circular	0.014	1.5	1.5		

NODE INVENTORY			
Node Name	Ground Elev. (ft)	Crown Elev. (ft)	Invert Elev. (ft)
1	30	20	15
2-18	185	180	175
3-14	235	230	225
4-14	340	325	320
5-10	380	360	355
6-08	405	400	395
7	460	460	450
8-05	475	474	470
9-02	480	479	475
20-3	485	482	480
21	468	465	460
23-4	471	464	464
30	512	511	507
32-7	507	505	503
33	500	492	490
38	473	471	469
41	477	475	473
42	480	477	476
43	490	487	485
44	504	501	499
55	484	481	479
56	485	483	481
57	490	486	485
58	496	486	485
63	505	497	495
64	500	495	493
66	500	493	492
68	495	487	485
73-15	485	479	475
75-17	380	377	373
76	385	379	375
77	385	380	379
78-16A	410	406	402
79	432	422	421
86	440	424	423
88-16	450	440	439

Modeled Drainage System Inventory

BASIN M

REACH INVENTORY							
Reach Name	Length (ft)	Conduit Class	Manning Coef.	Max Width (ft)	Depth or Diameter (ft)	Trapezoid Side Slopes	
106	130	Circular	0.014	1.5	1.5		
107	110	Circular	0.014	1.5	1.5		
109	50	Circular	0.014	1.5	1.5		
113	240	Circular	0.014	1.25	1.25		
114	60	Circular	0.014	1.5	1.5		
115	220	Circular	0.014	1.5	1.5		
119	900	Trapezoid	0.035	3	4	3	3
120	350	Trapezoid	0.035	3	4	3	3
121	240	Circular	0.024	4	4		
123	660	Trapezoid	0.035	3	4	2	2
125	900	Trapezoid	0.035	3	4	2	2
127	1500	Trapezoid	0.035	4	5	5	5
129	1900	Trapezoid	0.035	4	5	4	4
131	800	Trapezoid	0.035	2	4	4	4
133	200	Trapezoid	0.04	4	5	3	3
135	530	Trapezoid	0.045	4	3	2	2
140	710	Trapezoid	0.035	3	8	3	3

NODE INVENTORY			
Node Name	Ground Elev. (ft)	Crown Elev. (ft)	Invert Elev. (ft)
100-11	497	489	488
104	501	498	497
105	501	499	498
108-13	506	503	501
110	505	502	500
111	504	502	501
112-9	510	507	505
116	517	516	512
117	522	521	515
118-1	525	524	520
122	470	469	465
124	490	484	480
126-19	75	65	60
128	490	455	450
6-6a-6b	485	479	475
132	470	470	465
134-2a,2b	500	495	492
136	470	470	463
139	468	468	460

APPENDIX D.

HYDRAULIC ANALYSIS METHODS

Specific details of the hydraulic modeling are contained in this appendix. These are items relevant to the model development, but not major components of the simulation results and are presented for documentation purposes.

The drainage system was modeled using XPSWMM Version 6.1, which uses input data on rainfall and drainage basin features to predict runoff volume and flow through the drainage facilities. Modules of the program that were used for the analyses are the RUNOFF module, which predicts the volume of runoff over the course of a storm event, and the HYDRAULICS module, which models flow through drainage facilities.

Runoff Module

The RUNOFF module predicts runoff in a defined drainage area based on characteristics of the drainage area. Key input parameters include the width of overland flow, the size of the drainage area, the percent of ground surface covered with impervious surface, ground slope, roughness factors for impervious and pervious surfaces, depression storage, and soil infiltration parameters (maximum and asymptotic rates and the decay rate). The module computes runoff volume based on the total volume of rainfall, the volume of rainfall that evaporates or infiltrates into the soil, and the volume stored in depression areas.

Basin Delineation

Basin boundaries were established in the 1985 Storm Drainage Study (Brown and Caldwell) and expanded for newly incorporated areas in the 1993 Storm Drainage Technical Report (Hammond, Collier & Wade-Livingstone). For this plan, the boundaries were reviewed and modified as necessary. In some basins, recent development and new, more detailed topographical information required that the boundaries be redrawn. Basins with more than one outfall were divided into subbasins.

Basins and subbasins also were divided into subcatchments. Subcatchments are smaller, more distinct areas for modeling. They are defined primarily by topography, although man-made drainage systems can supersede the natural topography, particularly in urban areas. Instead of a boundary following a ridge, it may follow a street's gutter.

Each subcatchment is a self-contained drainage unit. The number of subcatchments is governed largely by the kind of information to be determined. If only the total runoff from a basin or subbasin is to be calculated, then no subcatchment divisions are required. When information is required about runoff throughout the drainage basin, then enough subcatchments must be identified to calculate the incremental runoff tributary to the main conveyance facility throughout the basin.

Basin Width

Several input parameters are required for the RUNOFF analysis. To calculate overland flow, the model requires input on the length and slope of the drainage path and roughness and depression storage characteristics of the overland flow areas. Subcatchment width represents the distance runoff travels overland before entering the conveyance network. For existing conditions, it is calculated as the total subcatchment area divided by the maximum overland flow distance to the water pathway.

As a watershed becomes more developed, the distance runoff travels before encountering formal drainage, such as curb and gutter or catchbasin and culvert, is short. This decreases the time it takes for water to travel through a basin and results in 'flashier' runoff peaks. Without having to model a potential (and unknown) conveyance network, this factor can be adjusted to 'imply' the additional infrastructure. In the XPSWMM models, the current and future imperviousness were compared. The width factor was adjusted for subbasins with more than a 20 percent increase in effective impervious area.

Roughness and Depression Storage

Roughness coefficients ('n' values) for overland flow in pervious and impervious areas were taken from current literature and the EPA SWMM manual. Pervious area 'n' values range from 0.25 to 0.4, depending on land use; the 'n' value for paved impervious areas is 0.14.

Depression storage represents the initial storage of rainfall due to surface ponding or wetting. As outlined in the XPSWMM manual, a depression storage factor of 0.1 is used for pervious areas in an urban environment, and depression storage for impervious areas is calculated as: Impervious Depression Storage = $0.0303 \times (\text{Slope} \times 100)^{-0.49}$

Infiltration

Infiltration parameters for pervious areas were selected by using USGS studies or SCS soil group types or soil survey maps. Infiltration capacity as a function of time was modeled by using the Horton equation. Parameters used in this equation include the maximum initial infiltration rate and minimum (asymptotic) infiltration rate. For soils such as those in Mukilteo (outwash underlain by till; Alderwood Type C), maximum infiltration can be as high as 0.5 inches per hour, but quickly reduces to 0.2 inches per hour. During peak rainfall periods in the design storm, infiltration is minimal. The figure on the next page plots the rainfall distribution (discussed in Chapter 4) and the infiltration curve versus time to illustrate this.

Evaporation

Evaporation was considered insignificant during times of anticipated high flows (winter) so no specific local data were generated. A sensitivity analysis showed no affect on runoff with several wintertime levels of evaporation (0 – 0.1 inches per day).

