City and Borough of Sitka

Stormwater Management Plan

FINAL

June 2013

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City and Borough of Sitka
STORMWATER MANAGEMENT PLAN

FINAL

JUNE 2013

Prepared for:
City and Borough of Sitka
Department of Public Works
100 Lincoln Street
Sitka, Alaska 99835

Prepared by:

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Project #T30692

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CHAPTER 1.
INTRODUCTION

Stormwater is the excess surface flow from rain and snowmelt that does not infiltrate. Sensible regulation and guidance in the development of stormwater infrastructure will result in conveyance systems that provide a greater level for service and a longer service life with lower maintenance costs. Flooding and erosion caused by poorly designed infrastructure can damage structures and threaten human safety. Conditions are potentially hazardous in Sitka, Alaska, due to steep slopes, unstable soils, poorly infiltrating soils, and freezing weather. Surface runoff can transport eroded sediment and pollutants from the built environment that can be harmful to human health and the greater environment. As the effects of stormwater pollution are more widely recognized, regulation of stormwater quality by state and federal agencies has increased. Municipalities that are proactive in addressing stormwater pollution will improve local water quality conditions and may face less regulation and associated expenses.

The City and Borough of Sitka (CBS) has recently begun a new phase of stormwater planning. This document is intended to guide the local government in decisions affecting stormwater management for the next 5 to 10 years. The CBS covers an enormous area. The precipitation analysis conducted as part of this plan addresses precipitation conditions throughout the Borough. Most of this plan, however, including the capital improvement project drainage problem assessment, addresses the urbanized area of Sitka from Starrigavan Creek east to Sawmill Creek (Figure 1-1). The purpose of this plan is to:

- Consolidate and present accumulated information on precipitation, soils, and topography useful in assessing stormwater runoff rates and volumes.
- Conduct hydrologic modeling.
- Assess and prioritize known drainage problems and develop a program for addressing these problems.
- Assess regulatory conditions regarding stormwater in Sitka.
- Assess low impact development and use of stormwater best management practices to improve runoff water quality and decrease peak runoff rates and volumes.
- Provide recommendations for action and further work.

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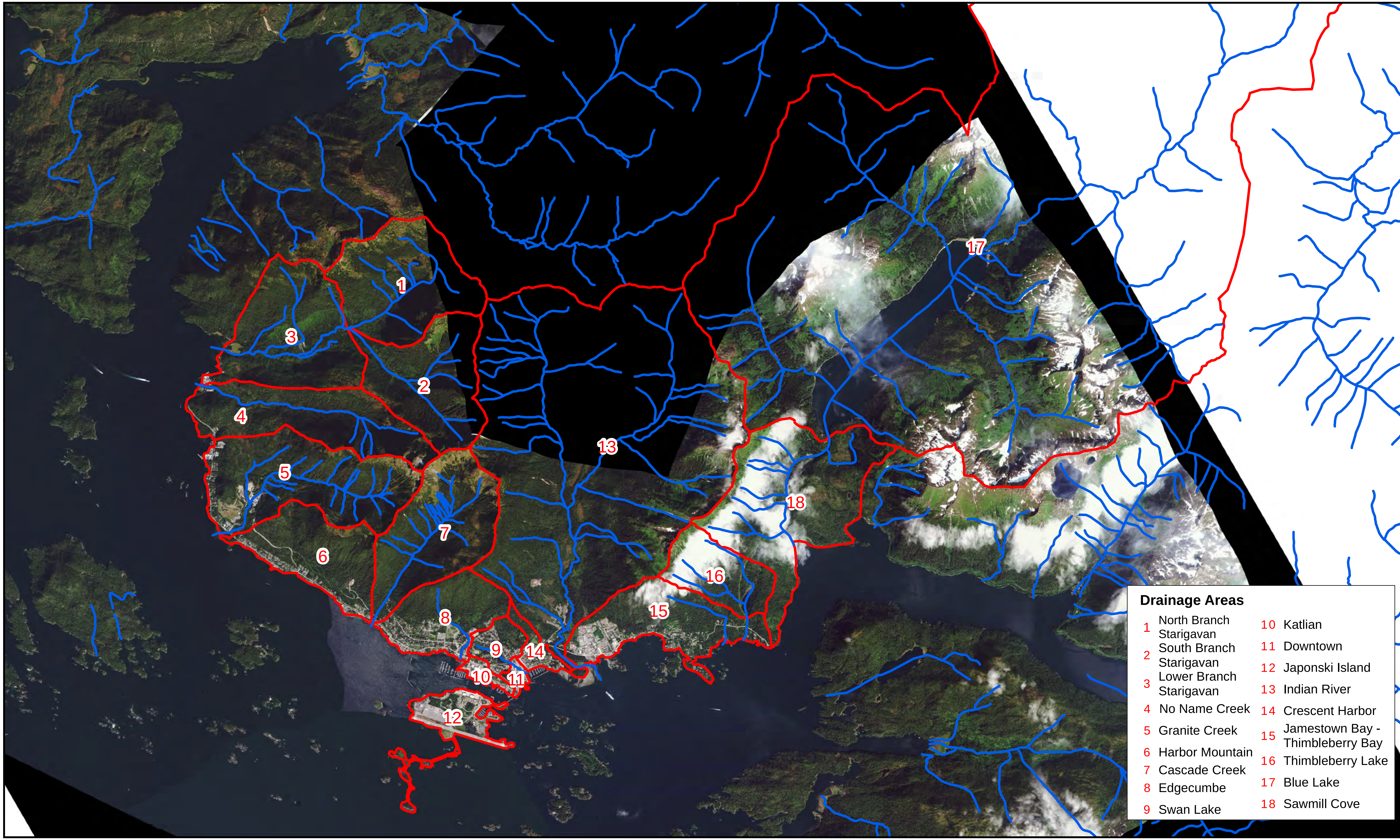

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CITY AND BOROUGH OF SITKA

Stormwater Management Plan

Figure 1 - 1

STUDY LOCATION & DRAINAGE AREAS

0 0.25 0.5 0.75 1 Kilometers

0 0.25 0.5 0.75 1 Miles

N

Legend

1:72,000

Drainage Areas

Streams

CHAPTER 2.
STORMWATER REGULATIONS

EXISTING FEDERAL, STATE AND LOCAL STORMWATER REGULATIONS

Stormwater is regulated by a range of federal, state, and local rules and laws. Relevant regulations are summarized in Table 2-1. Additional detail is found in Alaska Department of Environmental Conservation's (ADEC's) *Alaska Storm Water Guide*.

TABLE 2-1.
SUMMARY OF FEDERAL, STATE, AND LOCAL STORMWATER REGULATIONS

Program or Permit	Who is Regulated?	Description
National Pollutant Discharge Elimination System (NPDES) Municipal Stormwater Permit	U.S. Environmental Protection Agency (EPA)-designated for medium-sized cities	Requires development of a program that: regulates stormwater practices for new development, redevelopment, and construction sites; identifies and eliminates illicit discharges to the stormwater system; provides public education and involvement; and implements an operations and maintenance program for municipal operations.
NPDES General permit for Stormwater Discharges from Construction Activity (also known as the Construction General Permit [CGP])	Construction operators for sites with more than 1 acre of disturbance	Requires operators to develop and implement a Stormwater Pollution Prevention Plan (SWPPP) to define measures to be taken to reduce erosion and pollution during construction. For guidance on developing a SWPPP and design of construction site BMPs, refer to the ADOT&PF *Alaska Stormwater Pollution Prevention Plan Guide*.
NPDES Multi-Sector General Permit (MSGP) for stormwater from industrial sites	EPA-designated industrial activities	The MSGP requires permitted industrial facilities, including those owned or operated by municipalities, to develop a site-specific SWPPP to control stormwater pollution. In Sitka, this permit has been required for affected gravel operations and mines. Satisfying the requirements of this manual will not relieve the responsibility of obtaining an industrial stormwater discharge permit.
Federal Clean Water Act Section 401 Water Quality Certification	Project proponent for any project that may impact water quality in a regulated water body	Requires any applicant for a federal permit for any activity that may affect the quality of waters of the U.S. to also obtain a water quality permit from the state in which the discharge originates or will originate. In Alaska, the ADEC issues water quality permits.

TABLE 2-1. CONTINUED
SUMMARY OF FEDERAL, STATE, AND LOCAL STORMWATER REGULATIONS

Program or Permit	Who is Regulated?	Description
United States Army Corps of Engineers 404 Permit	Project proponents where any sort of fill material will be added to a regulated water body	Section 404 of the Clean Water Act authorizes the Secretary of the Army to issue permits for the discharge of dredged or fill material into waters of the U.S., including navigable waters and wetlands. The term “discharges of fill material” means the addition of rock, sand, dirt, concrete, or other material into the waters of the U.S. incidental to construction of any structure. A Section 404 permit may require stormwater quality or quantity best management practices as mitigation.
The Coastal Zone Act Reauthorization Amendments of 1990	Project proponent for any project that may impact water quality in a regulated water body	This act requires that every state participating in the federal Coastal Management Program use erosion and sediment control management measures. The Alaska Coastal Management Program (ACMP) requires that estuaries, wetlands, tide flats, lagoons, rivers, streams, and lakes be managed to protect natural vegetation, important fish and wildlife habitat, and natural water flow. The ACMP states that contractors for projects within the coastal zone must use “all feasible and prudent steps to maximize conformance” with this requirement. State and federal resource agencies that issue permits often require erosion control measures to ensure that a project will be consistent with the ACMP.
Endangered Species Act	Any activities that may injure an endangered species within its critical habitat are subject to review and regulation.	There currently are no endangered species in the Sitka area. In 1990, the eastern stock of Steller sea lion was listed as threatened by the National Marine Fisheries Service. The Endangered Species Act can be used to introduce increased stormwater regulation through federal programs such as the National Flood Insurance Program. Given the relatively small population and few other municipalities in the area, this may be unlikely.
Impaired Water Body List (303[d] list) and Water Cleanup Plans (TMDLs)	ADEC, residents and businesses within each watershed	The EPA requires the State of Alaska to periodically prepare a list of all surface waters in the state for which beneficial uses—such as drinking, recreation, aquatic habitat, and industrial use—are impaired by pollutants. Waters placed on the 303(d) list require the preparation of total maximum daily load (TMDL) plans. TMDLs identify the maximum amount of a pollutant to be allowed to be released into a water body so as not to impair uses of the water, and allocate that amount among various sources. TMDLs for residues, debris, solid waste, sediment and turbidity have been developed for several watersheds near downtown in Sitka (Granite, Swan Lake, Herring Cove, and Silver Bay). These TMDLs all identify stormwater runoff as a major source of pollutants and recommend that CBS develop a stormwater management program.

TABLE 2-1. CONTINUED
SUMMARY OF FEDERAL, STATE, AND LOCAL STORMWATER REGULATIONS

Program or Permit	Who is Regulated?	Description
Stormwater Disposal Plans, ADEC	Project proponent	Modification of a stormwater treatment or disposal system requires approval of ADEC per 18 AAC 72.600.
Alaska Statute 41.14.870, Anadromous Fish Act	Project proponent	The Alaska Department of Fish and Game (ADF&G) regulates construction activities that affect freshwater anadromous fish habitat. Any activity that will pollute or change the natural flow or bed of a stream important for the spawning, rearing, or migration of anadromous fish must be approved by ADF&G to ensure that the construction plans and specifications will protect fish and game. The ADF&G permit often requires an erosion and sediment control plan.
CBS Codes and Ordinances	Project proponent	Local regulations affecting surface water, stormwater, and water quality are found in CBS Municipal Code Titles 15, 19, 21 and 22. Stormwater regulations are limited but include providing detail on existing and proposed drainage in plat and conditional use permit applications, providing easements for water courses and preserving flood-prone land.

STORMWATER ORDINANCE MODIFICATIONS

The aim of a good stormwater ordinance is to provide property owners with the guidance to properly, safely, and efficiently design and construct drainage projects and in some cases to pass this infrastructure to the municipal owner to maintain. New ordinances would provide CBS permitting staff with the tools to ensure that stormwater facilities are built to modern and safe standards while allowing flexibility in implementation. An example of a proposed ordinance developed for the City of Ketchikan but appropriate to the CBS is included in Appendix A. This ordinance is consolidated in a single new title. Major issues of the ordinance are described in the following sections.

Special Drainage Use Areas

Existing open channel and piped drainage networks with drainage areas greater than 2 acres or with pipe diameters greater than 24 inches have been designated as Special Drainage Use Areas. The intent of the classification is to indicate to the public and CBS staff that these areas will face greater scrutiny during the permitting process and greater scrutiny for monitoring and maintenance.

Required Grading Permit

A grading permit is required for projects that alter a site’s stormwater drainage, including modification of the existing open channel and pipe drainage network, construction of over 2,000 square feet of new impervious surface, and logging or clearing in excess of 5,000 square feet. Depending on the scale and impact of the proposed project, the Director of Public works can require a detailed drainage plan be developed as part of the permit application.

Drainage Control Standards and Guidelines

Currently, CBS applies an ad hoc set of drainage construction and design standards. A comprehensive and modern set of standards will help promote the consistent and efficient development of stormwater infrastructure. The drainage standards should be developed and referenced in a new ordinance.

Easements

The CBS is required to obtain easements or dedicated tracts for maintenance access from private property owners for open channel and pipe networks that convey stormwater through a property. Required easement and maintenance access dimensions are detailed in the ordinance. Easements are not required for drainage infrastructure draining a single property, such as roof or yard drains.

Erosion and Sediment Control

Erosion and sediment control is required for all construction projects. Erosion and sediment control practices can include structural measures, such as silt fences and stockpile covers, and non-structural measures, such as work restrictions during periods of intense rain. An erosion control plan, as developed for the ADEC, is required to be submitted to CBS as part of the grading permit application for projects with a proposed land disturbance of 1 acre or more.

Prohibited Acts

The proposed ordinance prohibits various acts, including dumping trash and debris in the public drainage system or allowing pollutants to enter the public drainage system. The ordinance authorizes CBS to enforce these prohibitions as a misdemeanor.

CHAPTER 3.
SITKA HYDROLOGY

PRECIPITATION

Precipitation Summary

Sitka enjoys a cool maritime climate with abundant rainfall. Annual rainfall totals in Sitka city are approximately 90 inches per year (Sitka Japonski Airport, 50-8494 and Sitka Magnetic Observatory, 50-8503). Annual rainfall totals will vary considerably by location due to weather patterns, aspect, and orographic effects. Peak intensity rainfall for short-duration storm events typically occurs during convective storms in the late summer and early autumn. Peak rainfall intensities are more spatially uniform; therefore, the rainfall intensities developed as part of this study can be applied through the developed areas around the City of Sitka. Sitka averages about 35 inches of snow per year mostly falling in October through April (Sitka Japonski Airport, 50-8494, 1972-1996). However, snow does not usually persist or accumulate.