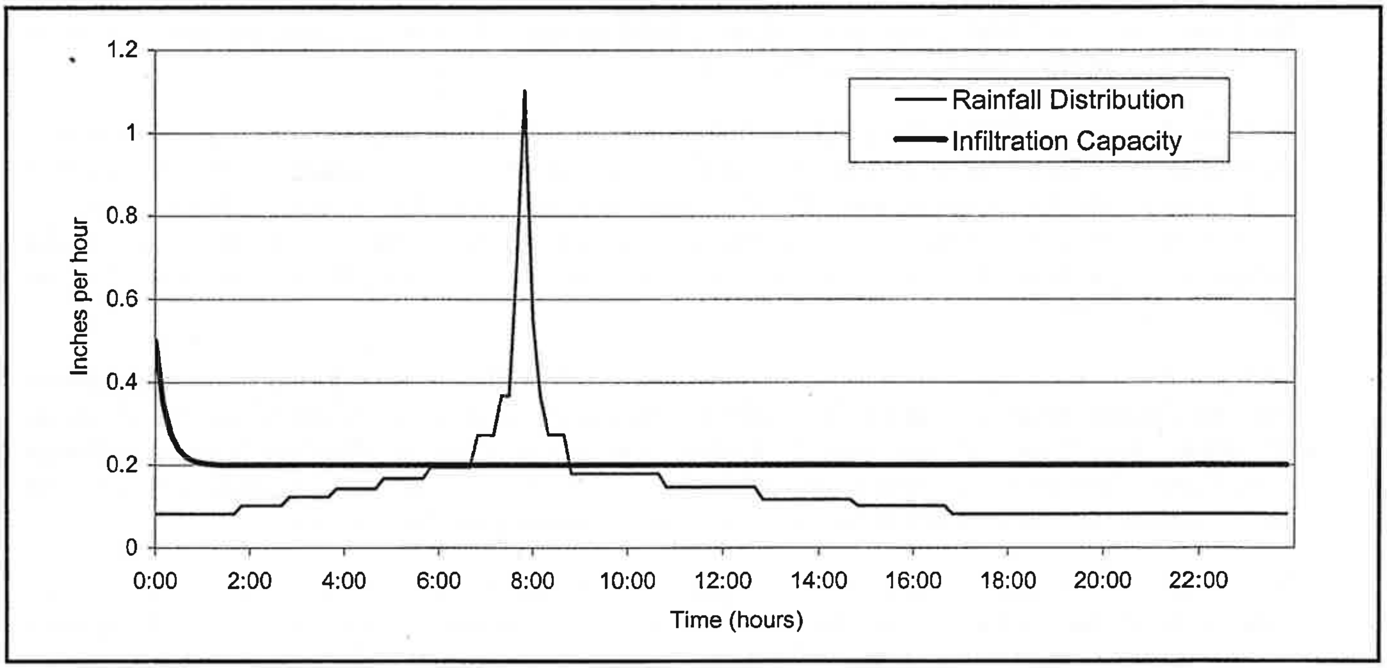


Figure D-1 Distribution of Rainfall and Infiltration

Hydraulics Module

The HYDRAULICS module simulates the routing of flows calculated by the RUNOFF module through the trunk drainage system. It requires input of the physical characteristics of the stormwater conveyance system, including conduit size, length, and roughness and junction (manhole) invert and rim elevations.

Drainage system schematics were developed from the ODM, the PVPM, and input from City staff. The ODM was the primary source for the system north of Big Gulch; to the south, as-built drawings and the PVPM were used. Field inventory was performed to provide additional information required for the modeling. Upstream and downstream invert elevations of culverts under roadways were assumed to match the corresponding ravine or ditch invert elevations. Some culverts and pipes could not be field located, due to dense stands of blackberry and brush, or could not be found without trespassing onto private property. In these cases culvert diameter and material were approximated based on upstream and downstream pipes in the same drainage network.

Ravines were assumed to be uniformly trapezoidal in cross section. Recent topographic mapping was used to estimate the channel cross sections for each reach of the creek. A roughness coefficient of 0.1 was used for the ravines, based on empirical values listed in the user's manual. Other 'n' values were 0.024 for corrugated metal pipes and 0.014 for concrete pipe.

For flooding culverts, a multi-link was used, modeling the culvert with a pipe segment and an equally long open channel. The open channel represented curb and gutter flow or street overtopping. This approach was used to convey runoff to the next node in the model so that floodwater was not lost from the system. Model results of flow through the open channel were used to predict the volume of flooding.

Output from the HYDRAULICS module includes storm sewer reach (conduit) flows, including peak flows, flow velocities, and hydraulic depth at each junction. HYDRAULICS output provides locations of local flooding and estimates flooding volumes throughout the conveyance system when hydraulic depths exceed junction rim elevations. The model compares peak flows that the system can convey to the peak runoff rate predicted by the RUNOFF module.

The junction summary statistics table in the HYDRAULICS output lists junction geometry and maximum hydraulic grade line elevations for all junctions. It specifies the location, duration, and time of occurrence during the simulation of flooding and surcharge conditions. Junction surcharge occurs when the hydraulic grade elevation exceeds the elevation of the crown of the uppermost conduit connected to the junction.

The conduit summary statistics table provides hydraulic information for each conduit. Design flows and velocities for full pipe uniform flow conditions are provided, along with the computed conduit flows and velocities. Comparisons between the computed and design flow data identify conduits as being inadequately or adequately sized. Under surcharge flow conditions, the depth of surcharge at both ends of the conduit is provided, along with the time of maximum computed flow during the model simulation.

Each computer run has an associated continuity error, which is an internal check on the stability of the model. Models with less than 5 percent continuity error are considered to be stable models. After each model was run, the continuity error was checked to ensure that it was less than 5 percent. If the continuity error was greater than 5 percent, indicating an unstable model, the unstable portion of the model was simplified or modified to eliminate the source of error.

Model Calibration

Hydrologic/hydraulic models such as XPSWMM can be used for comprehensive stormwater planning and, if they are carefully applied, to aid in the design of stormwater facilities. Ideally, hydrologic/hydraulic models are quantitatively calibrated to field measured data when possible. The necessary data for such a calibration include historical rainfall data and flow data.

Although local and regional rainfall data are available for Mukilteo, recorded flow rates in the conveyance systems are not. For each basin or subbasin model, a qualitative approach was used for calibration. This involved modifying the model input data until the results seemed reasonable and compared favorably to reported past events.

APPENDIX E.

ISSUE PAPERS FOR MUKILTEO SURFACE WATER RATES

Issue #1—Surface Water Rate Credits

The City of Mukilteo currently charges a rate for ongoing storm and surface water management that is based on impervious surface area as a measure of contribution of run-off. Some existing customers provide or operate surface water facilities that reduce their burden on the City's system. In addition, newer construction in the City is (or will be) required to provide on-site surface water facilities as a condition of development approval. The City does not currently offer credits for such on-site mitigation activities. The question asked is:

> *When is it reasonable (or required) to provide credits to customers for on-site mitigation and what is a rational basis for such credits?*

ALTERNATIVES

Generally, there are three acceptable alternative approaches to addressing credits for on-site mitigation of surface water run-off, whether for water quantity or water quality that have been implemented to our knowledge

- Grant no credits for on-site mitigation;
- Grant credits for those customers whose on-site mitigation facilities and activities *meet* the standards required by the City of new development;
- Grant credits for those customers whose on-site mitigation facilities and activities *exceed* the standards required by the City of new development.

ANALYSIS

Applicable statutes RCW 35.67.020 and RCW 35.92.020 grant discretion to city legislative bodies in the setting of rates and charges (and, it follows, credits), allowing for the consideration of such factors as differences in the cost and/or character of service provided and capital contributions made to the system. However, the statutes say that a city legislative body *may* consider such factors in establishing differences among customers for rate purposes, perhaps enabling a city to legally deny credits for on-site mitigation.

However, while it may be statutorily possible and defensible to deny credits for on-site mitigation, the practice may run counter to the objectives of the City or perhaps best management practices. A carefully structured credit system can provide incentives for new and existing development to provide facilities and services that serve their own developed property while improving surface water management Citywide. Furthermore, credits can be structured to limit the risk to needed utility revenues.

To that end, it is prudent to limit the provision of credits to an amount approximating that which is a truly saved cost to the utility. The issue of cost saving directly relates to the policy decision of whether credits should be provided for on-site mitigation that meets or exceeds City standards.

Comparatively, properties with on-site mitigation have less effect on the public system than similar property lacking this mitigation. However, just meeting City development standards might not reduce costs for the utility. Theoretically, it simply keeps the utility whole. Granting a credit for such activities would actually reduce the amount of financial resources available for basic services to the remainder of the customer base.

Exceeding standards, that is, providing capacity in addition to that needed by the developing (or developed) property in theory does reduce cost to the utility by, in effect, reducing the net utility service area. How much of a credit to grant can then be sized according to the extent to which on-site controls exceed the standards set by the City. For example, if a newly developed site included oversized detention facilities that reduced the design storm peak runoff rate by twenty-five percent (from that site), the approach used by many communities would allow that customer a twenty-five percent rate credit.

Therefore, the two criteria to check for are (1) effectiveness in reducing surface water runoff and (2) whether these on-site systems are designed to handle a greater amount of surface water than would be required as a condition of development approval. The additional capacity provided by the new development may then become the basis for the service charge credit amount.

RECOMMENDATION

We recommend that the City of Mukilteo surface water utility service charge ordinance incorporate a provision for credits, with the general criteria being that the surface water facility, constructed as a condition of development, must effectively reduce the utility's costs *above and beyond* the required amount called for in granting development approval. The cost of *meeting* City standards should be considered a "cost of doing business," since this only mitigates the extra impact of developing the private property in the first place. The amount of credit should be determined by the *extent* to which the on-site facility *exceeds* the minimum requirement. An example of how this recommendation has been applied in the City of Burlington, Washington is provided in the following Exhibit.

Finally, the determination of any service charge credits for future development in the City should be integrated into the City's plan review process. As drainage plans are approved, the amount of the credit should be established along with the inspection and maintenance requirements for continuing the service charge credit.

Exhibit
City of Burlington
Surface Water Rate Credit Policy

A. Generally. A credit against the service charge shall be available, upon application by the property owner, to all non-single family residential properties having constructed City-approved on-site stormwater mitigation facilities which exceed City standards. Under no circumstances shall the adjusted total charge be less than the base rate. Credit eligibility shall be contingent upon meeting all of the following conditions:
   1. the constructed facility is a detention, retention, and / or biofiltration system;
   2. the facility is constructed and maintained to the City's design specifications;
   3. the facility is available for inspection by the City;
   4. excess capacity, if not used by the property owner, is accessible and available for other related public purposes; and
   5. the credit is revocable under conditions where the facility no longer operates at the design level established during the drainage plan review / approval process.

B. Credit Calculation. The maximum amount to be credited shall be a function of (1) pre and post development flows from the site or (2) a fixed percentage reduction. For water quantity mitigation, the formula is expressed mathematically as follows:

$$A = F \times \left[1 - \left(\frac{Q_R}{Q_D}\right)\right]$$

Where:
A = the credit amount to be subtracted from the monthly fee;
F = the total monthly charge without credit;
Q_R = design storm peak runoff rate released from the developed site with improvements in place;
Q_D = design storm peak runoff rate from the site in its pre-development condition.

For qualifying biofiltration, the formula is expressed mathematically as follows:

$$A = F \times 30\%$$

Where:
A = the credit amount to be subtracted from the monthly fee;
F = the total monthly charge without credit.

C. Application Submittal. The following information must be submitted to the City Engineer in order to be eligible for a service charge credit:
   1. approved drainage plan;
   2. calculation of the credit amount based on site-specific data and credit calculation formula;
   3. signature of the person responsible for the accuracy of the credit application material.

Issue #2—Capital Facilities Charges

Connection charges, also referred to as capital facilities charges (CFCs), are fees imposed as conditions of service to recover an equitable share of capital investment incurred by a utility. In the State of Washington, common components of a CFC are a general facilities charge (GFC), and a system development charge (SDC). The GFC is based on the original constructed cost of existing facilities, while the SDC is based on the estimated costs of planned future capital improvements needed to serve growth. The City of Mukilteo does not currently charge either of the two CFC elements. The question asked is:

> *Would a capital facilities charge be an appropriate instrument to use in the City to provide equity between existing and future users and generate revenue for capital construction costs?*

ALTERNATIVES

There are at least four alternative approaches to addressing surface water capital facilities charges that have been implemented in the State of Washington:

- Do not charge a CFC of any kind (a continuation of the existing policy);
- Charge only the general facilities charge (GFC) component as a development buy-in to the existing surface water infrastructure;
- Charge only the system development charge (SDC) component as a means of ensuring that "growth pays for growth";
- Charge a full capital facilities charge that includes both the GFC and the SDC.

ANALYSIS

While State law is clear that CFCs may include the original costs of existing facilities, the statutes are fairly ambiguous on the inclusion of planned future facilities costs in the CFC calculation. The Revised Code of Washington (RCW) grants cities the authority to devise charges for connecting to sewerage systems, defined to include surface water (drainage) facilities. The statute further authorizes cities to assess connection charges that have been determined by the city legislative body appropriate "in order that such property owners shall bear their equitable share of the cost of such system."

This language, found in both RCW 35.67.020 and RCW 35.92.020, appears to clearly and explicitly authorize the general facilities charge component of the CFC. However, in order to be equitable, only those capital costs previously financed by ratepayers are appropriate for inclusion in the charge. Often in newly formed utilities, the stormwater infrastructure has been funded by developer cash contributions, donated facilities, or general fund tax sources, and a buy-in is not appropriate. In the City of Mukilteo's case however, a surface water utility has been in place for some time and, to the extent that rates were used to pay for capital construction, there might be a cost basis for the buy-in based general facilities charge.

At this time, Washington statutes do not explicitly allow or disallow a city capital facilities charge that includes future costs, and many cities have been reluctant to include a future cost based system development charge component without that authorization. Interestingly, RCW 57.08.010 grants special sewer districts similar authority to devise connection charges and also defines a method for calculating an equitable share of both existing and future facilities costs – not found in RCW 35.67.020 or RCW 35.92.020. Under this special district statute, future facilities costs must be addressed in an adopted comprehensive system plan and planned for construction within ten years.

Case law, such as *Boe vs. Seattle*, *Prisk vs. Poulsbo*, and *Hillis Homes vs. Mukilteo Water District*, has established some precedents related to the issue of including future facilities costs in connection charges at a time when special water and sewer district authority was nearly identical to current city authority.

In addition to State and case law, legal opinions[1] are also available concurring with the concept of including growth-related future costs in CFC's. Most notably, an opinion from Hugh Spitzer of Foster Pepper & Shefelman states that cities have "ample authority to include the cost of future facilities so long as the impact of each new customer is documented by engineers and/or financial consultants and the local utility expressly relies on professional studies by those engineers or consultants in adopting that component of the capital facilities charge." Mr. Spitzer, in citing the case law mentioned above, further notes that "Washington courts have upheld the ability of governmental utilities to include future capital costs in the determination of connection charges when no express grant existed."

RECOMMENDATION

Based on the above information, which express guidelines for devising acceptable and equitable charges, we believe CFC's to be generally appropriate for recovering the costs of capital facilities already built and to be built to serve the added capacity or demand impacts of new development. However, CFC's may not be appropriate for the City of Mukilteo at this time, because much of the City's remaining growth to buildout[2] has already been permitted and would not be subject to such a charge. Further, much of the City's remaining growth is expected to be commercial in nature and will provide on-site and/or City facilities as a condition of development. If the City does wish to proceed with the implementation of CFC's, then we strongly recommend that the City obtain the concurrence of its City Attorney before implementing the SDC component made up of projected future costs.

If implemented the SDC, or future-looking fee, should be based on an analysis that follows the process described below in order to establish that eligible costs have been allocated appropriately:

- Project the overall cost of improvements;
- Project the capacity of the improvements;
- Determine the necessity of the improvements to serve new customers versus current system deficiencies; and
- Demonstrate a direct linkage between the cost of improvements and the necessity of those facilities to serve the customers who are being charged for their development.

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[1] Recent opinions from Hugh Spitzer, Foster Pepper & Shefelman; Oskar Rey, City of Kirkland; and David Svaren, City of Burlington.
[2] Indicated by City staff to be projected in 2006.

APPENDIX F.

FINANCIAL TECHNICAL ANALYSIS

City of Mukilteo
Stormwater Rate Analysis
Summary of Key Findings

Page: 1

Scenario Description

Capital	Operations
Base Program	Base Program
	--
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	--

This table describes the contents of the stormwater program for each rate scenario.

Year 2000 $'s

Projected Revenue Requirement and Rates: **Pay-as-you-go Capital Funding**

	2000	2001	2002	2003	2004	2005
Sources of Funds						
Beginning Fund Balances						
Operating Fund	$ 267,907	$ 301,732	$ 327,163	$ 334,768	$ 322,601	$ 288,570
Capital Fund	0	0	0	0	0	0
subtotal	$ 267,907	$ 301,732	$ 327,163	$ 334,768	$ 322,601	$ 288,570
Min. Operating Fund Balance	*$ 43,149*	*$ 44,191*	*$ 45,959*	*$ 47,797*	*$ 49,709*	*$ 51,698*
Revenues						
Operations						
Service Charge Revenues	$ 767,316	$ 778,826	$ 790,508	$ 802,366	$ 814,401	$ 826,617
Other Income	14,395	16,087	17,358	17,738	17,130	15,429
Capital						
Loan Proceeds	0	0	0	0	0	0
subtotal	$ 781,711	$ 794,912	$ 807,866	$ 820,104	$ 831,531	$ 842,046
Uses of Funds						
Expenditures						
Operations						
Cash Operating Expenses	$ 434,586	$ 443,649	$ 461,395	$ 479,851	$ 499,045	$ 519,007
Non-CIP Capital Outlays	3,300	3,432	3,569	3,712	3,861	4,015
Capital						
Debt Service	$ -	$ -	$ -	$ -	$ -	$ -
Capital Construction	310,000	322,400	335,296	348,708	362,656	377,162
Additional D. S. Covg.	-	-	-	-	-	-
subtotal	$ 747,886	$ 769,481	$ 800,261	$ 832,271	$ 865,562	$ 900,184
Ending Fund Balance	$ 301,732	$ 327,163	$ 334,768	$ 322,601	$ 288,570	$ 230,431
Resulting Monthly Rate per ESU	**$ 5.40**	**$ 5.40**	**$ 5.40**	**$ 5.40**	**$ 5.40**	**$ 5.40**
Annual % Increase Required		*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
Cumulative % Increase		*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*