Precipitation Analysis

An analysis of precipitation in the Borough was conducted to develop data for hydrologic studies and design of hydraulic structures. Data deliverables include:

- Intensity-duration-frequency (IDF) curves for 5- to 60-minute durations from 2- to 100-year return intervals,
- Nested, scalable short-duration (1- and 2-hour) storm hyetographs,
- Five scalable, long-duration (up to 72 hours) storm hyetographs,
- 24-hour rainfall totals for 2- to 100-year return intervals for two gages located near downtown, and
- Method and data for calculating 24-hour totals for areas in the Borough outside of the downtown area.

The analysis used precipitation from the National Oceanic and Atmospheric Administration (NOAA) rainfall gages within the Borough. These gages generally recorded data at a daily interval; therefore, the analysis also used data gathered at shorter durations (5-minute and hourly) at sites elsewhere in southeast Alaska, British Columbia, and Washington State. The complete Precipitation Frequency Analysis is found in Appendix B.

Maximum 24-Hour Precipitation

Maximum 24-hour precipitation for the Sitka area was developed using the daily or 24-hour rainfall data from Sitka, Annette Airport, Prince Rupert, and McInnis Island (NOAA). The results for the two gages in the Sitka area are shown in Table 3-1.

TABLE 3-1.
24-HOUR MAXIMUM PRECIPITATION (INCHES)

Station	Recurrence Interval (years)							
	2	5	10	25	50	100	200	500
Sitka Rocky Gutierrez Airport	3.75	4.50	5.05	5.85	6.45	7.10	7.75	8.65
Sitka Magnetic Observatory	3.90	4.65	5.20	6.05	6.70	7.40	8.05	9.00

Intensity-Duration-Frequency Curves

Rainfall IDF curves were developed by applying precipitation frequency data from other climatologically similar areas in Alaska and British Columbia to the Sitka area. This was necessary because there are no long-term records of hourly or sub-hourly precipitation for Sitka. Resulting IDF data are shown in Tables 3-2 and 3-3. The IDF curves are plotted in Figure 3-1.

TABLE 3-2.
PRECIPITATION INTENSITIES FOR IDF RELATIONSHIP FOR SITKA AREA (IN/HR)

Duration (minutes)	Recurrence Interval (years)					
	2	5	10	25	50	100
5	1.70	2.32	2.78	3.50	4.08	4.73
10	1.27	1.67	1.99	2.38	2.86	3.29
15	1.08	1.37	1.62	1.95	2.27	2.65
20	0.95	1.20	1.42	1.70	1.95	2.25
30	0.78	0.98	1.14	1.38	1.58	1.80
45	0.63	0.78	0.90	1.08	1.23	1.40
60	0.59	0.72	0.82	0.99	1.12	1.26

TABLE 3-3.
PRECIPITATION DEPTHS FOR IDF RELATIONSHIP FOR SITKA AREA (INCHES)

Duration (minutes)	Recurrence Interval (years)					
	2	5	10	25	50	100
5	0.14	0.20	0.23	0.29	0.34	0.39
10	0.21	0.28	0.33	0.40	0.48	0.55
15	0.27	0.34	0.41	0.49	0.57	0.66
20	0.32	0.40	0.47	0.57	0.65	0.75
30	0.39	0.49	0.57	0.69	0.79	0.90
45	0.47	0.59	0.67	0.81	0.93	1.05
60	0.59	0.72	0.82	0.99	1.12	1.26

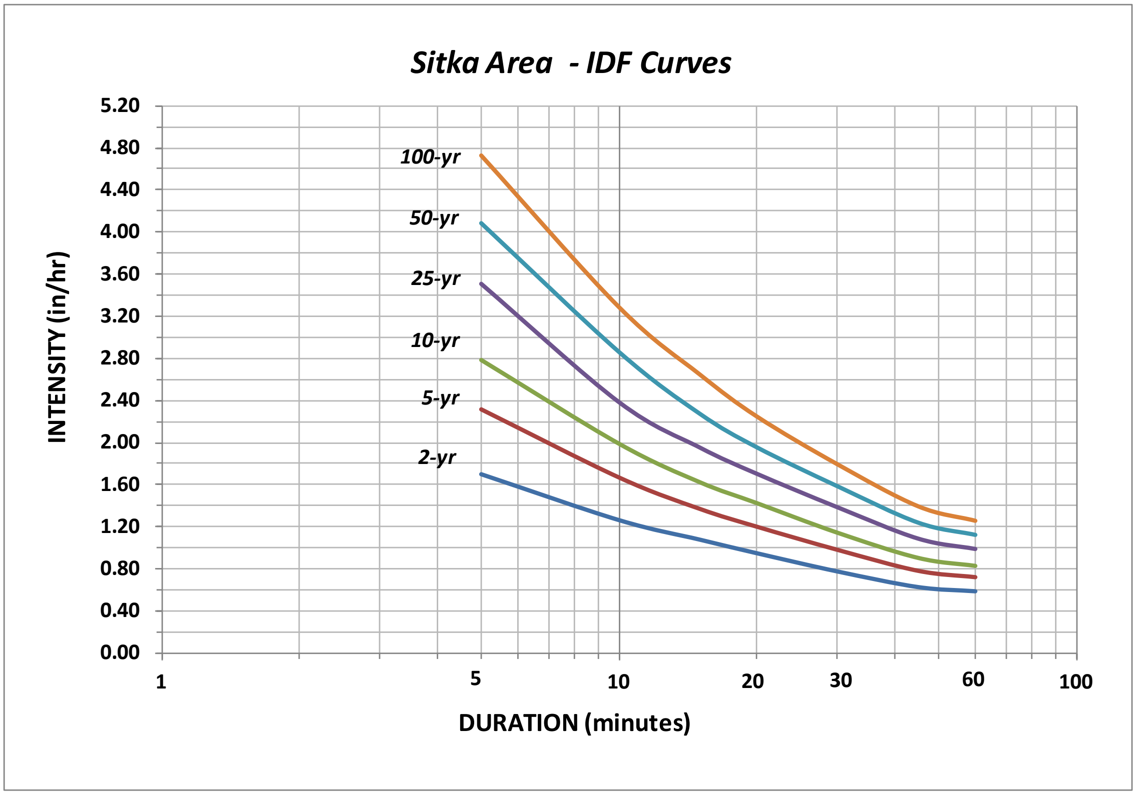

Figure 3-1. Intensity-duration-frequency curves for Sitka area

Scalable Short-Duration Design Hyetograph

A hyetograph (a chart showing discrete rainfall amounts over time) is typically used as an input to a rainfall-runoff model to size conveyance facilities in small urbanized basins. A synthetic short-duration design storm was assembled using the incremental precipitation amounts obtained from the IDF curve values (Table 3-2). Figure 3-2 depicts the short-duration design hyetograph for a 50-year recurrence interval. The design storm is scalable to other recurrence intervals using the ratio of 60-minute precipitation amount for the desired recurrence interval to that of the 50-year recurrence interval (see 60-minute row in Table 3-3). A spreadsheet provided to CBS can be used for automatically scaling and plotting design storms.

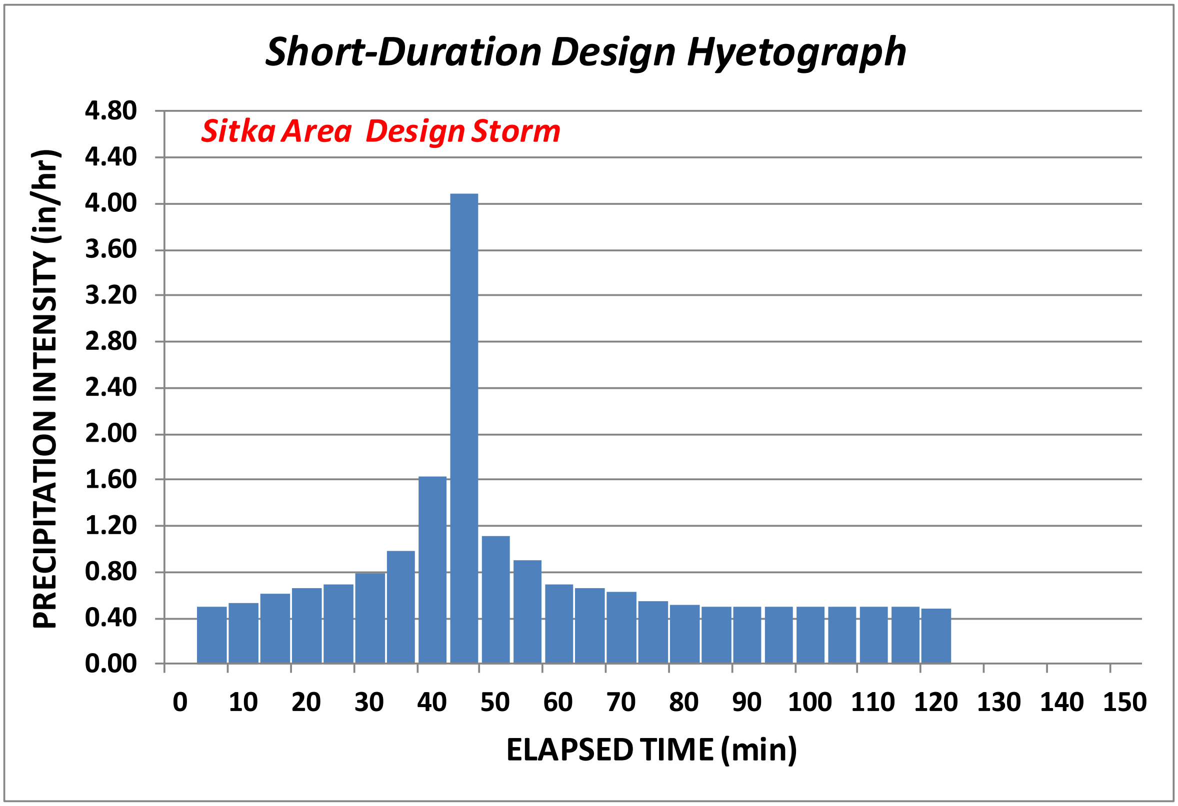

Figure 3-2. Example of Sitka area short-duration design hyetograph for 50-year recurrence interval (1-hour precipitation equals 1.12 inches and total precipitation equals 1.62 inches).

Scalable Long-Duration Design Storms

Long-duration historical storms provide hyetographs for use in rainfall-runoff modeling of larger watersheds and where flooding may be due to runoff volume rather than peak flow rates. The precipitation intensities in long-duration storms are less than the short-duration high intensities reflected in the IDF curves. The local data record had a statistically insufficient magnitude and number of storms to develop synthetic or historical hyetographs; therefore, data from other gauges were used. Long-duration design storms for Sitka were developed using representative historical storms recorded at Yakutat Airport, Annette Airport, and Quillayute Airport in Washington State. Figure 3-3 shows one of these long-duration design storms developed by scaling the historical storm data to the 24-hour rainfall total for a 50-year recurrence interval. The other two historical storms are shown in Appendix B. Results for other recurrence intervals can be obtained by multiplying the values in this graph by the ratio of 24-hour precipitation amount for the desired recurrence interval to that of the 50-year recurrence interval (from Table 3-1). A spreadsheet provided to CBS can be used for automatically scaling and plotting the long-duration design storms for different recurrence interval events for the three historical storms.

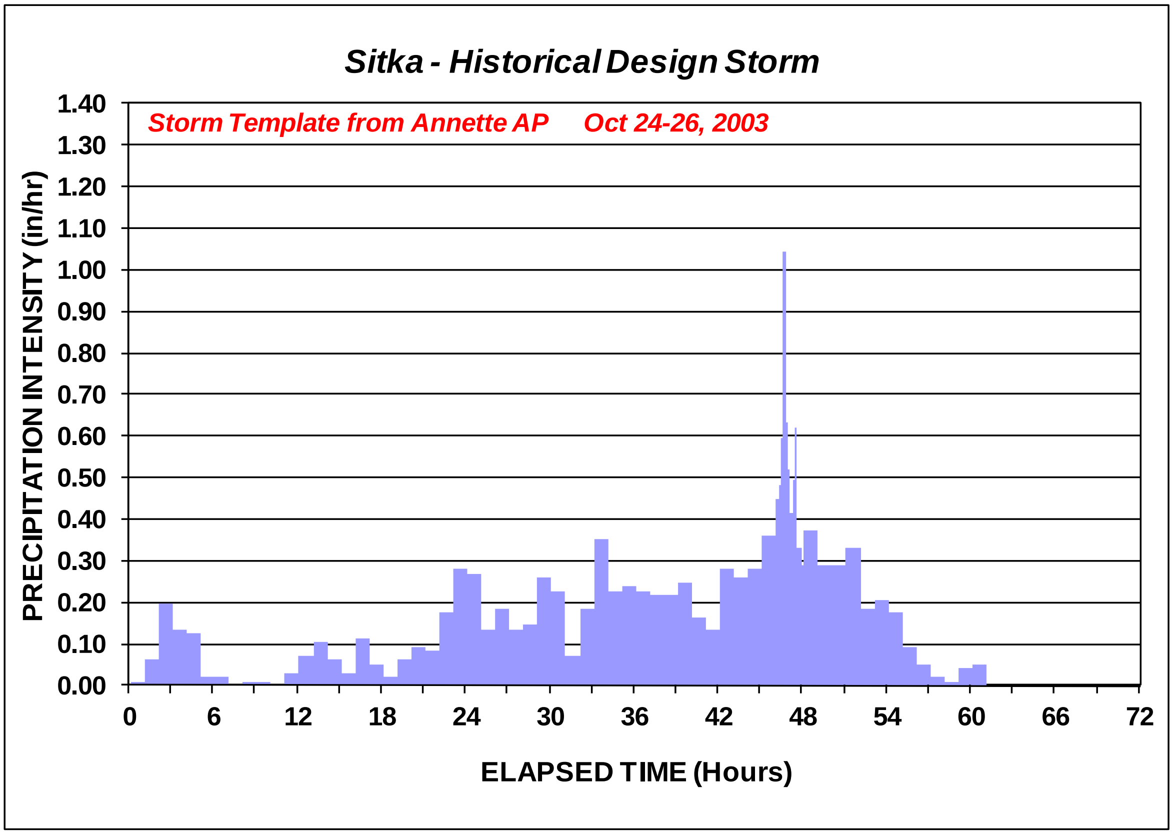

Figure 3-3. Example of Sitka area long-duration design storm for 50-year recurrence interval (24-hour precipitation equals 6.45 inches and total precipitation equals 9.74 inches; historical storm was originally recorded at Annette Airport Alaska, October 24-26, 2003).

APPLICATION OF PRECIPITATION DATA

Hydrologic Modeling

Due to the steep slopes, poorly infiltrating soils, small catchments, and lack of regulations requiring volume control, hydraulic infrastructure in Sitka typically can be designed for peak flow rates using IDF curves and the rational method or the short-duration scaled design storm and the unit-hydrograph method. For watershed modeling, particularly for larger catchments and where stormwater runoff volumes are an issue, all three long-duration design storms and the short-duration design storm should be used to determine the critical event for hydraulic structure design. The critical event is assumed to be the event generating the largest peak flow or greatest flooding extents.