City of Mukilteo
Stormwater Management Plan
Capital Improvement Program - Estimates Only

Construction Cost Escalation Rate: 4.00%

Rank	Cost in Fiscal Year 2000	Year	Description	Include? (1 = Y; 0 = N)	2000	2001	2002	2003	2004	2005	TOTAL
1	$ 310,000	2000	Base Program	1	$ 310,000	$ -	$ -	$ -	$ -	$ -	$ 310,000
2	310,000	2001	Base Program	1	-	322,400	-	-	-	-	322,400
3	310,000	2002	Base Program	1	-	-	335,296	-	-	-	335,296
4	310,000	2003	Base Program	1	-	-	-	348,708	-	-	348,708
5	310,000	2004	Base Program	1	-	-	-	-	362,656	-	362,656
6	310,000	2005	Base Program	1	-	-	-	-	-	377,162	377,162
7					-	-	-	-	-	-	-
8	2,254,000	2001	Six-year CIP	0	-	-	-	-	-	-	-
9	2,254,000	2002	Six-year CIP	0	-	-	-	-	-	-	-
10	2,254,000	2003	Six-year CIP	0	-	-	-	-	-	-	-
11	2,254,000	2004	Six-year CIP	0	-	-	-	-	-	-	-
12	2,254,000	2005	Six-year CIP	0	-	-	-	-	-	-	-
13					-	-	-	-	-	-	-
14	1,353,000	2001	Ten-year CIP	0	-	-	-	-	-	-	-
15	1,353,000	2002	Ten-year CIP	0	-	-	-	-	-	-	-
16	1,353,000	2003	Ten-year CIP	0	-	-	-	-	-	-	-
17	1,353,000	2004	Ten-year CIP	0	-	-	-	-	-	-	-
18	1,353,000	2005	Ten-year CIP	0	-	-	-	-	-	-	-
19					-	-	-	-	-	-	-
20	676,000	2001	Twenty-year CIP	0	-	-	-	-	-	-	-
21	676,000	2002	Twenty-year CIP	0	-	-	-	-	-	-	-
22	676,000	2003	Twenty-year CIP	0	-	-	-	-	-	-	-
23	676,000	2004	Twenty-year CIP	0	-	-	-	-	-	-	-
24	676,000	2005	Twenty-year CIP	0	-	-	-	-	-	-	-
25					-	-	-	-	-	-	-
26	828,333	2001	6-yr CR CIP (1)	0	-	-	-	-	-	-	-
27	828,333	2002	6-yr CR CIP (1)	0	-	-	-	-	-	-	-
28	828,333	2003	6-yr CR CIP (1)	0	-	-	-	-	-	-	-
29	828,333	2004	6-yr CR CIP (1)	0	-	-	-	-	-	-	-
30	828,333	2005	6-yr CR CIP (1)	0	-	-	-	-	-	-	-
31					-	-	-	-	-	-	-
32	497,000	2001	10-yr CR CIP (1)	0	-	-	-	-	-	-	-
33	497,000	2002	10-yr CR CIP (1)	0	-	-	-	-	-	-	-
34	497,000	2003	10-yr CR CIP (1)	0	-	-	-	-	-	-	-
35	497,000	2004	10-yr CR CIP (1)	0	-	-	-	-	-	-	-
36	497,000	2005	10-yr CR CIP (1)	0	-	-	-	-	-	-	-
37					-	-	-	-	-	-	-
38	248,500	2001	20-yr CR CIP (1)	0	-	-	-	-	-	-	-
39	248,500	2002	20-yr CR CIP (1)	0	-	-	-	-	-	-	-
40	248,500	2003	20-yr CR CIP (1)	0	-	-	-	-	-	-	-
41	248,500	2004	20-yr CR CIP (1)	0	-	-	-	-	-	-	-
42	248,500	2005	20-yr CR CIP (1)	0	-	-	-	-	-	-	-
43					-	-	-	-	-	-	-
	$1,860,000		Net Construction Cost		$ 310,000	$ 322,400	$ 335,296	$ 348,708	$ 362,656	$ 377,162	$2,056,222

Options are mutually exclusive. Toggle only one with a "1", and set the others at "0".

NOTE:

(1) Assumes annual cost of Citizen Response Projects =

828,333	for 6-year CIP implementation
497,000	for 10-year CIP implementation
248,500	for 20-year CIP implementation

City of Mukilteo
Stormwater Management Plan
Debt Service Sizing
- Estimates Only -

Page: 3

Financing Assumptions:

Fund Earnings %	5.00%	Interim Financing:	
		BANs Used? (1=Y,0=N)	0
CIP Bond Financed or Pay-as-you-go?		BAN Interest Rate:	6.50%
(1=Debt, 0=No Debt)	0		
		Long-Term Financing:	
Issuance Cost:		Revenue Bonds:	
Short-Term	2.50%	Life of Debt (Years)	20
Long-Term:		Interest Rate	7.00%
Revenue Bonds	3.00%	Coverage Factor Required	1.25
State Revolving Fund	0.00%	Fund Reserve from Proceeds? (1=Y,0=N)	1
		State Revolving Fund	
		Life of Debt (Years)	10
		Interest Rate	3.50%

Fiscal Year	2000	2001	2002	2003	2004	2005
Type of Long Term Debt Issued (1=Y,0=N):						
Revenue Bonds	1	1	1	1	1	1
State Revolving Fund	0	0	0	0	0	0
Project Duration in years (if SRF)	0	0	0	0	0	0

Capital Improvements Financing	2000	2001	2002	2003	2004	2005
Capital Costs to be Funded	$310,000	$322,400	$335,296	$348,708	$362,656	$377,162
less: Grant Funding	0	0	0	0	0	0
less: Direct Rate Funding (pay-as-you-go)	106,817	86,955	77,072	85,636	114,619	166,139
less: Capital Fund Contribution	203,183	235,445	258,224	263,072	248,037	211,024
Amount to be Financed	$0	$0	$0	$0	$0	$0
Interim Borrowing:						
BANs Issued:	$0	$0	$0	$0	$0	$0
less: Borrowing Cost	0	0	0	0	0	0
less: Interest Payments	0	0	0	0	0	0
plus: Interest Earnings	0	0	0	0	0	0
Net Available from BANS	$0	$0	$0	$0	$0	$0
Long-term Borrowing:						
Revenue Bonds:						
Amount Borrowed	$0	$0	$0	$0	$0	$0
less: Financing Cost	0	0	0	0	0	0
less: Reserve Funding	0	0	0	0	0	0
less: Refunding of BANs	0	0	0	0	0	0
Net Funds from Revenue Bonds	$0	$0	$0	$0	$0	$0
State Revolving Fund:						
Amount Borrowed	$0	$0	$0	$0	$0	$0
less: Financing Cost	0	0	0	0	0	0
less: Refunding of BANs	0	0	0	0	0	0
Net Funds from SRF	$0	$0	$0	$0	$0	$0
New Annual Debt Service:						
Debt Service						
Revenue Bonds	$0	$0	$0	$0	$0	$0
State Revolving Fund Loan	$0	$0	$0	$0	$0	$0
Coverage	$0	$0	$0	$0	$0	$0
Reserve Funding	$0	$0	$0	$0	$0	$0

City of Mukilteo
Stormwater Management Plan
Statement of Revenues and Expenses
- Estimates Only -

Pay-as-you-go Capital Funding
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Economic Assumptions:

% Growth in ESU's per Year	1.50%
Annual O&M Cost Inflation	4.00%
State Excise Tax Rate	1.50%

Revenue & Expense Category		2000	2001	2002	2003	2004	2005
Operating Revenue:							
Revenue at Existing Rate:	$ 5.40	$767,316	$778,826	$790,508	$802,366	$814,401	$826,617
Other Fees / Misc. Revenues		1,000	1,000	1,000	1,000	1,000	1,000
Operating Fund Interest (Expense)		13,395	15,087	16,358	16,738	16,130	14,429
Total Operating Revenues:		781,711	794,912	807,866	820,104	831,531	842,046
Operating & Administrative Expenses:							
Salaries & Wages		127,080	132,163	137,450	142,948	148,666	154,612
Personnel Benefits		46,276	48,127	50,052	52,054	54,136	56,302
Supplies		24,500	25,480	26,499	27,559	28,662	29,808
Other Services & Charges	Include?	124,360	129,334	134,508	139,888	145,484	151,303
Catch Basin Cleaning (1)	0	[redacted]	0	0	0	0	0
Detention Facility Maint. (1)	0	[redacted]	0	0	0	0	0
Ditch Enclosure Program (1)	0	[redacted]	0	0	0	0	0
Capital Program Management (1)	0	[redacted]	0	0	0	0	0
Intergovernmental Services (2)		36,000	37,440	38,938	40,495	42,115	43,80(
Interfund Payments for Service		76,370	71,105	73,949	76,907	79,983	83,183
Depreciation (3)		90,397	94,013	97,773	101,684	105,752	109,982
Total Expenses:		524,983	537,662	559,169	581,536	604,797	628,989
Debt Service Interest		0	0	0	0	0	0
Capital Outlays (4)		3,300	3,432	3,569	3,712	3,861	4,015
Net Operating Income		$253,428	$253,818	$245,128	$234,856	$222,874	$209,042

Notes:

(1) Estimated annual costs as follows:

Catch Basin Cleaning	$187,500		
Detention Facility Maint.	496,000	@$155	@$75
Ditch Enclosure Program	$1,600,000	1,600,000	770,000
Program Management	76,923	(1 FTE)	

(2) Includes taxes.
(3) Treated as a non-cash expense for revenue requirements purposes.
(4) Non-CIP.

City of Mukilteo
Stormwater Management Plan
Projection of Revenue Requirements & Monthly Rates

Pay-as-you-go Capital Funding
Page: 5

	2000	2001	2002	2003	2004	2005
Projection of Cash Flow:						
Rate Revenues	$767,316	$778,826	$790,508	$802,366	$814,401	$826,617
Other Fees / Misc. Revenues	1,000	1,000	1,000	1,000	1,000	1,000
Operating Fund Interest	13,395	15,087	16,358	16,738	16,130	14,429
Interest on Bond Reserve	0	0	0	0	0	0
less: Operating Expenses (net Depreciation)	434,586	443,649	461,395	479,851	499,045	519,007
less: Addition to Operating Reserve	0	0	0	0	0	0
less: Total Debt Service	0	0	0	0	0	0
less: Rate-funded Capital Outlays	3,300	3,432	3,569	3,712	3,861	4,015
less: Pay-as-you-go CIP Funding	106,817	86,955	77,072	85,636	114,619	166,139
less: Direct Operating Fund Contributions (1)	0	0	0	0	0	0
less: Bond Reserve Funding	0	0	0	0	0	0
Net Cash	$237,008	$260,876	$265,830	$250,905	$214,006	$152,885
Net Deficiency (Surplus)	($237,008)	($260,876)	($265,830)	($250,905)	($214,006)	($152,885)
Test of Coverage Requirement:						
Operating Expenses	$434,586	$443,649	$461,395	$479,851	$499,045	$519,007
Debt Service - Revenue Bonds	0	0	0	0	0	0
Additional Coverage at 1.25	0	0	0	0	0	0
Total Revenue Req. with Coverage	$434,586	$443,649	$461,395	$479,851	$499,045	$519,007
Total Applicable Revenues	$781,711	$794,912	$807,866	$820,104	$831,531	$842,046
Net Funds less Coverage	$347,125	$351,263	$346,471	$340,253	$332,486	$323,038
Coverage Realized:	0.00	0.00	0.00	0.00	0.00	0.00
Revenue Deficiency (Surplus):	($347,125)	($351,263)	($346,471)	($340,253)	($332,486)	($323,038)
Projection of Revenue Sufficiency:						
Net Deficiency	$0	$0	$0	$0	$0	$0
Additional State Taxes	$0	$0	$0	$0	$0	$0
Total Deficiency	0	0	0	0	0	0
Total Revenue Generated from Rates	$ 767,316	$ 778,826	$ 790,508	$ 802,366	$ 814,401	$ 826,617
Cash Surplus	$237,008	$260,876	$265,830	$250,905	$214,006	$152,885
Cumulative Required Increase		0.00%	0.00%	0.00%	0.00%	0.00%
Annual Percent Increase Required		0.00%	0.00%	0.00%	0.00%	0.00%
Monthly Rate with Required Increase	$5.40	$5.40	$5.40	$5.40	$5.40	$5.40

NOTE

	2000	2001	2002	2003	2004	2005
(1) Direct Rate Funding (operations)	0	0	0	0	0	0

City of Mukilteo
Stormwater Management Plan
Projection of Funds Flows and Balances

Pay-as-you-go Capital Funding

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	2000	2001	2002	2003	2004	2005

Operating Fund Activity

	2000	2001	2002	2003	2004	2005
Beginning Balance (4)	$267,907	$301,732	$327,163	$334,768	$322,601	$288,570
plus: Additions to Fund to Meet MIN	0	0	0	0	0	0
plus: Direct Rate Contributions	0	0	0	0	0	0
less: Transfers to Capital Fund (> MAX)	203,183	235,445	258,224	263,072	248,037	211,024
plus: Ending Cash Surplus	237,008	260,876	265,830	250,905	214,006	152,885
Ending Balance	301,732	327,163	334,768	322,601	288,570	230,431
MIN Balance (30 days operating expenses)	*$43,149*	*$44,191*	*$45,959*	*$47,797*	*$49,709*	*$51,698*
MAX Balance (45 days operating expenses)	*$64,724*	*$66,287*	*$68,939*	*$71,696*	*$74,564*	*$77,547*

Capital Fund Activity

	2000	2001	2002	2003	2004	2005
Initial Balance	$0	$0	$0	$0	$0	$0
plus: Transfers from Operating Fund	$203,183	$235,445	$258,224	$263,072	$248,037	$211,024
less: Contribution to Project	203,183	235,445	258,224	263,072	248,037	211,024
plus: Fund Earnings	0	0	0	0	0	0
Ending Balance	$0	$0	$0	$0	$0	$(

City of Mukilteo
Stormwater Management Plan
Calculation of ERUs
- Estimates Only -

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Calculation of ERU's:

Square Feet per ERU: 2,500

ERUs lost to credits / delinquency (as %): 0.91%

Buildout ERUs: 17,700

Annual growth increment: 959 ERUs every year to buildout.

	2000	2001	2002	2003	2004	2005
Total ERUs	11,950	12,909	13,868	14,827	15,786	16,745
Lost ERUs	109	117	126	135	144	152
Net ERUs	11,841	12,792	13,742	14,692	15,642	16,593

City of Mukilteo
Stormwater Management Plan
Example Capital Facilities Charges

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CFC Calculation			Value	Notes
General Facilities Charge Calculation				
1.	**Cost Basis (original cost)**			
	Land	$	150,000	from comparative balance sheet (12/31/98)
	Pipe		4,571,325	from City staff estimates (12/31/99)
	Catch Basins		1,123,724	from City staff estimates (12/31/99)
	Subtotal	$	5,845,049	
	less: debt outstanding	$	-	
	less: contributions		(3,572,695)	from comparative balance sheet (12/31/98)
	Total	$	2,272,354	
	plus: ten years interest (1)		3,185,840	simple interest at prevailing rate
	Grand Total	$	5,458,194	
2.	**Capacity Basis**			
	Existing ERUs (2)		11,950	Equivalent Residential Units (ERUs)
	Growth in ERUs		5,750	ERUs
	Year 2006 ERUs		17,700	ERUs
3.	**Sample General Facilities Charge**			
	Cost Basis / Total ERUs	$	308	per ERU
System Development Charge Calculation				
1.	**Cost of Future Facilities**	$	13,524,000	to serve growth through 2006
2.	**Capacity Basis**			
	Year 2006 ERUs		17,700	ERUs
3.	**Sample System Development Charge**			
	Cost Basis / Total ERUs	$	764	per ERU
Capital Facilities Charge Calculation				
1.	General Facilities Charge	$	308	per ERU
2.	System Development Charge		764	per ERU
3.	Capital Facilities Charge	$	1,072	per ERU

NOTES

(1) Assumes average age of system is 18 years (from City staff estimates). Prevailing interest rate = 14.02% investment yield for T-bills 12/31/81.