Antecedent Snow

The seasonality of short-duration precipitation for Sitka was assessed by examining annual maximum 1-hour precipitation events at Annette Airport. Figure 3-4 depicts the monthly distribution of these events from 1949-2009. Because the short-duration storms typically occur in warmer months, antecedent snow conditions do not need to be accounted for in hydrologic modeling of these storms.

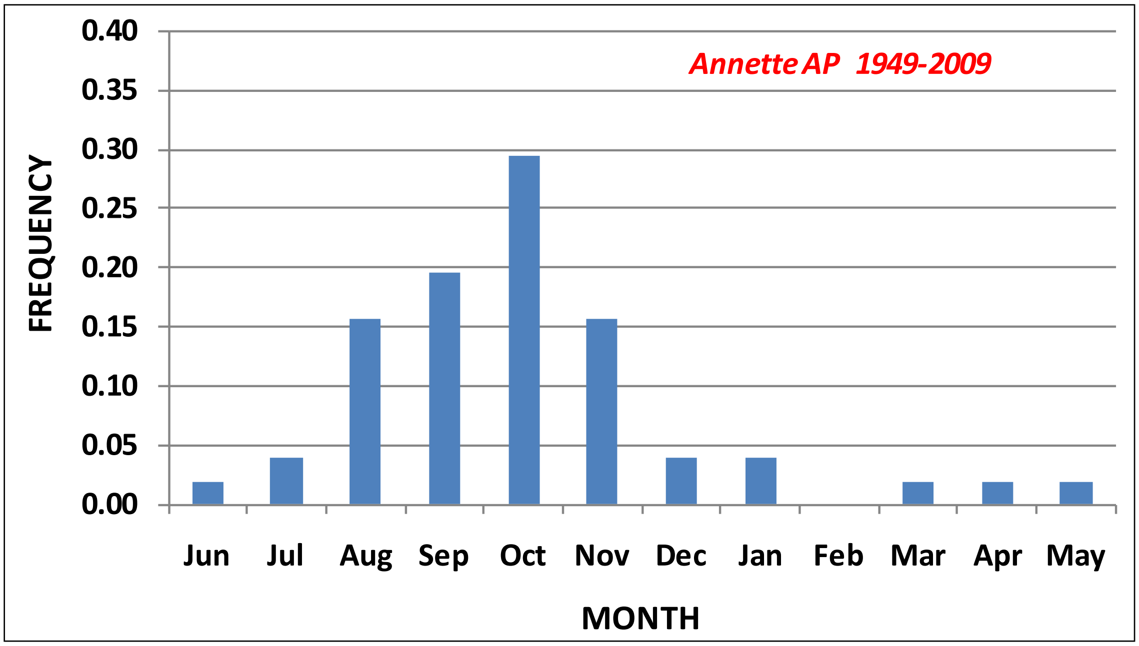

Figure 3-4. Seasonality of occurrence for annual maximum 1-hour precipitation at Annette Airport.

Long-duration storms can occur during winter months, so snowmelt may be a factor in peak flows and runoff volumes. For modeling of large catchments and for design problems where runoff volumes are a factor, antecedent snow conditions should be determined on a case by case basis.

LAND USE AND LAND COVER

The population of CBS is 8,881 with the majority living in Sitka city. The population grew considerably in the 1970s but has maintained the current population since 1990 (U.S. Census Bureau 2013). Development in the Sitka city area primarily extends for about 5 miles east and west of downtown. Building is mostly on the flatter coastal strip with some development on the adjacent steeper slopes. Slopes are generally from 0 to 10 percent along the shoreline and Indian Creek and Granite Creek valleys, and 5 to 15 percent in the older developed neighborhoods near downtown. Slopes in some newer developments like Hillside and forested headwaters are 15 percent and greater.

Dense commercial and industrial development occurs in downtown along Katlian Street west of downtown; along Jarvis, Smith, and Price Streets east of downtown; and in pockets along Halibut Point Road and Sawmill Creek Road. Residential development is densest near downtown at about six dwelling units per acre. Riparian corridors and disturbed areas are dominated by dense red alder and willow species while forested slopes are covered by dense stands of Sitka spruce, western hemlock and western red cedar with sparse understory. Higher elevations (about 2,000 feet) in larger watershed forest give way to meadows and rock or scree fields.

SOILS

The U.S Forest Service conducted a soils survey of much of the developed areas in the Sitka area; however, many of the areas around downtown Sitka were not mapped. The Soil Conservation Service (SCS) hydrologic soils group data were used later as input for rainfall-runoff modeling.

The Natural Resources Conservation Service (NRCS) conducted a soil survey within the Borough in 2011 and results of the survey will be available in the near future. Survey data will likely include georeferenced soil groups with hydrologic soil group classifications.

DRAINAGE BASIN DELINEATION

Drainage basins were delineated for 18 major watershed basins using existing topography, aerial photography and as-built plans, and previous and newly acquired stormwater inventory data. Larger subbasins and drainage areas of larger lakes (Swan Lake, Blue Lake, and Thimbleberry Lake) were further sub-delineated. Drainage basin areas and description are summarized in Table 3-4 and shown in Figure 1-1.

TABLE 3-4.
DRAINAGE AREAS

Subbasin	Area (acres)	General Description and Land Use
North Branch Starrigavan Creek	1,429	Open channel through forested land.
South Branch Starrigavan Creek	1,264	Open channel through forested land.
Lower Starrigavan Creek	1,504	Open channel though mostly forested land with some development along Halibut Point Road.
No Name Creek	1,330	Open channel though mostly forested land with some development along Halibut Point Road.
Cascade Creek	1,392	Entire Cascade Creek drainage: mostly forested with some high elevation open slopes and some medium density residential.
Granite Creek	1,737	Forested in upper watershed, gravel mining, golf course, residential and commercial development along Halibut Point Road.
Harbor Mountain	802	Several small drainages. Forested with some development along Halibut Point Road.
Edgecumbe	163	Several small piped drainages and one larger unnamed creek. Forested upper watershed and medium density residential land use in lower watershed.
Swan Lake	230	Several small drainages leading to Swan Lake. Half medium-density single-family residential, half forested on east side of watershed.
Katlian	8,838	Piped drainage through industrial and high density residential land use.
Downtown	63	Piped drainage through commercial and high density residential land use.
Japonski Island	419	Several small piped and open drainages through commercial and forested land use including airport.
Indian River	7,822	Mostly forested with some residential development along lower Indian River.
Crescent Harbor	85	Several small piped drainages through some forested and mostly medium density residential land use.
Jamestown Bay-Thimbleberry Bay	984	Several small drainages including lower Thimbleberry Creek. Industrial and medium density residential on west side and forested and low density residential on east side.
Thimbleberry Lake	652	Forested land including Thimbleberry Lake.
Blue Lake	23,497	Forested land including Blue Lake.
Sawmill Cove	2,072	Lower reach of Blue Lake Creek and other mostly forested drainages leading to Sawmill Creek cove. Industrial area at Sawmill Creek Cove.

HYDROLOGIC MODELING

The CBS requested estimates of peak runoff rates for typical land use scenarios in the Sitka area for use in assessing development proposals and for maintenance of the existing system. The flow estimates would only be used as planning-level information and site-specific hydrologic models would need to be developed for further analysis.

Model Setup

Peak runoff rates were determined for 1-acre drainage basins for four typical land use scenarios in Sitka using the U.S. Army Corps of Engineers rainfall-runoff model HEC-HMS. Rainfall–runoff models were run for the 100-year, 25-year, and 10-year recurrence interval events. The precipitation hyetograph used in the model was the 5-minute interval, 2-hour short-duration synthetic storm hyetograph developed in Phase 1 of the project (see Appendix B). The hyetograph was developed by nesting short-duration events with longer duration events at the same recurrence interval such that the hyetograph can be applied to a range of watersheds with different concentration times to model a single recurrence interval.

Land use in the four modeled scenarios consisted of a combination of three types (grass, impervious, and forest) as shown in Table 3-5. Figure 3-5 shows an approximate representation of these four scenarios in central Sitka. The distribution of hydrologic soil groups through the Sitka area was reviewed and the following distribution of soil types was selected for each scenario as representative of the average conditions in Sitka: 10 percent Soil Type B, 40 percent Soil Type C and 50 percent Soil Type D. The composite curve number as a function of land use and soil type was calculated for each scenario using the TR-55 manual (USDA 1986) and results are shown in Table 3-6. Runoff from the separate land uses in each scenario was modeled separately and the total outflow hydrograph was the sum of the up to three land use hydrographs. Surface slopes were assumed to be 5 percent for all land use types. The basin shape was assumed to be square with the flow path on the square's diagonal. Lag time was calculated for each land use type assuming sheet flow for a length of 150 feet and shallow concentrated flow for 145 feet. The SCS curve number was used as the loss method and the SCS unit hydrographs were used as the transform method for each land use type.

TABLE 3-5
LAND USE FOR 1-ACRE MODEL SCENARIOS

	Percent of Total Area		
Scenario	Forest	Grass	Impervious
Forest	100	0	0
Low Density Development	85	5	10
Medium Density Development	0	40	60
High Density Development	0	10	90

TABLE 3-6
COMPOSITE CURVE NUMBERS FOR MODELED SCENARIOS

Scenario	Composite Curve Number
Forest	72.0
Low Density Development	74.8
Medium Density Development	88.7
High Density Development	95.8

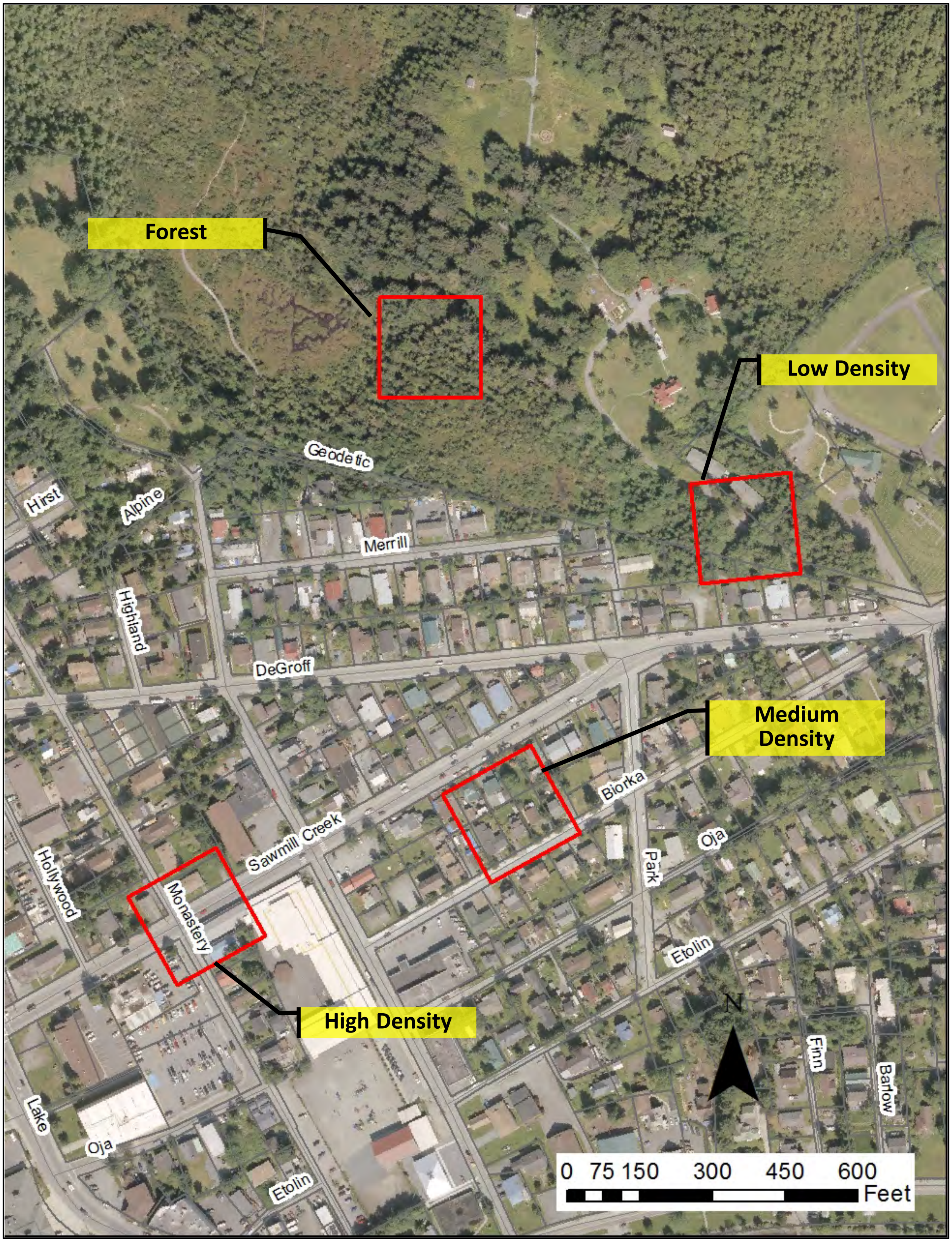

Figure 3-5. Approximate representation of modeled scenarios.

Model Results

Peak flow rates for the four 1-acre scenarios for the 100-, 25- and 10-year recurrence intervals are shown in Table 3-7.

TABLE 3-7.
PEAK RUNOFF RATES FOR FOUR 1-ACRE SCENARIOS

	Peak Runoff Rate (cfs)		
Scenario	100-year	25-year	10-year
Forest	0.18	0.09	0.05
Low Density Development	0.47	0.37	0.31
Medium Density Development	2.78	2.18	1.80
High Density Development	4.17	3.27	2.71

Additional assessment of the effect of hydrologic variables such as slope, soil type, and basin size on peak runoff rates was conducted for runoff hydrographs and additional model scenarios.

For the high, medium, and low density scenarios, the peak runoff rate is principally due to runoff from the impervious surfaces. The grass and forest hydrograph components are lagged due to the slower overland flow rates; therefore, runoff from these components does not affect the peak runoff rate from the faster and much larger runoff from the impervious surface. For these development scenarios, the choice of hydrologic soil type for the pervious surfaces would not significantly affect the peak runoff rate. The peak runoff rate for the forest scenario is highly sensitive to the choice of soil type. The peak runoff rate for 1-acre forest scenario with exclusively hydrologic soil group D (curve number 77) was 0.25 cubic feet per second (cfs) compared to the peak runoff rate for average Sitka soil conditions (curve number 72) of 0.18 cfs.

The time of concentration of the impervious surface in small watersheds is extremely fast and is much faster than the 5-minute minimum time step of the precipitation analysis. Therefore, in modeled scenarios with different surface slopes the peak runoff rate will be determined by the same peak 5-minute rainfall intensity. In addition, the sheet flow component of the time of concentration is relatively insensitive to slope. The peak flows from a forest with a 2 percent slope, 5 percent slope, and 10 percent slope are very similar: 0.17 cfs, 0.18 cfs, and 0.19 cfs, respectively. Therefore, for all of the modeled scenarios the peak flow rate does not vary considerably with slope.

Peak runoff from large 10-acre watersheds was modeled to investigate the effect of basin size on peak flow rate. The time of concentration was calculated by assuming sheet flow for the first 150 feet and shallow concentrated flow for the remaining length. Because the slower sheet flow accounts for a majority of the total lag time, the total lag time for the 10-acre basins is only slightly longer than the total lag time for the 1-acre basins. However, peak flow rates per acre for the 1-acre basins were 10 percent to 20 percent higher than the peak flow rates per acre for the 10-acre basins. Using the 1-acre results will, therefore, provide conservatively high peak flow estimates when applied to large basins.

CHAPTER 4.
DRAINAGE INVENTORY

INVENTORY DATA COLLECTION

The goal of the stormwater inventory is to create an accurate depiction of stormwater infrastructure elevations, materials, dimensions, connectivity, and condition. The inventory will be used in assessing existing drainage problems and for ongoing maintenance and management of the system.

Field crews collected stormwater inventory data according to the attribute data format shown in Appendices C and D. Open channels were later modified to also collect buffer width and vegetation condition data. Data were then reviewed with a quality assurance and quality control procedure to identify missing and erroneous data. Individual point data (e.g., culvert inlets and outlets, manholes, catch basins, stream, and ditch points) were connected by creating pipe and open channel elements using azimuths of incoming and outgoing infrastructure to form a continuous stormwater network. The following issues are not detailed in the field data collection manual.

- **Azimuth Data**—Azimuth data of incoming and outgoing pipes and open channels were collected in the field by using magnetic north datum. Azimuth data were then converted to true north using a declination of 20 degrees 8 minutes.
- **Vertical Datum**—The vertical datum for the inventory is mean lower low tide, as determined by North American Vertical Datum of 1988 (NAVD88).
- **Horizontal Datum**—Horizontal data were collected according to the state plane system.

Network Construction

The process of collecting feature information and building a comprehensive geographical information system (GIS) database involved a four-step iterative process, as shown in Figure 4-1. The stormwater network required several rounds of processing and quality assurance to create the final inventory.

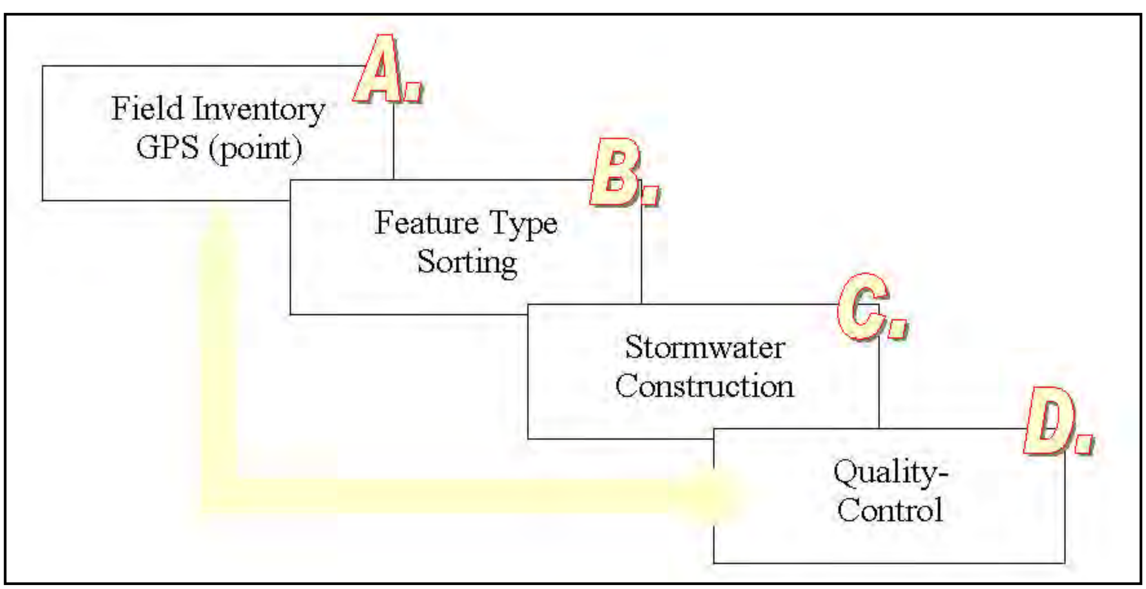

Figure 4-1. Inventory data processing steps.

Step A—Field Inventory GPS

Existing inventory data were initially reviewed to determine priority areas for field inventory. Areas within higher priority areas with recent as-built records were excluded from the field inventory. Stormwater infrastructure was inventoried using global positioning system or GPS equipment or ground survey as found in the field, and data were input to a file for later sorting in the office.

Step B—Feature Type Sorting

Stormwater infrastructure point data were sorted into the following coded feature types:

- CB—catch basin – drainage structure with an inlet
- FL—open channel point
- IE—culvert/pipe inlet or outlet
- POND—detention pond

Step C—Stormwater Network Construction

Once collected, stormwater point data were moved through a semi-automated process of stormwater network construction. Network construction consists of creating linear storm features (i.e., pipes and channels) to connect the catch basin, manhole, culvert/pipe, and ditch point data collected in the field.

One of the most critical attributes for stormwater network construction is azimuth, the orientation of the pipe inflow or outflow relative to true north. Pipe azimuth is a required attribute for all incoming and outgoing catch basin and manhole pipes, and culverts/pipe inlets and outlets. The initial network construction algorithm uses the azimuth ±15 degrees to connect pipes to and from catch basins, manholes, and culverts/pipes. Using the 30-degree triangle, the program looks for the closest point with the correct azimuth. In the case of a catch basin with multiple incoming pipes, the pipe with the closest azimuth is selected. Ditch and culvert data are also incorporated into the network construction process using azimuth. Figure 4-2 demonstrates the automated processing of flow arrows using azimuth and the connection of catch basins and drain points using flow azimuths ±15 degrees. An example is shown in Figure 4-3.

Other critical attributes collected in the field are diameter, material, and elevation. These attributes are valuable for confirming stormwater network connectivity during the quality control process. Drainage pipes sometimes connect at wyes and tees and not at catch basins and manholes. These points were added to the inventory during network construction and labeled as “transitions.”

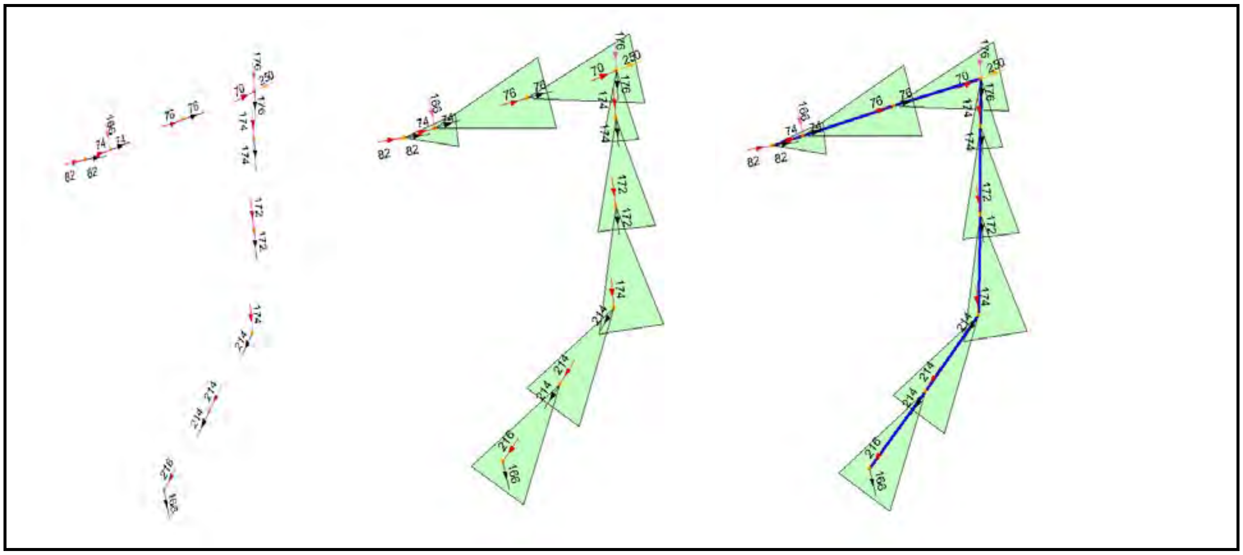

Figure 4-2. Process of creating azimuth flow arrows and conveyance vectors.

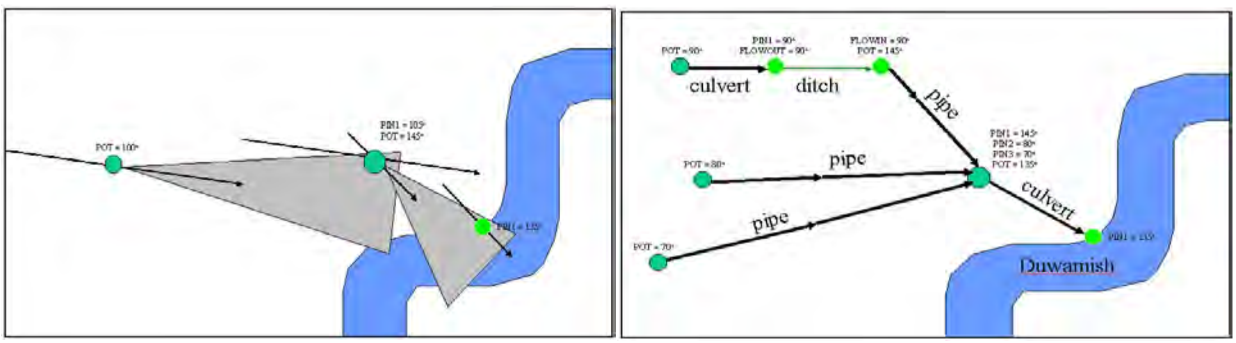

Figure 4-3. Initial network connection process.

Step D—Quality Control

The stormwater network construction process required several quality assurance steps before arriving at the final product of lines representing pipes and ditches. Errors were detected during network construction and during manual review of the map. The quality control process began by spotlighting constructed pipes and ditches with specific attribute problems, which include pipe diameter, material, and elevation. Pipes that did not have identical diameter or material at both ends were flagged as possible problems. Also flagged were pipes and ditches that have errors in slope.

The final tier of quality control was review of the constructed stormwater networks by Tetra Tech and CBS staff. Several areas of incomplete system networks were clarified by this review and either manually repaired in the GIS or identified as areas in need of additional field inventory. As-built data from CBS and ADOT&PF projects were used to fill gaps in the field inventory. In Phase 2, information from site visits, site photographs, and Google Street view photographs were also used to add data and build the drainage network. The source data attribute will annotate the data source for each inventory point.

INVENTORY RESULTS

Phase 1 Inventory

Phase 1 of the inventory work took place in April 2012. The number of points surveyed during the inventory process or added from as-built drawings during network creation is summarized in Table 4-1.

TABLE 4-1.
PHASE 1 STORMWATER INVENTORY POINTS

Inventory Point Type	Survey	As-Built	Total
Catch basin	273	90	**363**
Culvert/Pipe In/Out	183	11	**194**
Pond	2	0	**2**
Transition	0	9	**9**
Open Channel/Ditch	97	0	**97**
Total	**564**	**101**	**665**

Using the field-collected and as-built points, 344 pipe segments, 55 culverts, and 99 ditch segments were created.

Part of the Phase 1 work was to specifically catalog water quality or water quantity control structures. Sitka contains few public purpose-built water quality or water quantity control structures. Examples of these structures include:

- Flow retention/detention ponds adjacent to Granite Creek Road,
- Stormceptor hydrodynamic separator located on Lincoln Street at outfall from Monastery Road drainage system, and
- Grade control/flow control check dams along Granite Creek ditch.

Ditch and open channel material, condition, and buffer width were determined from the stream/ditch point inventory data. Of the 99 ditch/open channel segments created, 17 segments or 17 percent were grass with the remainder rock or gravel. Also, 71 segments or 73 percent were evaluated to be in poor condition.

Phase 2 Inventory

Phase 2 of the inventory work took place in May 2013. The number of points surveyed during the inventory process or added from as-built drawings during network creation is summarized in Table 4-2. Some points added during Phase 1 using as-built information were replaced by points surveyed in Phase 2.

TABLE 4-2.
PHASE 2 STORMWATER INVENTORY POINTS

Inventory Point Type	Survey	As-Built/Observed	Total
Catch basin	230	26	**256**
Culvert/Pipe In/Out	105	27	**132**
Pond	0	0	**0**
Transition	0	16	**16**
Open Channel/Ditch	43	9	**52**
Total	**378**	**78**	**456**

Using the field-collected and as-built points, 344 pipe segments, 55 culverts, and 99 ditch segments were created. During Phase 2 network construction, some pipe, ditch, and culvert segments created in the first phase were replaced by newer more accurate segments.

Total Inventory

The total number of points surveyed during the inventory process or added from as-built drawings during network creation is summarized in Table 4-3. Figures 4-4 through 4-16 show the drainage inventory network.

TABLE 4-3.
TOTAL STORMWATER INVENTORY POINTS

Inventory Point Type	Survey	As-Built/Observed	Total
Catch basin	500	125	**625**
Culvert/Pipe In/Out	286	38	**324**
Pond	2	0	**2**
Transition	0	24	**24**
Open Channel/Ditch	140	9	**149**
Total	**928**	**196**	**1,124**

Using the field-collected and as-built points, 678 pipe segments, 82 culverts, and 215 ditch segments were created.