(2) One ERU = 2,500 square feet of impervious surface area.

City of Mukilteo
Stormwater Rate Analysis
Summary of Key Findings

Scenario Description

Capital	Operations
Base Program	Base Program
	Catch Basin Cleaning
--	--
	--

This table describes the contents of the stormwater program for each rate scenario.

Year 2000 $'s

Projected Revenue Requirement and Rates: **Pay-as-you-go Capital Funding**

		2000		2001		2002		2003		2004		2005
Sources of Funds												
Beginning Fund Balances												
Operating Fund	$	267,907	$	301,732	$	132,163	$	93,941	$	93,941	$	93,941
Capital Fund		0		0		0		0		0		0
subtotal	$	267,907	$	301,732	$	132,163	$	93,941	$	93,941	$	93,941
Min. Operating Fund Balance	*$*	*43,149*	*$*	*60,219*	*$*	*62,628*	*$*	*65,133*	*$*	*67,738*	*$*	*70,448*
Revenues												
Operations												
Service Charge Revenues	$	767,316	$	778,826	$	959,732	$	1,041,013	$	1,083,186	$	1,127,050
Other Income		14,395		16,087		7,608		5,697		5,697		5,697
Capital												
Loan Proceeds		0		0		0		0		0		0
subtotal	$	781,711	$	794,912	$	967,340	$	1,046,710	$	1,088,883	$	1,132,747
Uses of Funds												
Expenditures												
Operations												
Cash Operating Expenses	$	434,586	$	638,649	$	664,195	$	690,763	$	718,394	$	747,130
Non-CIP Capital Outlays		3,300		3,432		3,569		3,712		3,861		4,015
Capital												
Debt Service	$	-	$	-	$	-	$	-	$	-	$	-
Capital Construction		310,000		322,400		335,296		348,708		362,656		377,162
Additional D. S. Covg.		-		-		-		-		-		-
subtotal	$	747,886	$	964,481	$	1,003,061	$	1,043,183	$	1,084,910	$	1,128,307
Ending Fund Balance	$	301,732	$	132,163	$	96,442	$	97,468	$	97,914	$	98,381
Resulting Monthly Rate per ESU	**$**	**5.40**	**$**	**5.40**	**$**	**5.80**	**$**	**5.90**	**$**	**5.90**	**$**	**5.90**
Annual % Increase Required				*0.00%*		*21.41%*		*6.87%*		*2.51%*		*2.51%*
Cumulative % Increase				*0.00%*		*21.41%*		*29.74%*		*33.00%*		*36.34%*

City of Mukilteo
Stormwater Rate Analysis
Summary of Key Findings

Scenario Description

Capital	Operations
Base Program	Base Program
	--
--	Detention Facility Maint.
	--

This table describes the contents of the stormwater program for each rate scenario.

Year 2000 $'s

Projected Revenue Requirement and Rates: **Pay-as-you-go Capital Funding**

		2000		2001		2002		2003		2004		2005
Sources of Funds												
Beginning Fund Balances												
Operating Fund	$	267,907	$	301,732	$	129,884	$	129,884	$	129,884	$	129,884
Capital Fund		0		0		0		0		0		0
subtotal	$	267,907	$	301,732	$	129,884	$	129,884	$	129,884	$	129,884
Min. Operating Fund Balance	*$*	*43,149*	*$*	*86,589*	*$*	*90,053*	*$*	*93,655*	*$*	*97,401*	*$*	*101,297*
Revenues												
Operations												
Service Charge Revenues	$	767,316	$	1,102,165	$	1,337,321	$	1,391,415	$	1,447,676	$	1,506,193
Other Income		14,395		16,087		7,494		7,494		7,494		7,494
Capital												
Loan Proceeds		0		0		0		0		0		0
subtotal	$	781,711	$	1,118,252	$	1,344,815	$	1,398,909	$	1,455,171	$	1,513,687
Uses of Funds												
Expenditures												
Operations												
Cash Operating Expenses	$	434,586	$	959,489	$	997,869	$	1,037,784	$	1,079,295	$	1,122,467
Non-CIP Capital Outlays		3,300		3,432		3,569		3,712		3,861		4,015
Capital												
Debt Service	$	-	$	-	$	-	$	-	$	-	$	-
Capital Construction		310,000		322,400		335,296		348,708		362,656		377,162
Additional D. S. Covg.		-		-		-		-		-		-
subtotal	$	747,886	$	1,285,321	$	1,336,734	$	1,390,204	$	1,445,812	$	1,503,644
Ending Fund Balance	$	301,732	$	134,662	$	137,965	$	138,589	$	139,243	$	139,927
Resulting Monthly Rate per ESU	$	5.40	$	7.20	$	8.10	$	8.10	$	8.10	$	8.10
Annual % Increase Required				*41.52%*		*19.54%*		*2.51%*		*2.51%*		*2.50%*
Cumulative % Increase				*41.52%*		*69.17%*		*73.41%*		*77.76%*		*82.21%*

City of Mukilteo
Stormwater Rate Analysis
Summary of Key Findings

Scenario Description

Capital	Operations
Base Program	Base Program
[redacted]	--
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[redacted]	Ditch Enclosure Program

This table describes the contents of the stormwater program for each rate scenario.

Year 2000 $'s

Projected Revenue Requirement and Rates: **Pay-as-you-go Capital Funding**

	2000	2001	2002	2003	2004	2005
Sources of Funds						
Beginning Fund Balances						
Operating Fund	$ 267,907	$ 301,732	$ 271,438	$ 271,438	$ 271,438	$ 271,438
Capital Fund	0	0	0	0	0	0
subtotal	$ 267,907	$ 301,732	$ 271,438	$ 271,438	$ 271,438	$ 271,438
Min. Operating Fund Balance	*$ 43,149*	*$ 180,959*	*$ 188,197*	*$ 195,725*	*$ 203,554*	*$ 211,696*
Revenues						
Operations						
Service Charge Revenues	$ 767,316	$ 2,411,225	$ 2,542,135	$ 2,644,708	$ 2,751,389	$ 2,862,342
Other Income	14,395	16,087	14,572	14,572	14,572	14,572
Capital						
Loan Proceeds	0	0	0	0	0	0
subtotal	$ 781,711	$ 2,427,311	$ 2,556,707	$ 2,659,280	$ 2,765,961	$ 2,876,914
Uses of Funds						
Expenditures						
Operations						
Cash Operating Expenses	$ 434,586	$ 2,107,649	$ 2,191,955	$ 2,279,634	$ 2,370,819	$ 2,465,652
Non-CIP Capital Outlays	3,300	3,432	3,569	3,712	3,861	4,015
Capital						
Debt Service	$ -	$ -	$ -	$ -	$ -	$ -
Capital Construction	310,000	322,400	335,296	348,708	362,656	377,162
Additional D. S. Covg.	-	-	-	-	-	-
subtotal	$ 747,886	$ 2,433,481	$ 2,530,821	$ 2,632,054	$ 2,737,336	$ 2,846,829
Ending Fund Balance	$ 301,732	$ 295,562	$ 297,324	$ 298,665	$ 300,063	$ 301,522
Resulting Monthly Rate per ESU	**$ 5.40**	**$ 15.70**	**$ 15.70**	**$ 15.70**	**$ 15.70**	**$ 15.70**
Annual % Increase Required		*209.60%*	*3.87%*	*2.50%*	*2.50%*	*2.50%*
Cumulative % Increase		*209.60%*	*221.58%*	*229.61%*	*237.84%*	*246.27%*

City of Mukilteo
Stormwater Rate Analysis
Summary of Key Findings

Scenario Description

Capital	Operations
Base Program	Base Program
[redacted]	--
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[redacted]	Ditch Enclosure Program

This table describes the contents of the stormwater program for each rate scenario.