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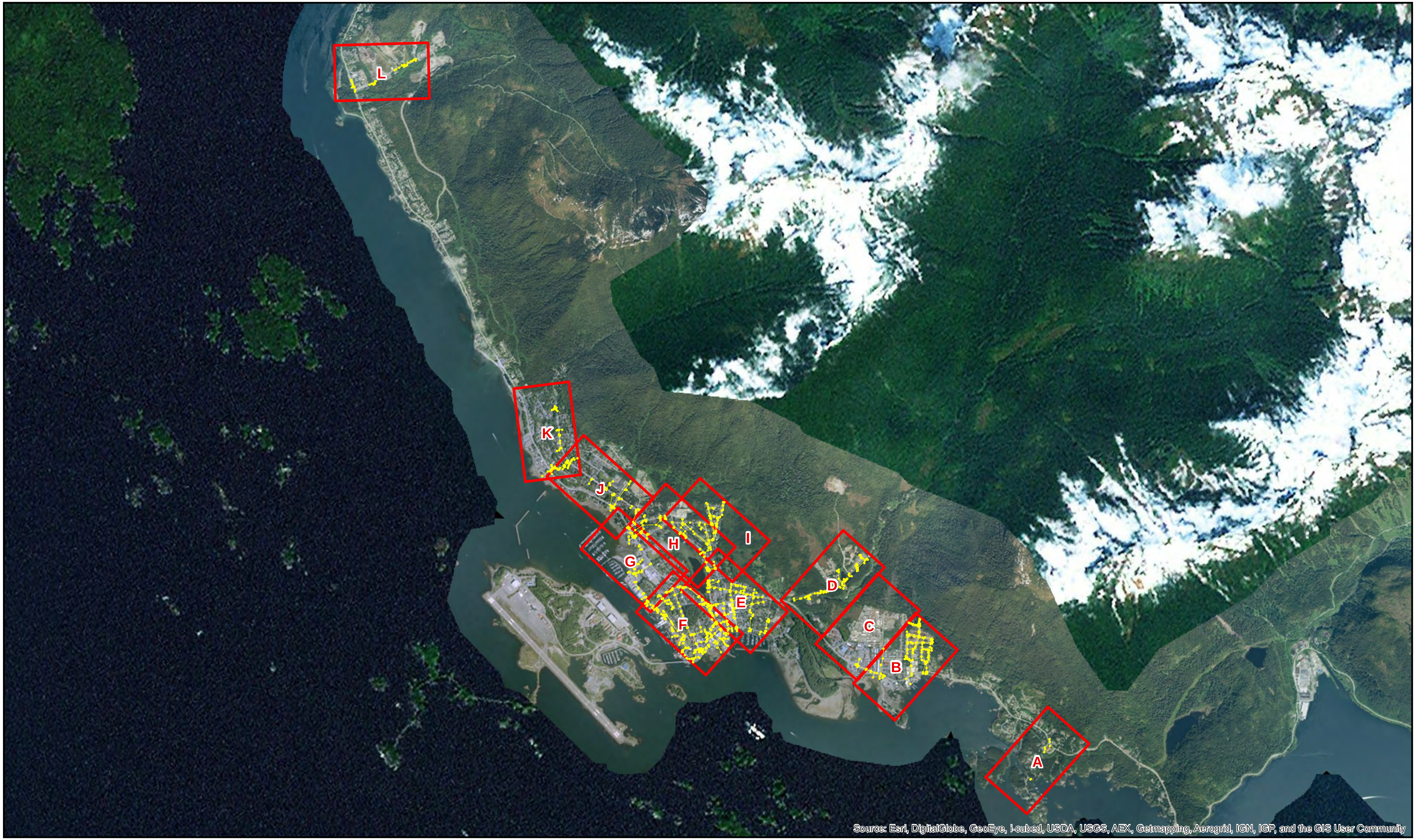

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Stormwater Management Plan

Figure 4-4

DRAINAGE INVENTORY AREAS INDEX

0 0.25 0.5 0.75 1 Miles

N

Legend

Phase 1-2 Inventoried Assets

1:36,000

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Figure 4-5

DRAINAGE INVENTORY
AREA A

0 100 200 300 400 Feet

1:2,400

N

Legend

- Catch Basin
- Ditch Flow Point
- Inlets and Outlet
- ssTransition_Point
- Ponds
- Culvert
- Ditch
- Pipe

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Figure 4-6

DRAINAGE INVENTORY
AREA B

0 100 200 300 400 Feet

1:2,400

Legend

- Catch Basin
- Ditch Flow Point
- Inlets and Outlet
- ssTransition_Point
- Ponds
- Culvert
- Ditch
- Pipe

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Figure 4-7

DRAINAGE INVENTORY
AREA C

0 100 200 300 400 Feet

1:2,400

Legend

- Catch Basin
- Ditch Flow Point
- Inlets and Outlet
- ssTransition_Point
- Ponds
- Culvert
- Ditch
- Pipe

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Figure 4-8

DRAINAGE INVENTORY
AREA D

0 100 200 300 400 Feet

1:2,400

Legend

- Catch Basin
- Ditch Flow Point
- Inlets and Outlet
- ssTransition_Point
- Ponds
- Culvert
- Ditch
- Pipe

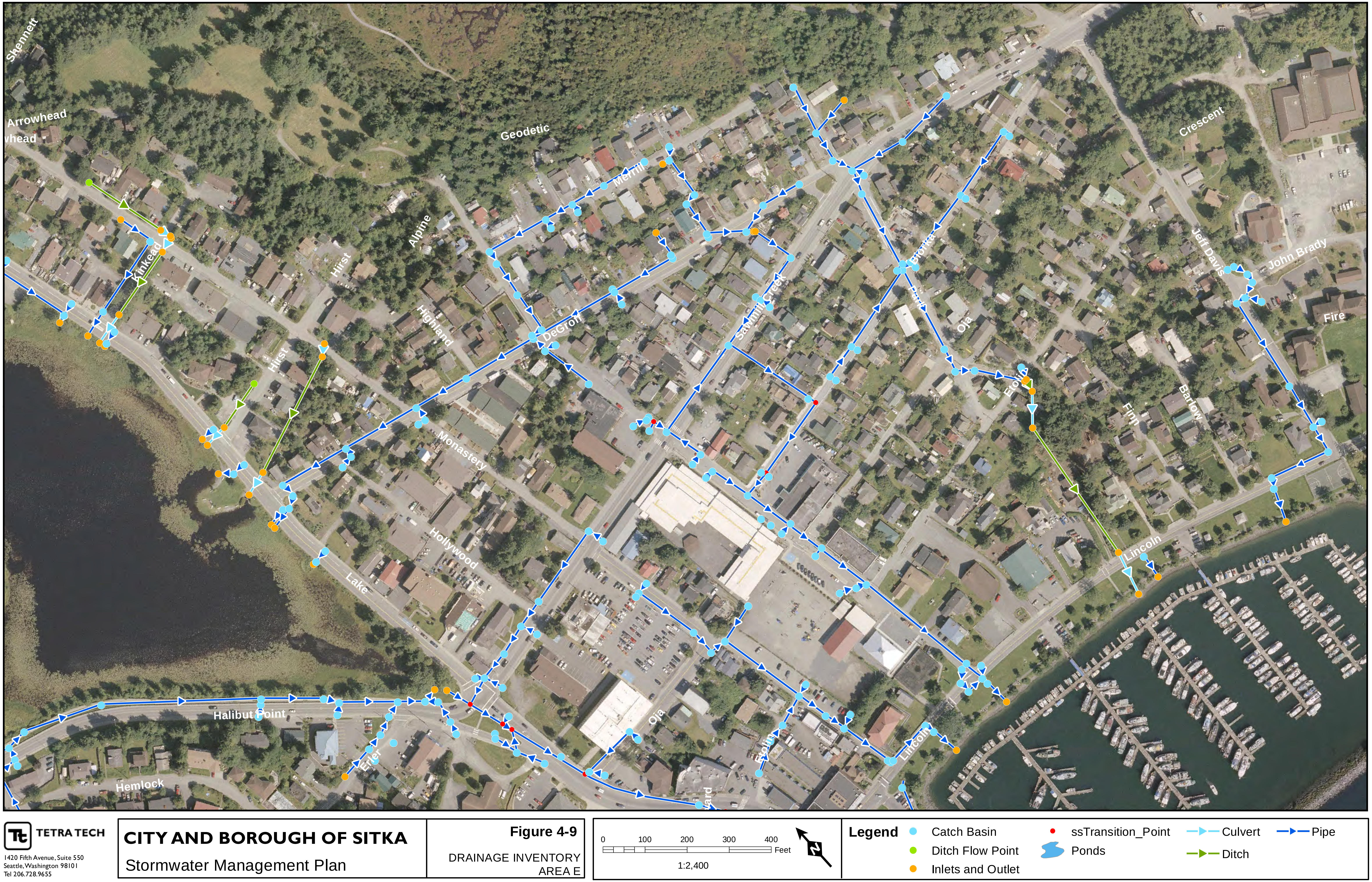

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Figure 4-9
DRAINAGE INVENTORY
AREA E

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Figure 4-10

DRAINAGE INVENTORY
AREA F

0 100 200 300 400 Feet

1:2,400

Legend

- Catch Basin
- Ditch Flow Point
- Inlets and Outlet
- ssTransition_Point
- Ponds
- Culvert
- Ditch
- Pipe

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Figure 4-11

DRAINAGE INVENTORY
AREA G

0 100 200 300 400 Feet

1:2,400

Legend

- Catch Basin
- Ditch Flow Point
- Inlets and Outlet
- ssTransition_Point
- Ponds
- Culvert
- Ditch
- Pipe

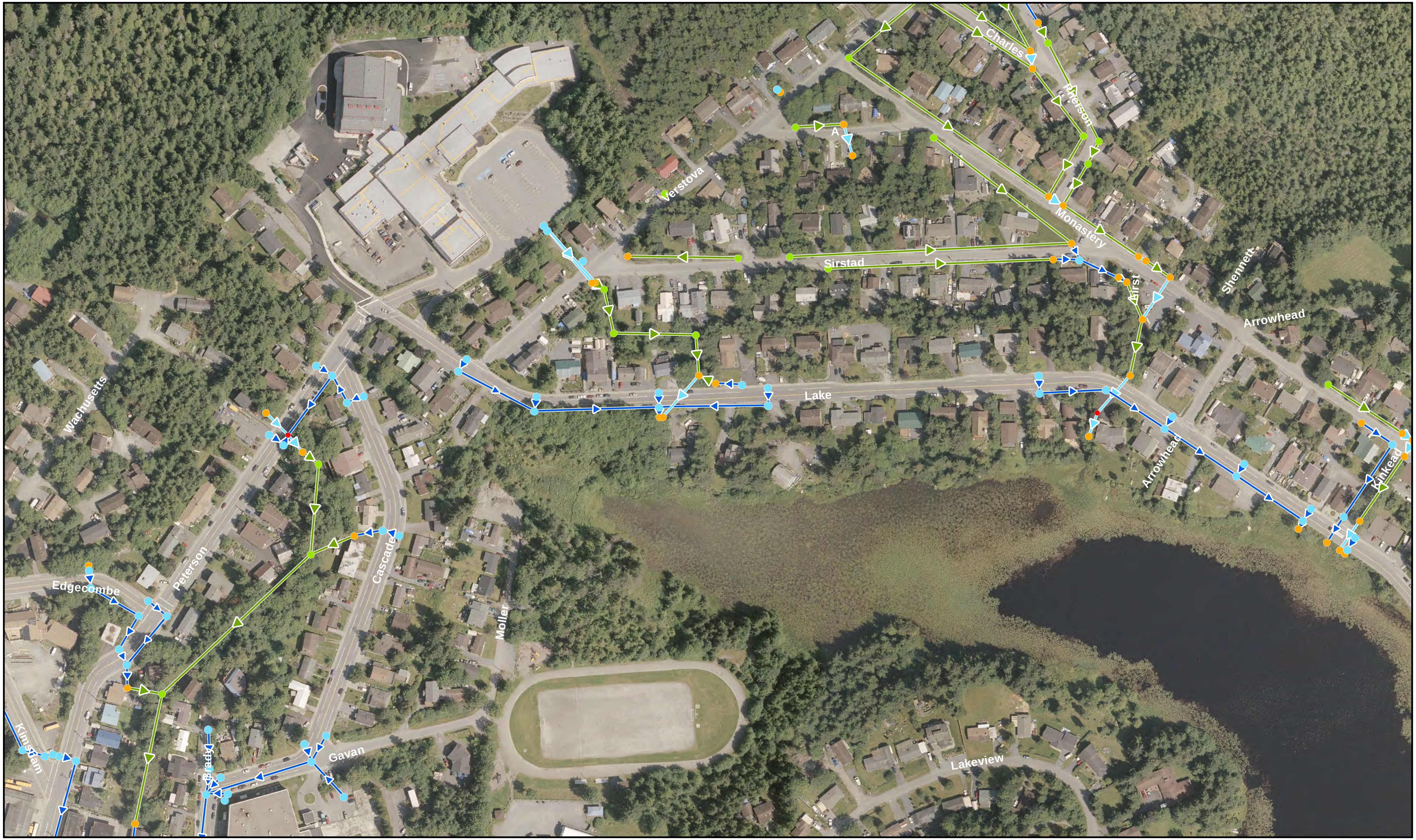

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Figure 4-12

DRAINAGE INVENTORY
AREA H

0 100 200 300 400 Feet

1:2,400

Legend

- Catch Basin
- Ditch Flow Point
- Inlets and Outlet
- ssTransition_Point
- Ponds
- Culvert
- Ditch
- Pipe

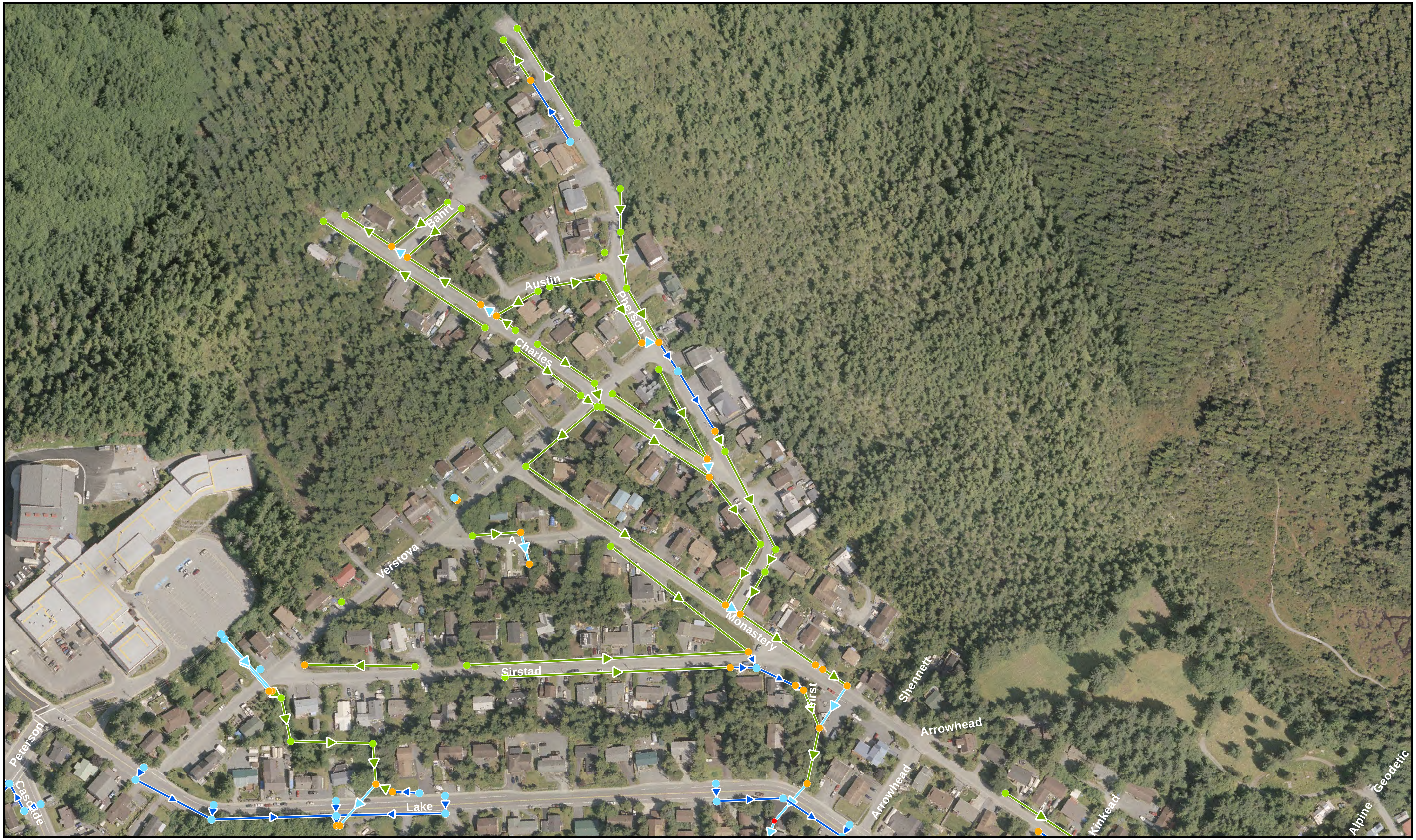

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Figure 4-13

DRAINAGE INVENTORY
AREA I

0 100 200 300 400 Feet

1:2,400

Legend

- Catch Basin
- Ditch Flow Point
- Inlets and Outlet
- ssTransition_Point
- Ponds
- Culvert
- Ditch
- Pipe

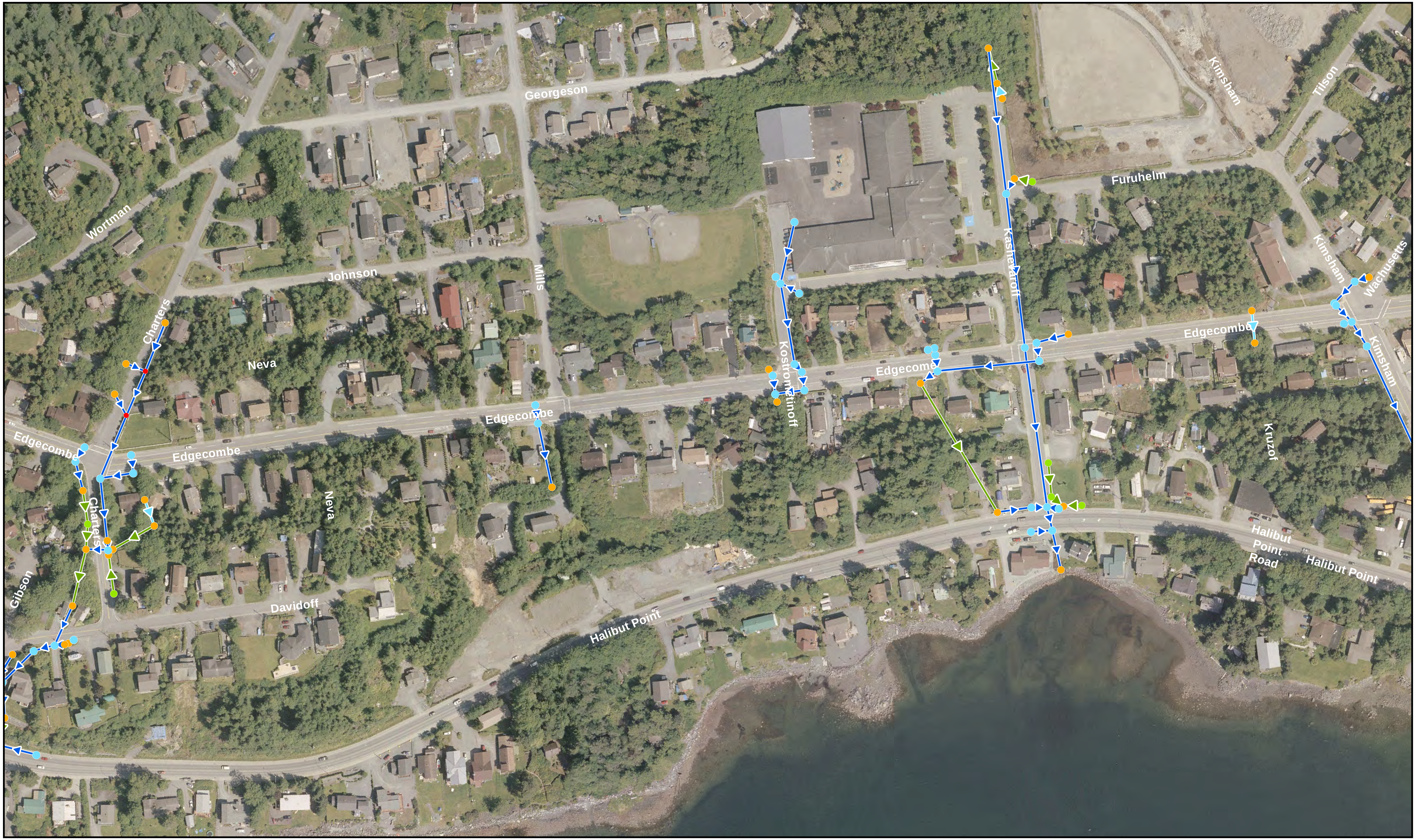

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Figure 4-14
DRAINAGE INVENTORY
AREA J

0 100 200 300 400 Feet
1:2,400

Legend
Catch Basin
Ditch Flow Point
Inlets and Outlet
ssTransition_Point
Ponds
Culvert
Ditch
Pipe

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Stormwater Management Plan

Figure 4-15
DRAINAGE INVENTORY
AREA K

0 100 200 300 400 Feet
1:2,400

Legend
- Catch Basin
- Ditch Flow Point
- Inlets and Outlet
- ssTransition_Point
- Ponds
- Culvert
- Ditch
- Pipe

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Stormwater Management Plan

Figure 4-16

DRAINAGE INVENTORY
AREA L

0 100 200 300 400 Feet

1:2,400

N

Legend

- Catch Basin
- Ditch Flow Point
- Inlets and Outlet
- ssTransition_Point
- Ponds
- Culvert
- Ditch
- Pipe

CHAPTER 5.
DRAINAGE PROBLEM ASSESSMENT

DRAINAGE PROBLEM IDENTIFICATION

Drainage problems were primarily identified by CBS staff using reports from the public and from infrastructure maintenance history. Some identified problems were added to the list through the field inventory and field visits.

DRAINAGE PROBLEM ASSESSMENT

Full descriptions of the problems, planning-level solutions, and cost estimates are found in Appendix E. Table 5-1 provides a summary of the drainage projects assessed as part of this study.

TABLE 5-1.
CAPITAL IMPROVEMENT PROJECT LIST

Project Name	Concern	Ownership	Estimated Construction Cost
Edgecumbe Drive Storm Drain Crossings	Pipe condition	CBS	$372,000
Barracks Street and Lincoln Street Drainage System Realignment	Pipe alignment and condition	CBS/Private	$299,000
Davidoff Street Drainage System to Halibut Point Road	Pipe, inlet, and outlet condition	CBS/Private	$265,000
Lake Street Storm Drain Crossing	Pipe, inlet, and outlet condition	CBS/Private	$189,000
Viking Way and Valhalla Drive Drainage Improvements	Pipe, inlet, and outlet condition, Insufficient drainage system	CBS	$160,000
Tlingit Way - Install New Drainage System	Insufficient drainage system	CBS	$141,000
Hillside Subdivision Drainage System	Drainage system performance	CBS	$128,000
Hollywood Drainage System	Insufficient drainage system	CBS/Private	$124,000
Shotgun Alley/Rands Drive/Winchester Way Drainage System	Insufficient drainage system	CBS/Private	$92,000
Peterson Avenue Culvert Crossing	Pipe condition	CBS	$87,000
Granite Creek Road Detention and Retention Pond Improvements	Drainage system performance	CBS/Private	$20,000
Merrill Street Drainage Improvements	Drainage system performance	Private	$0

COST ESTIMATES

Cost estimates were developed using bid tabs from recent CBS and other southeast Alaska drainage projects. Tables 5-2 and 5-3 show the bid item cost estimates and percentage items used in developing Capital Improvement Project cost estimates. Lineal foot pipe costs include excavation, disposal of existing pipe, pipe material, installation and bedding, backfill, and compaction.

TABLE 5-2.
STORMWATER UNIT COSTS

Item	Unit	Unit Cost
Catch Basin Type 1	Each	$ 3,000
Catch Basin Type 2	Each	$ 4,500
Storm Drain Manhole Type 1	Each	$ 4,400
Storm Drain Manhole Type 1	Each	$ 5,000
Install Curb And Gutter	Linear feet	$ 30
Sawcut and Remove Pavement	Square yard	$ 9
Asphalt Pavement Repair	Square feet	$ 9
8-in-dia Corrugated Plastic Pipe	Linear feet	$ 60
12-in-dia Corrugated Plastic Pipe	Linear feet	$ 80
18-in-dia Corrugated Plastic Pipe	Linear feet	$ 90
24-in-dia Corrugated Plastic Pipe	Linear feet	$ 110
30-in-dia Corrugated Plastic Pipe	Linear feet	$ 140
36-in-dia Corrugated Plastic Pipe	Linear feet	$ 150
48-in-dia Corrugated Plastic Pipe	Linear feet	$ 180
Culvert Inlet with Trash Rack and Beehive	Each	$ 17,500
Man Rock	Cubic yard	$ 200
Crushed Surface Top Course	Cubic yard	$ 45
Trash Rack	Each	$ 5,000
Controlled Density Fill	Cubic yard	$ 140
Energy Dissipater	Each	$ 3,000

**TABLE 5-3.
STORMWATER COST PERCENTAGE ITEMS**

Item	Percentage
Construction Management	10%
Contingency	30%
Dewatering	3%
Engineering/Legal/Admin	25%
Erosion and Sedimentation Control	5%
Mobilization (General Requirement)	10%
Sales Tax	6%
Traffic Control	3%
Permitting (Const. less than $50,000)	20%
Permitting (Const. less than $250,000)	10%
Permitting (Const. greater than $250,000)	5%
Survey/Easements/Row Acquisition	25%

EVALUATION AND PRIORITIZATION OF IDENTIFIED PROBLEM AREAS

Identified drainage problem areas were ranked to select which should have the highest priority for implementation of improvements. The evaluation considered both the severity of the problem and the costs and benefits of an assumed improvement project that would resolve the problem permanently.

Evaluation Criteria

The first step in evaluating drainage problems was to establish evaluation criteria. Problems were rated by assigning each of them a numerical score (1 to 5) for each selected criterion. Each criterion was weighted to indicate its importance to CBS. The most important criteria were given a weight of 3, and the least were given a weight of 1. A project's weighted score for each criterion is the product of the weight and the rating. Each project's total score is the sum of its weighted scores for all criteria. The criteria and weighting used for the evaluation were as follows:

- Risk of Failure/Flooding (weight = 3)—This criterion indicates the likelihood of a failure or flooding event in the problem area. A high score indicates structure is failing or has a high risk of failing while a low score indicates the structure is in good condition or has a low risk of failure.
- Consequence of Failure or Flooding (weight = 3)—This criterion indicates the consequence of the anticipated failure or flooding event. Problem areas on steep slopes with nearby houses or next to large roads score higher than problem areas in flat terrain away from infrastructure. Problem areas in large drainage systems score higher than those in drainage systems with lower flows and volumes.
- Capital Cost (weight = 1)—This criterion indicates the cost to upgrade the drainage system. A low score indicates a total cost of more than $500,000. A moderate score indicates a project cost between $100,000 and $250,000. A high score indicates a cost less than $50,000.

- Responsibility (weight = 2)—This criterion indicates the perceived responsibility of CBS to address the problem. It assigns a score based on ownership of the drainage infrastructure or parcel. Problem areas on CBS property such as road rights of way or problem areas conveying flows from CBS property score higher than problem areas on private or ADOT&PF property.
- Coordination (weight = 2)—This criterion indicates whether a project can be constructed in conjunction with another existing or proposed CBS improvement project. If it is part of a larger project, project costs such as paving or management can be shared. A low score indicates that project construction is independent of other local improvements. A moderate score indicates that the project may be in the vicinity of a proposed roadway project, but the extents are not known. A high score indicates the project is definitely near or included in another planned project.
- Maintenance (weight = 1)—This criterion evaluates projects based on their effects on maintenance. A low score is given if predicted maintenance costs will go up significantly. A moderate score is assigned if the new drainage facilities will not affect the maintenance workload. An example would be increasing the size of an outfall to accommodate greater flow contribution from upstream; the outfall itself does not flood, but it does require ongoing maintenance. A high score indicates a reduction of maintenance requirements through increased capacity or reduced damages.

Evaluation Results

Identified drainage problem areas were scored and ranked using the evaluation criteria described above. High scores indicate high-priority problems that should be addressed soon. Low scores indicate problems that can be scheduled as funding permits. Problems with no ranking were determined to require no work, to require only maintenance, or to require further investigation. Table 5-4 shows a summary of the evaluation of the identified problem areas.

**TABLE 5-4.
PROBLEM AREA EVALUATION**

		Score						
Location	Ownership	**Total Score**	Risk (x3)	Consequence (x3)	Capital Cost (x1)	Responsibility (x2)	Coordination (x2)	Maintenance (x1)
Lake Street Storm Drain Crossing	CBS/Private	**43**	4	4	3	5	1	4
Hillside Subdivision Drainage System	CBS	**41**	4	3	3	5	1	5
Davidoff Street Drainage System to Halibut Point Road	CBS/Private	**40**	4	3	2	4	3	3
Edgecumbe Drive Storm Drain Crossings	CBS	**38**	3	4	2	5	1	3
Peterson Avenue Culvert Crossing	CBS	**38**	2	4	4	5	1	4
Barracks Street and Lincoln Street Drainage System Realignment	CBS/Private	**34**	2	4	2	3	3	2
Viking Way and Valhalla Drive Drainage Improvements	CBS	**34**	2	3	3	3	3	4
Shotgun Alley/Rands Drive/Winchester Way Drainage System	CBS/Private	**33**	2	3	4	4	1	4
Tlingit Way - Install New Drainage System	CBS	**29**	2	2	3	4	2	2
Granite Creek Road Detention and Retention Pond Improvements	CBS/Private	**25**	1	1	5	5	1	2
Hollywood Drainage System	CBS/Private	**20**	1	1	3	3	1	3
Merrill Street Drainage Improvements	Private	**0**						

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CHAPTER 6.
LOW IMPACT DEVELOPMENT AND STORMWATER BEST MANAGEMENT PRACTICES

INTRODUCTION

Water Quantity

Development and conversion of land from native conditions increases stormwater runoff flow rates and volumes. Increases in flow rates and volumes can cause erosion, channel widening, loss of riparian vegetation, and increased wetland inundation depths and durations. Increased runoff can overload a downstream conveyance system, causing flooding and damage to built infrastructure.

The Sitka area is constrained by a lack of easily buildable land, so housing is relatively expensive. Traditional flow control such as detention ponds would consume buildable land and raise development costs. This plan, therefore, concentrates on flow control approaches that are more easily implemented and have aesthetic and water quality benefits.