Year 2000 $'s

Projected Revenue Requirement and Rates: Pay-as-you-go Capital Funding

		2000		2001		2002		2003		2004		2005
Sources of Funds												
Beginning Fund Balances												
Operating Fund	$	267,907	$	301,732	$	165,016	$	165,016	$	165,016	$	165,016
Capital Fund		0		0		0		0		0		0
subtotal	$	267,907	$	301,732	$	165,016	$	165,016	$	165,016	$	165,016
Min. Operating Fund Balance	*$*	*43,149*	*$*	*110,011*	*$*	*114,411*	*$*	*118,987*	*$*	*123,747*	*$*	*128,697*
Revenues												
Operations												
Service Charge Revenues	$	767,316	$	1,427,058	$	1,636,342	$	1,702,468	$	1,771,243	$	1,842,773
Other Income		14,395		16,087		9,251		9,251		9,251		9,251
Capital												
Loan Proceeds		0		0		0		0		0		0
subtotal	$	781,711	$	1,443,145	$	1,645,593	$	1,711,718	$	1,780,494	$	1,852,024
Uses of Funds												
Expenditures												
Operations												
Cash Operating Expenses	$	434,586	$	1,244,449	$	1,294,227	$	1,345,997	$	1,399,836	$	1,455,830
Non-CIP Capital Outlays		3,300		3,432		3,569		3,712		3,861		4,015
Capital												
Debt Service	$	-	$	-	$	-	$	-	$	-	$	-
Capital Construction		310,000		322,400		335,296		348,708		362,656		377,162
Additional D. S. Covg.		-		-		-		-		-		-
subtotal	$	747,886	$	1,570,281	$	1,633,093	$	1,698,416	$	1,766,353	$	1,837,007
Ending Fund Balance	$	301,732	$	174,596	$	177,516	$	178,318	$	179,156	$	180,033
Resulting Monthly Rate per ESU	**$**	**5.40**	**$**	**9.30**	**$**	**9.90**	**$**	**9.90**	**$**	**9.90**	**$**	**9.90**
Annual % Increase Required				*83.23%*		*12.97%*		*2.50%*		*2.50%*		*2.50%*
Cumulative % Increase				*83.23%*		*107.00%*		*112.18%*		*117.49%*		*122.93%*

City of Mukilteo
Stormwater Rate Analysis
Summary of Key Findings

Scenario Description

Capital	Operations
Base Program	Base Program
[redacted]	--
Twenty-year CIP	--
[redacted]	--

This table describes the contents of the stormwater program for each rate scenario.

Year 2000 $'s

Projected Revenue Requirement and Rates: **Pay-as-you-go Capital Funding**

	2000	2001	2002	2003	2004	2005
Sources of Funds						
Beginning Fund Balances						
Operating Fund	$ 267,907	$ 301,732	$ 66,287	$ 66,287	$ 66,287	$ 66,287
Capital Fund	0	0	0	0	0	0
subtotal	$ 267,907	$ 301,732	$ 66,287	$ 66,287	$ 66,287	$ 66,287
Min. Operating Fund Balance	*$ 43,149*	*$ 44,191*	*$ 45,959*	*$ 47,797*	*$ 49,709*	*$ 51,698*
Revenues						
Operations						
Service Charge Revenues	$ 767,316	$ 900,386	$ 1,197,832	$ 1,246,216	$ 1,296,541	$ 1,348,883
Other Income	14,395	16,087	4,314	4,314	4,314	4,314
Capital						
Loan Proceeds	0	0	0	0	0	0
subtotal	$ 781,711	$ 916,473	$ 1,202,146	$ 1,250,531	$ 1,300,855	$ 1,353,198
Uses of Funds						
Expenditures						
Operations						
Cash Operating Expenses	$ 434,586	$ 443,649	$ 461,395	$ 479,851	$ 499,045	$ 519,007
Non-CIP Capital Outlays	3,300	3,432	3,569	3,712	3,861	4,015
Capital						
Debt Service	$ -	$ -	$ -	$ -	$ -	$ -
Capital Construction	310,000	703,040	731,162	760,408	790,824	822,457
Additional D. S. Covg.	-	-	-	-	-	-
subtotal	$ 747,886	$ 1,150,121	$ 1,196,126	$ 1,243,971	$ 1,293,730	$ 1,345,479
Ending Fund Balance	$ 301,732	$ 68,084	$ 72,307	$ 72,847	$ 73,412	$ 74,005
Resulting Monthly Rate per ESU	**$ 5.40**	**$ 5.85**	**$ 7.25**	**$ 7.25**	**$ 7.25**	**$ 7.25**
Annual % Increase Required		*15.61%*	*31.07%*	*2.50%*	*2.50%*	*2.50%*
Cumulative % Increase		*15.61%*	*51.53%*	*55.32%*	*59.20%*	*63.18%*

City of Mukilteo
Stormwater Rate Analysis
Summary of Key Findings

Scenario Description

Capital	Operations
Base Program	Base Program
	--
Ten-year CIP	--
	--

This table describes the contents of the stormwater program for each rate scenario.

Year 2000 $'s

Projected Revenue Requirement and Rates: **Pay-as-you-go Capital Funding**

	2000	2001	2002	2003	2004	2005
Sources of Funds						
Beginning Fund Balances						
Operating Fund	$ 267,907	$ 301,732	$ 66,287	$ 66,287	$ 66,287	$ 66,287
Capital Fund	0	0	0	0	0	0
subtotal	$ 267,907	$ 301,732	$ 66,287	$ 66,287	$ 66,287	$ 66,287
Min. Operating Fund Balance	*$ 43,149*	*$ 44,191*	*$ 45,959*	*$ 47,797*	*$ 49,709*	*$ 51,698*
Revenues						
Operations						
Service Charge Revenues	$ 767,316	$ 1,615,027	$ 1,941,058	$ 2,019,172	$ 2,100,415	$ 2,184,912
Other Income	14,395	16,087	4,314	4,314	4,314	4,314
Capital						
Loan Proceeds	0	0	0	0	0	0
subtotal	$ 781,711	$ 1,631,114	$ 1,945,373	$ 2,023,487	$ 2,104,730	$ 2,189,227
Uses of Funds						
Expenditures						
Operations						
Cash Operating Expenses	$ 434,586	$ 443,649	$ 461,395	$ 479,851	$ 499,045	$ 519,007
Non-CIP Capital Outlays	3,300	3,432	3,569	3,712	3,861	4,015
Capital						
Debt Service	$ -	$ -	$ -	$ -	$ -	$ -
Capital Construction	310,000	1,407,120	1,463,405	1,521,941	1,582,819	1,646,131
Additional D. S. Covg.	-	-	-	-	-	-
subtotal	$ 747,886	$ 1,854,201	$ 1,928,369	$ 2,005,504	$ 2,085,724	$ 2,169,153
Ending Fund Balance	$ 301,732	$ 78,645	$ 83,290	$ 84,270	$ 85,292	$ 86,360
Resulting Monthly Rate per ESU	**$ 5.40**	**$ 10.50**	**$ 11.75**	**$ 11.75**	**$ 11.75**	**$ 11.75**
Annual % Increase Required		*107.37%*	*18.41%*	*2.49%*	*2.49%*	*2.49%*
Cumulative % Increase		*107.37%*	*145.55%*	*151.65%*	*157.91%*	*164.32%*

City of Mukilteo
Stormwater Rate Analysis
Summary of Kèy Findings

Scenario Description

Capital	Operations
Base Program	Base Program
[redacted]	--
Six-year CIP	--
[redacted]	--

This table describes the contents of the stormwater program for each rate scenario.

Year 2000 $'s

Projected Revenue Requirement and Rates: Pay-as-you-go Capital Funding

		2000	2001	2002	2003	2004	2005
Sources of Funds							
Beginning Fund Balances							
Operating Fund		$ 267,907	$ 301,732	$ 66,287	$ 66,287	$ 66,287	$ 66,287
Capital Fund		0	0	0	0	0	0
	subtotal	$ 267,907	$ 301,732	$ 66,287	$ 66,287	$ 66,287	$ 66,287
Min. Operating Fund Balance		*$ 43,149*	*$ 44,191*	*$ 45,959*	*$ 47,797*	*$ 49,709*	*$ 51,698*
Revenues							
Operations							
Service Charge Revenues		$ 767,316	$ 2,566,123	$ 2,930,198	$ 3,047,877	$ 3,170,268	$ 3,297,560
Other Income		14,395	16,087	4,314	4,314	4,314	4,314
Capital							
Loan Proceeds		0	0	0	0	0	0
	subtotal	$ 781,711	$ 2,582,210	$ 2,934,512	$ 3,052,192	$ 3,174,583	$ 3,301,874
Uses of Funds							
Expenditures							
Operations							
Cash Operating Expenses		$ 434,586	$ 443,649	$ 461,395	$ 479,851	$ 499,045	$ 519,007
Non-CIP Capital Outlays		3,300	3,432	3,569	3,712	3,861	4,015
Capital							
Debt Service		$ -	$ -	$ -	$ -	$ -	$ -
Capital Construction		310,000	2,344,160	2,437,926	2,535,443	2,636,861	2,742,336
Additional D. S. Covg.		-	-	-	-	-	-
	subtotal	$ 747,886	$ 2,791,241	$ 2,902,891	$ 3,019,007	$ 3,139,767	$ 3,265,358
Ending Fund Balance		$ 301,732	$ 92,700	$ 97,908	$ 99,472	$ 101,103	$ 102,804
Resulting Monthly Rate per ESU		**$ 5.40**	**$ 16.70**	**$ 17.75**	**$ 17.75**	**$ 17.75**	**$ 17.75**
Annual % Increase Required			*229.49%*	*12.50%*	*2.48%*	*2.48%*	*2.48%*
Cumulative % Increase			*229.49%*	*270.67%*	*279.86%*	*289.28%*	*298.92%*

City of Mukilteo
Stormwater Rate Analysis
Summary of Key Findings

Scenario Description

Capital	Operations
Base Program	Base Program
[redacted]	--
20-yr CR CIP	--
[redacted]	--

This table describes the contents of the stormwater program for each rate scenario.