The alternative to traditional flow detention is to design with runoff in mind by using pervious surfaces and a natural type of drainage system to reduce runoff peaks and volumes. These methods are collectively known as “low impact development” (LID) or “green stormwater infrastructure” and have been used in communities throughout the U.S. This approach reduces and slows water flows, reducing the effect on downstream conditions. Reduction in runoff rates and volumes also increases the efficiency of downstream water quality treatment facilities and decreases their required size. As a part of LID, water quantity source control typically focuses on larger scale approaches to reduce runoff by minimizing construction of impervious surfaces and preserving natural infiltration.

Water Quality

Stormwater runoff from development can contain a wide variety of pollutants from many sources. During and after construction, sediment is transported to surface waters from developed sites at rates much greater than under pre-development conditions. Runoff from industrial developments can include oils, greases, and metals. Runoff from residential areas can include nutrients and pesticides from landscapes and fecal coliform bacteria from pet wastes. Automobile traffic is a major source of oil and grease from leaks, metals from brake pads and tires, and hydrocarbons from exhaust fallout.

Two broad strategies for controlling pollution in stormwater runoff include source control and stormwater quality treatment. Source control best management practices (BMPs) are activities, prohibitions of practices, maintenance procedures, and structural and/or managerial practices that prevent or reduce the potential for pollutants to come in contact with stormwater and be transported to the natural environment. Pollution source control measures can be separated into operational and structural measures.

Water quality treatment BMPs are structures used to treat or remove pollutants after they have come in contact with runoff. These BMPs use processes such as settling, filtration, and biological treatment to reduce pollutant levels. Treatment BMPs target a wide range of stormwater pollutants, including sediment, oil and grease, metals, and nutrients. This chapter details design and construction considerations for water quality treatment structures, and outlines thresholds such as the level of sediment in a structure that calls for cleaning or the minimum infiltration rate for infiltration facilities.

Preventing pollutants from contacting stormwater is a much more effective and cost-efficient method of pollution control than removing pollutants from stormwater. Water quality treatment BMPs are expensive to construct and maintain and are not 100 percent effective at removing pollutants. Many pollutants have biological and physical impacts at very low concentrations that approach irreducible levels where BMPs cannot feasibly remove pollutants below these concentrations.

RECOMMENDED WATER QUALITY BMPS

Application of stormwater quality BMPs in Sitka is challenging due to snow, ice, frozen soils, heavy use of road traction material, poor infiltrating soils, and steep slopes. This section contains a brief summary of recommended water quality BMPs and general guidance on locations within Sitka where they could be implemented. Appendix F contains 4- to 5-page summaries including more information and design guidance for each of these BMPs.

Biofiltration Swale

Bioswales are linear features that provide conveyance of stormwater while also providing treatment through filtration and, where feasible, infiltration. Conveyance of flow through the swale should occur as sheet or shallow flow to allow the maximum contact with soil and vegetation. Swales can be fitted with underdrains to allow drainage and check dams to reduce velocities and create temporary ponding. Bioswales are appropriate for roadside drainage or could be incorporated into parking lots. Within Sitka bioswales could be incorporated into new residential construction where grade will allow. Existing ditch structures could be retrofit as bioswales where right of way widths allow.

Filter Strip

Filter strips are vegetated buffers adjacent to roads and other impervious surfaces that convey stormwater as sheet flow while filtering and slowing flow to promote sedimentation and infiltration before outfalling to another conveyance structure. Filter strips are typically vegetated with turf grass, but other low growing plants and shrubs can be used. Filter strips are most appropriate adjacent to roadways or parking lots where turf grass growth can accommodate deposition of road traction material.

Wet Pond

Wet ponds are permanently wet impoundments of water. Wet ponds facilitate settling of sediments and associated pollutants and allow biological processes that treat nutrients and metals. Selection of vegetation adjacent to ponds can reduce the attraction to waterfowl. Steep slopes and available land may preclude placement of wet ponds in many areas in Sitka.

Hydrodynamic Separator

Hydrodynamic separators are modified underground catch basins that trap sediment, oils, and debris. Hydrodynamic separators are typically proprietary designs sold as off-the-shelf plastic structures fitted into typical manhole structures. They include downspouts and overflow weirs that enhance settling and trapping of medium-sized sediments and floatables while reducing the transport of the trapped pollutants. They are typically too small to trap small-diameter sediment most associated with some pollutants but are relatively inexpensive and are easily implementable in many areas. Hydrodynamic separators could be installed on many of the piped drainage systems in higher density developments where the other BMPs may not be feasible due to space constraints.

Water Quality BMPs Design and Sizing

Sizing water quality BMPs is an optimization problem; larger BMPs treat a greater proportion of total runoff from a site but take up more space and are more expensive while smaller sized BMPs will treat less runoff and will be more likely to allow trapped pollutants to be washed out. Municipalities have used different methods for setting water quality treatment levels. These methods include: the 90 percent exceedance, 91 percent runoff using continuous simulation or the intensity or volume that would treat 90 percent of total precipitation (King County 2009; City of Portland 2008; ADEC 2009). Some municipalities (City of Portland 2008) have justified the selection of the 90 percent exceedance by observing a significant “elbow” or increase in plots of storm depth versus percent exceedance around the 90 percent exceedance level. This level represents the greatest “bang for the buck” in sizing BMPs, as BMPs sized for a larger event will be significantly larger and have a decreasing return on volume of runoff treated. Monitoring data have shown King County’s water quality treatment level (using 90 percent exceedance) achieves the treatment goal of 80 percent removal of total suspended sediment for most water quality BMPs.

Water quality BMPs such as wet ponds and infiltration basins are sized to treat a specific runoff volume. Other water quality treatment BMPs, such as biofiltration swales and oil-water separators, are sized based to a specific peak flow rate. In the absence of continuous hydrologic model results, municipalities have used recurrence interval-based data to set water quality treatment levels. The water quality design flow rate is frequently set to 60 percent of the peak runoff rate from the 2-year, 24-hour storm event. For the water quality design volume, municipalities have used the volume of 60 percent of the total runoff from the 2-year, 24-hour storm or a volume corresponding to three times the runoff from the mean annual storm.

RECOMMENDED LID APPROACHES

Large-Scale Site Design

Preserve Open Space

LID begins with conducting a site inventory to identify and locate resources on site that naturally store, infiltrate, and convey water. These resources include naturally occurring, highly infiltrative soils, wetlands, streams, and native vegetation. The initial inventory process provides baseline information necessary for the site design. Development areas should be located outside of natural resource protection areas and within designated buildable areas to minimize soil and vegetation disturbance and take advantage of a site’s natural ability to store and infiltrate stormwater.

Minimize Impervious Areas

A main concept of LID is to limit the construction of impervious surfaces. At the large scale, development can be designed to limit the length of road per developable lot through more efficient layout with more cross streets without cul-de-sacs. Grid patterns provide multiple access routes to each parcel and may include alleyways between blocks with garages located at the back of the house. Development can be clustered with smaller setbacks to preserve open space. Clustered development can provide the same number and size of lots with fewer road surfaces and more connected open space.

Small-Scale Site Design

Preserve Natural Vegetation

During site layout, existing vegetation should be preserved to the maximum extent possible. With a well thought out construction sequence, complete grading of a site may not be necessary. Trees should be protected from damage to branches and trunks from construction traffic. Damage to tree roots and compaction of soil around the tree should be prevented by restricting traffic at least from the tree drip line. Preserving vegetated buffers along streams can also enhance the site and help protect water quality.

Revegetate with Native Plants

After construction, landscaped areas should be revegetated with plant materials appropriate to site conditions. Plant materials should also be selected to minimize the need for additional chemical fertilizers and herbicides. Native vegetation can be superior to other materials as it is adapted to the local climate and ecosystem.

Preserve Soil Infiltration During Construction

During construction, vehicle traffic should be limited in order to prevent compaction of soils. After site grading and demolition, areas where site traffic is not required should be fenced off from construction traffic. Site traffic and staging should use existing impervious surfaces as much as possible.

Soil Amendment of Graded Areas

Areas of rich topsoil should be left in place or, if excavated in construction areas, used elsewhere on the site to amend areas with sparse or nutrient-deficient topsoil. After construction, graded areas to be landscaped should be amended to improve soil fertility and runoff retention, infiltration, or filtration.

Minimize Impervious Surface Area

Roadways

Excessively wide streets are the greatest source of impervious cover (and stormwater runoff) in most residential developments. Inappropriate standards result from blanket application of high volume/high speed road design criteria, overestimates of on-street parking demand, and the perception that wide streets result in faster emergency response times.

Narrower road sections and alternative road profiles can reduce stormwater runoff and mitigate its impacts while still allowing safe travel, emergency vehicle access, adequate parking, and snow removal or storage. For low traffic roads, a road width as narrow as 24 feet may be sufficient to accommodate two-way traffic, and even narrower widths should be used in very low traffic conditions (e.g., a six-lot subdivision). Roadways can be designed without traditional curb and gutter to allow sheet flow to an adjacent vegetated filter strip.

Cul-de-sacs can result in construction of large areas of impervious surface. Where cul-de-sacs are required, alternative designs can reduce runoff and improve neighborhood character, while still providing sufficient room for fire trucks and school buses to maneuver. One simple approach (applicable to both new construction and retrofits) is to create a landscaped island in the middle of a standard-size cul-de-sac. A 30-foot island in an 80-foot-diameter cul-de-sac will reduce the impervious surface by 15 percent. If the island is designed and built as a bio-retention area, and the roadway graded appropriately, this strategy can also treat roadway runoff.

The benefit of narrow streets to minimize impervious surface has to be balanced against the impact of narrow streets on movement of fire and other emergency vehicles and the use of roads for temporary snow storage and safe snow removal. The National Fire Protection Administration Uniform Fire Code (2003) recommends a minimum unobstructed width of just 20 feet, with the recognition that local authorities may set lower standards if turnouts or alternate exits are available.

Sidewalks

Impervious sidewalk surface areas can be minimized by reducing widths and requiring sidewalks on only one side of the street where pedestrian safety allows. Sidewalks can be constructed using pervious surface such as pavers or gravel. Sidewalks can be disconnected from other impervious surfaces by grading the sidewalks to drain to grassy or landscaped areas between the road and the sidewalk.

Driveways

Driveway sizes and widths can be reduced by designing common driveways that serve multiple properties or using a “hammerhead” rather than larger circular vehicle turnarounds. Driveway widths and design must be balanced by the need for emergency access and snow storage and removal.

Building Footprint

Taller, narrower buildings create less impervious surface than lower, single- and two-story buildings. Parking structures result in less impervious surface than traditional parking lots. Existing codes and zoning may restrict their application in some areas but could be amended to allow or possibly promote.

NON-STRUCTURAL APPROACHES TO WATER QUALITY

Non-Structural Stormwater Actions

Non-structural options to improve water quality may include:

- Encourage source control BMPs in residential and commercial land uses including spill prevention, hazardous material storage and disposal, onsite sewage treatment maintenance, and vehicle fueling. Appendix G contains examples of source control BMPs.
- Further implement source control best management practices for municipal operations including disposal of street wastes, road de-icing, and snow removal and disposal.
- Encourage LID techniques and use of drainage BMPs including impervious surface disconnection, impervious surface reduction, and drainage infiltration and dispersion where feasible during development review.
- Continue and promote municipal hazardous waste collection events. Promote recycling and proper disposal of potentially hazardous materials such as batteries and fluorescent light bulbs.
- Review policy for wetland and stream setbacks.
- Review and optimize catch basin maintenance scheduling particularly for arterial catch basins.
- Develop drainage design standards and guidelines including erosion control during construction.

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CHAPTER 7.
RECOMMENDATIONS

HYDRAULIC DESIGN STANDARDS

Hydraulic design standards should be developed to provide guidance for the development of stormwater infrastructure. Clear design standards can prevent poorly designed and constructed infrastructure. Design standards should include recommended measures and BMPs to control erosion and sedimentation during and after construction. Erosion and sediment control should also be further encouraged for all (single-family house construction and larger disturbance area) development projects as part of building and/or grading permits to the same level and in conjunction with the ADEC construction general permit requirements. The hydraulic design standards should complement the existing CBS standard plans and standard specifications. Appendix H contains a draft of design standards applicable to Sitka.

DRAINAGE PLAN

A drainage plan is the documentation submitted by a project proponent to CBS during the permitting process that displays how the project will follow local ordinances and CBS hydraulic design standards. A drainage plan is referred to in the existing CBS municipal code. Clear guidance on what elements should be included in the drainage plan will help ensure efficient and detailed review of project construction documents and basis of design. Sitka should develop guidance to project proponents on what should be submitted in a site plan and promulgate this process to the public. Appendix I contains a draft of drainage plan requirements appropriate to Sitka.

COMPLETE STORMWATER INFRASTRUCTURE INVENTORY

The first two phases of stormwater inventory were not able to survey all of the CBS stormwater infrastructure in the Sitka area. In some instances, either infrastructure was buried or otherwise could not be found; therefore, the drainage network could not be accurately created. These instances will need to be investigated and corrected on a case by case basis. Larger areas that require infrastructure survey include:

- Mills Street and Georgeson Loop - pipe and ditch drainage system.
- Edgecumbe drainage basin - trace and survey several large open water and pipe systems across Halibut Point Road to salt water.
- Lake Street near 703 Lake Street - 42-inch CMP crossing.
- Cascade Creek Road - pipe and ditch drainage system.
- Katlian Street and Olga Street - piped drainage system was partially mapped using infrastructure observed through photographs.
- Lake Street and Lincoln Street - piped drainage network was drawn using as-built drawings.
- Monastery Street, Baranof Street, Jefferson Davis Street, and Park Street - piped drainage systems were drawn partially using as-built drawings, and infrastructure was observed through photographs.
- Japonski Island - piped and open channel drainage systems.
- College Drive and Lincoln Street - piped drainage system.
- Jamestown Way - piped drainage system.
- Knutson Drive and Sawmill Creek Road - piped and open channel drainage system.

CAPITAL IMPROVEMENT PROJECT INVESTIGATION AND IMPLEMENTATION

Drainage problem investigation was conducted only by observation of pipe conditions from ends of pipes or from the surface of structures. Several of the identified drainage problems require further investigation to determine the extent and nature of deterioration of the existing pipes. Further investigation may revise the prioritization determined in this report. Cost estimates and project prioritization should also be revised by incorporating cost savings realized by simultaneous replacement of sewer, water, and road infrastructure in the vicinity of the identified drainage projects. Several of the identified drainage problems are in danger of failure. Failure could result in danger to the public and may be much more expensive to address in an emergency situation. The identified higher priority projects should be addressed as soon as possible.

FUNDING

The existing backlog of Capital Improvement Projects (CIPs) and maintenance needs may exceed the funding allocated from the CBS general fund. CBS should investigate funding mechanisms to pay for infrastructure improvements. Funding sources could include fees for development review, local improvement districts for system-wide problem areas, and organizing a city-wide stormwater utility.