Year 2000 $'s

Projected Revenue Requirement and Rates: **Pay-as-you-go Capital Funding**

	2000	2001	2002	2003	2004	2005
Sources of Funds						
Beginning Fund Balances						
Operating Fund	$ 267,907	$ 301,732	$ 68,723	$ 68,723	$ 68,723	$ 68,723
Capital Fund	0	0	0	0	0	0
subtotal	$ 267,907	$ 301,732	$ 68,723	$ 68,723	$ 68,723	$ 68,723
Min. Operating Fund Balance	*$ 43,149*	*$ 44,191*	*$ 45,959*	*$ 47,797*	*$ 49,709*	*$ 51,698*
Revenues						
Operations						
Service Charge Revenues	$ 767,316	$ 778,826	$ 1,068,714	$ 1,111,939	$ 1,156,897	$ 1,203,659
Other Income	14,395	16,087	4,436	4,436	4,436	4,436
Capital						
Loan Proceeds	0	0	0	0	0	0
subtotal	$ 781,711	$ 794,912	$ 1,073,150	$ 1,116,375	$ 1,161,333	$ 1,208,0
Uses of Funds						
Expenditures						
Operations						
Cash Operating Expenses	$ 434,586	$ 443,649	$ 461,395	$ 479,851	$ 499,045	$ 519,007
Non-CIP Capital Outlays	3,300	3,432	3,569	3,712	3,861	4,015
Capital						
Debt Service	$ -	$ -	$ -	$ -	$ -	$ -
Capital Construction	310,000	580,840	604,074	628,237	653,366	679,501
Additional D. S. Covg.	-	-	-	-	-	-
subtotal	$ 747,886	$ 1,027,921	$ 1,069,038	$ 1,111,800	$ 1,156,272	$ 1,202,523
Ending Fund Balance	$ 301,732	$ 68,723	$ 72,834	$ 73,298	$ 73,784	$ 74,295
Resulting Monthly Rate per ESU	**$ 5.40**	**$ 5.40**	**$ 6.50**	**$ 6.50**	**$ 6.50**	**$ 6.50**
Annual % Increase Required		*0.00%*	*35.19%*	*2.51%*	*2.51%*	*2.50%*
Cumulative % Increase		*0.00%*	*35.19%*	*38.58%*	*42.05%*	*45.61%*

City of Mukilteo
Stormwater Rate Analysis
Summary of Key Findings

Scenario Description

Capital	Operations
Base Program	Base Program
[redacted]	--
10-yr CR CIP	--
[redacted]	--

This table describes the contents of the stormwater program for each rate scenario.

Year 2000 $'s

Projected Revenue Requirement and Rates: **Pay-as-you-go Capital Funding**

	2000	2001	2002	2003	2004	2005
Sources of Funds						
Beginning Fund Balances						
Operating Fund	$ 267,907	$ 301,732	$ 66,287	$ 66,287	$ 66,287	$ 66,287
Capital Fund	0	0	0	0	0	0
subtotal	$ 267,907	$ 301,732	$ 66,287	$ 66,287	$ 66,287	$ 66,287
Min. Operating Fund Balance	*$ 43,149*	*$ 44,191*	*$ 45,959*	*$ 47,797*	*$ 49,709*	*$ 51,698*
Revenues						
Operations						
Service Charge Revenues	$ 767,316	$ 1,038,670	$ 1,341,646	$ 1,395,784	$ 1,452,091	$ 1,510,656
Other Income	14,395	16,087	4,314	4,314	4,314	4,314
Capital						
Loan Proceeds	0	0	0	0	0	0
subtotal	$ 781,711	$ 1,054,757	$ 1,345,961	$ 1,400,098	$ 1,456,406	$ 1,514,970
Uses of Funds						
Expenditures						
Operations						
Cash Operating Expenses	$ 434,586	$ 443,649	$ 461,395	$ 479,851	$ 499,045	$ 519,007
Non-CIP Capital Outlays	3,300	3,432	3,569	3,712	3,861	4,015
Capital						
Debt Service	$ -	$ -	$ -	$ -	$ -	$ -
Capital Construction	310,000	839,280	872,851	907,765	944,076	981,839
Additional D. S. Covg.	-	-	-	-	-	-
subtotal	$ 747,886	$ 1,286,361	$ 1,337,816	$ 1,391,329	$ 1,446,982	$ 1,504,861
Ending Fund Balance	$ 301,732	$ 70,127	$ 74,432	$ 75,057	$ 75,711	$ 76,396
Resulting Monthly Rate per ESU	**$ 5.40**	**$ 6.75**	**$ 8.15**	**$ 8.15**	**$ 8.15**	**$ 8.15**
Annual % Increase Required		*33.36%*	*27.26%*	*2.50%*	*2.50%*	*2.50%*
Cumulative % Increase		*33.36%*	*69.72%*	*73.96%*	*78.30%*	*82.75%*

City of Mukilteo
Stormwater Rate Analysis
Summary of Key Findings

Scenario Description

Capital	Operations
Base Program	Base Program
[redacted]	--
6-yr CR CIP	--
[redacted]	--

This table describes the contents of the stormwater program for each rate scenario.

Year 2000 $'s

Projected Revenue Requirement and Rates: **Pay-as-you-go Capital Funding**

	2000	2001	2002	2003	2004	2005
Sources of Funds						
Beginning Fund Balances						
Operating Fund	$ 267,907	$ 301,732	$ 66,287	$ 66,287	$ 66,287	$ 66,287
Capital Fund	0	0	0	0	0	0
subtotal	$ 267,907	$ 301,732	$ 66,287	$ 66,287	$ 66,287	$ 66,287
Min. Operating Fund Balance	*$ 43,149*	*$ 44,191*	*$ 45,959*	*$ 47,797*	*$ 49,709*	*$ 51,698*
Revenues						
Operations						
Service Charge Revenues	$ 767,316	$ 1,388,425	$ 1,705,392	$ 1,774,079	$ 1,845,519	$ 1,919,820
Other Income	14,395	16,087	4,314	4,314	4,314	4,314
Capital						
Loan Proceeds	0	0	0	0	0	^
subtotal	$ 781,711	$ 1,404,512	$ 1,709,706	$ 1,778,394	$ 1,849,833	$ 1,924,1
Uses of Funds						
Expenditures						
Operations						
Cash Operating Expenses	$ 434,586	$ 443,649	$ 461,395	$ 479,851	$ 499,045	$ 519,007
Non-CIP Capital Outlays	3,300	3,432	3,569	3,712	3,861	4,015
Capital						
Debt Service	$ -	$ -	$ -	$ -	$ -	$ -
Capital Construction	310,000	1,183,867	1,231,221	1,280,470	1,331,689	1,384,957
Additional D. S. Covg.	-	-	-	-	-	-
subtotal	$ 747,886	$ 1,630,948	$ 1,696,186	$ 1,764,033	$ 1,834,595	$ 1,907,979
Ending Fund Balance	$ 301,732	$ 75,296	$ 79,808	$ 80,647	$ 81,525	$ 82,443
Resulting Monthly Rate per ESU	**$ 5.40**	**$ 9.05**	**$ 10.35**	**$ 10.35**	**$ 10.35**	**$ 10.35**
Annual % Increase Required		*78.27%*	*21.01%*	*2.49%*	*2.49%*	*2.49%*
Cumulative % Increase		*78.27%*	*115.73%*	*121.11%*	*126.61%*	*132.25%*