STORMWATER QUALITY SOURCE CONTROL

Removing pollutants from stormwater in Sitka is particularly difficult because of frozen conditions, poorly infiltrating soils, and large volumes of runoff. Many pollutants cause negative health and environmental effects at extremely low levels. Preventing pollutants from contacting stormwater in the first place can be the most efficient and effective means of preventing pollution. CBS should continue to develop and promote water quality source control appropriate to conditions within Sitka.

CHAPTER 8.
REFERENCES

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APPENDIX A.
EXAMPLE OF PROPOSED STORMWATER ORDINANCE

APPENDIX A
PROPOSED STORMWATER ORDINANCE

DRAFT 2-10-2011 ORDINANCE NO.

AN ORDINANCE OF THE CITY OF KETCHIKAN, ALASKA, ESTABLISHING POLICIES AND PROCEDURES FOR THE CONTROL OF STORM DRAINAGE, ESTABLISHING PENALTIES FOR VIOLATIONS, AND ESTABLISHING AN EFFECTIVE DATE.

WHEREAS, an expanding population and increased development of land, coupled with inadequate drainage controls, has led to drainage, flooding, and runoff problems within the City of Ketchikan, and

WHEREAS, these drainage, flooding and runoff problems contribute to increased sedimentation in the creeks and streams, thereby degrading water quality, and

WHEREAS, inadequate storm drainage planning and practices lead to erosion, property damage, increased maintenance costs, increased long-term capital costs and risk to life; and

WHEREAS, excess water runoff on streets and highways poses a safety hazard to both lives and property, and

WHEREAS, the City Council finds it necessary to decrease drainage-related hazards to life and the threat of drainage-related damage to public and private property from existing and future storm runoff; to promote sound development policies which respect, preserve and enhance the City's watercourses; to ensure the safety of public roads and rights-of-way; and to protect the health, safety, and welfare of the people of Ketchikan.

NOW THEREFORE BE IT ORDAINED by the Council of the City of Ketchikan, Alaska as follows:

Section 1.

There is hereby enacted a new Title of the Ketchikan Municipal Code to be designated "Title 21 Storm Drainage" as follows:

<u>Title 21</u>
<u>STORM DRAINAGE</u>

<u>Chapters:</u>

21.01 General Provisions
21.10 Special Drainage Use Areas
21.20 Design and Construction Standards
21.30 Permit Requirements and Procedures
21.35 Drainage Plans

Chapter 21.01
GENERAL PROVISIONS

Sections:

21.01.010 Purpose. This Title is established to promote, protect, and preserve the public interest by regulating the planning, construction, and maintenance of public and private storm drainage systems within the City.

The specific objectives of this Title include but are not limited to:

1) The prevention and abatement of flooding and runoff related property damage, nuisances, or hazards;

2) The prevention of water quality degradation caused by erosion and sedimentation due to construction, logging, clearing, quarrying or other land development operations;

3) The prevention of adverse effects of alterations in ground and surface water quantities, locations, and flow patterns;

4) The prevention of actions or practices which would reduce the ability of the public drainage system to convey storm drainage at its intended capacity;

5) The establishment of minimum standards for planning, construction, and maintenance of storm drainage improvements within the City; and

6) The establishment of administrative procedures for permits, plan reviews, and construction quality control for grading or drainage improvements significantly affecting the public drainage system.

This Title is intended to promote the health, safety and welfare of the public and nothing herein is intended to or shall be deemed to create a duty in the City to protect or promote the interests of any particular person or class of persons. The existence of these regulations or any failure, refusal or omission of the City to enforce any provision herein shall not prevent, supplant or affect the right of any person affected by the clearing, grading, or drainage operations of another to invoke such private remedies as may be available against such other person.

21.01.020 Applicability.

(a) This Title shall apply to all property within the City, both privately and publicly owned, and to the extent permitted by law, to those lands which are outside the City limits which discharge storm and surface waters into the City.

(b) To the extent permitted by law, governmental entities, including municipal corporations and their departments, government owned utilities, school districts, and agencies and departments of State and Federal government, shall be subject to the provisions of this Title.

(c) Other City, Borough, State and Federal laws and regulations may apply to storm drainage related matters within the City. Compliance with the provisions of this Title does not guarantee compliance with such other requirements.

21.01.030 Administration. The Director of Public Works is charged with the administration and enforcement of this Title. The Director is empowered to establish such administrative procedures and guidelines as are required in the execution of this authority.

21.01.040 Definitions. The following words and phrases, whenever used in this Title, shall be construed as defined in this section unless from the context a different meaning is intended, or unless different meaning is specifically defined and more particularly directed to the use of such words or phrases:

(1) "Brush" means vegetation one foot to eight feet in height.

(2) “City Drainage System" means all drainage systems lying within City owned lands or within easements and rights-of-way specifically dedicated to the City of Ketchikan.

(3) "Comprehensive Storm Drainage Study" means a detailed analysis of City drainage basins, hydraulic capacity of existing storm drainage systems, and various drainage system maps and other data which are on file at the City Department of Public Works and available for public inspection during normal City business hours.

(4) "Computations" mean calculations, including runoff coefficients and other pertinent data, made to prepare a drainage plan, with rates of flow of water given in cubic feet per second (cfs).

(7) "Director of Public Works" means either the Director of City's Department of Public Works or the Director's designee.

(8) "Design Storm" means a rainfall event of chosen intensity and duration selected for a storm drainage analysis or system design, and is usually expressed as having a statistical probability of recurrence, such as once in every 5, 10, 50, or 100 years on average. A 100-year storm has a 1% probability of occurring in a given year.

(9) "Designated Special Drainage Use Areas" means areas within the City which have been designated as critical to the passage of stormwater runoff from upland origins to salt water discharge.

(10) "Development" means, but is not limited to, buildings, bridges, road building, grading, land-filling, excavations, utilities or other capital improvements and other land-use changes that add impervious area.

(11) "Drainage Area" means the area that contributes runoff to the point under consideration.

(12) "Drainage Basins" means those lands draining to a common watercourse or outlet including the headwaters of said watercourse.

(13) "Drainage Plan" means a plan for the collection and transport of stormwater runoff within a project area and for discharge of runoff to the City drainage system.

(14) "Drainage System" means the system of facilities for collecting and conveying stormwater runoff, including streams, pipelines, channels, ditches, lakes, wetlands, and other drainage structures and appurtenances, natural and manmade.

(15) "Erosion" means the process by which stormwater dislodges and transports soil and other materials.

(16) "Excavation" means the physical, man-made removal of earth material.

(17) "Flood Plain" means the low-lying area adjacent to a watercourse onto which excessive water flows during periods of prolonged and intensive precipitation. The flood plain for a particular watercourse is a geographical area flooded by a storm of specified recurrence interval.

(18) "Ground Cover" means vegetation normally less than one foot in height.

(19) "Grade" means the vertical elevation of the ground surface.

(20) “Grading" means any act which changes the elevation of the ground surface.

(21) "Grubbing" means the act of root vegetation removal from beneath the surface of the earth.

(22) "Impervious" means impenetrable -completely resisting the entrance of liquids.

(23) "Natural Locations" means the location of those channels, swales, and other non-manmade water conveyance systems as defined by the first documented topographic contours existing for the subject property either from maps or photographs.

(24) "Peak Discharge" means the maximum rate of stormwater runoff at a particular point determined for the design storm.

(25) "Professional Engineer" means an individual or corporation licensed to practice civil engineering in the State of Alaska.

(26) "Public Drainage System" means all drainage systems lying within dedicated public easements and rights-of-way or other public lands, and watercourses through private lands which serve as integral parts of drainage systems which convey surface water from streets or public lands, or which provide common drainage from more than one parcel.

(27) "Recurrence interval" is the estimated interval of time between storms of a given intensity and duration.

(28) "Sediment" means waterborne particles, graded or undefined, occurring by erosive action.

(29) "Sedimentation" means the deposition of debris and soil sediment displaced by erosion and transported by runoff.

(30) "Storm Drainage Control Standards and Guidelines" means a manual of technical and administrative procedures established by the Director of Public Works which delineates methods to be used, the level of analysis required, and other details for implementation of the provisions of this Title.

(31) "Storm Sewer" means an underground conduit to convey discharges to an outfall point.

(32) "Stream" means a surface water route generally consisting of a channel with bed, banks, or sides, in which surface waters flow in draining from higher to lower land, both perennial and intervening; the channel and intervening artificial components, excluding flows which do not persist more than 24 hours after cessation of rainfall at some time of the year.

(33) "Watercourse" means the course or route followed by waters draining from the land, generally formed by nature.

Chapter 21.10
SPECIAL DRAINAGE USE AREAS

Standards:

21.10.010 Designated Special Drainage Use Areas. Areas within the City which are critical or may reasonably become critical to the passage of stormwater runoff from upland origins to saltwater discharge are hereby established as "Designated Special Drainage Use Areas." Critical areas are those in which existing or potential flooding, drainage, erosion, and/or instability conditions present a reasonable likelihood of harm to the welfare and safety of surrounding property, or to the integrity of the surface or groundwater system.

21.10.020 Maps Adopted. Designated Special Drainage Use Areas have been identified and shown on a series of maps bearing the same name as part of the City's Comprehensive Storm Drainage study.

These maps are hereby adopted as officially defining Designated Special Drainage Use Areas for purposes of this Title.

The Director of Public Works shall be responsible for maintaining and updating maps of Designated Special Drainage Use Areas, and for identifying properties lying within Designated Special Drainage Use Area boundaries.

The Director of Public Works shall update maps to include annexed areas within ninety (90) days of annexation, and as a whole at not more than five (5) year intervals.

21.10.030 Development Restrictions. In general, development in Designated Special Drainage Use Areas shall be permitted subject to compliance with other provisions of this Title. However development projects affecting Designated Special Drainage Use Areas will face greater scrutiny during the permitting process.

21.10.040 Flood Plains. Development in City areas designated by the Ketchikan Gateway Borough as "FP Zone - Superimposed Flood Plain Zone" shall not be permitted unless the property owner has requested and received the prior engineering approval required by Borough Ordinance.

Chapter 21.20
DESIGN AND CONSTRUCTION STANDARDS

Sections:

21.20.010 Standards Adopted.

(a) Design and construction standards for storm drainage improvements within the City shall be prepared, maintained, and revised from time-to-time by the Director of Public Works and made available in written form to the general public upon request at a nominal charge sufficient to cover the cost of reproduction.

(b) These standards shall be referred to as "Ketchikan Storm Drainage Control Standards and Guidelines" and are hereby adopted as official City standards for design and construction of culverts, catch basins, drains, ditches, drainage inlets, and other ordinary drainage improvements.

21.20.020 Compliance Required. Construction of drainage improvements in public rights-of-way, easements and areas for which drainage permits are required by Chapter 21.30 of this Code shall be designed and constructed in compliance with standards adopted in this Chapter.

21.20.030 Modifications and Revisions. The Director of Public Works may revise and update the "Ketchikan Storm Drainage Control Standards and Guidelines" from time-to-time to reflect changes in technology, new information concerning hydrologic or meteorological assumptions, changes in type and availability of construction materials, and standards guidance from other government entities.

21.20.040 Variances. The Director of Public Works may allow deviations from the "Ketchikan Storm Drainage Control Standards and Guidelines" when he/ she determines that drainage can be better accommodated by alternate design or construction methods, or when substitutions of alternate construction materials would not result in loss of essential function. A variance may also be granted by the Director of Public Works when he or she finds that:

(1) Downstream facilities have sufficient capacity under design conditions to safely convey the proposed runoff;

(2) The quality of the receiving waters will be maintained;

(3) There is minimal potential for adverse effects from the proposed retention or detention of flow;

(4) The proposed system can be maintained, and;

(5) The proposed system does not compromise the structural integrity of abutting foundations and structures.

CHAPTER 21.30
PERMIT REQUIREMENTS AND PROCEDURES

Sections:

21.30.010 Grading Permit Required. No property owner may engage in or allow any of the following activities on his or her property within the City unless he or she first obtains a Grading Permit from the Director of Public Works;

(1) Connection of drain lines to the City drainage system;

(2) Grading, excavation, or other construction activities which temporarily or permanently reroute or in any way modify the quantity or quality of storm water entering the public drainage system;

(3) Grading, excavation, or other construction activities which temporarily or permanently increase the volume of surface drainage exiting the property;

(4) Grading, excavation, or other construction activities which create temporary or permanent impoundments of surface water in excess of 1000 gallons;

(5) Extensions of culverts subject to tidal or other submergence;

(6) Quarry and borrow pit operations;

(7) Logging and clearing operations in excess of 5000 square feet in area or on slopes in excess of 15%;

(8) Construction of greater than 2000 square feet of new impervious surface;

(9) Any type of construction within the Flood Plain Zone identified by ordinances of the Ketchikan Gateway Borough;

(10) Any type of construction within designated Special Drainage Use Areas;

(11) Construction or alteration of dams or bridges;

(12) Dumping or filling of muskeg or other highly erodible construction waste;

(13) Construction of driveways or roads crossing ditches which adjoin public roads or lie within public rights-of-way;

21.30.011 Obligation of Person Performing Work. Every contractor or other person performing or directing the performance of any work requiring a permit under this chapter shall have in his/her possession prior to commencement of and during all phases of the work, approved plans and specifications, an original or copy of a valid permit therefore, and shall further have a duty to be familiar with the terms and conditions of the permit and approved plans and specifications.

21.30.015 Drainage Plan Required. Submittal to the Director of Public Works of a Drainage Plan conforming to the requirements of Chapter 21.35 shall be required of any owner of real property within the City when the Director of Public Works determines that significant drainage modifications are proposed:

(1) Simultaneous with the filing of any preliminary plat of re-subdivision for land within the City;

(2) As part of application requirements for a Grading Permit;

(3) Simultaneous with the filing of improvement plans accompanying a petition for formation of a Local Improvement District within the City;

(4) Simultaneous with the filing of plat alteration requests with the Ketchikan Gateway Borough when:

(a) Natural drainage swales and/or natural retention areas are located within the short plat and exceed one foot in depth. These shall be identified by the applicant on the plat;

(b) The plat lies within a designated Special Drainage Use Area as defined by Chapter 21.10;

(c) The plat is located within or adjacent to a flood plain.

(5) Simultaneous with the filing of a rezone request.

21.30.020 Relation to Other Permits.

(a) Any improvement for which a building permit is required under Title 19 of this Code shall require a grading permit, unless the Director of Public Works determines that no significant drainage modifications are included in the proposed work.

(b) When the Director of Public Works determines that drainage modifications are involved, he/she shall so advise the applicant, and receipt of a grading permit shall automatically become a prerequisite to the issuance of the building permit.

(c) Issuance of a grading permit shall not relieve the responsibility of securing other permits, State, Federal, or local.

21.30.030 Application Procedures.

(a) Applications for Grading Permits shall be on forms and in the format established and published by the Director of Public Works.

(b) Approval of grading permit applications shall be automatic within twenty one (21) calendar days of filing unless the Director either disapproves the application in writing, or advises the applicant in writing of requirements for special application data.

(c) Upon receipt of special application data approval of grading permits shall be automatic within twenty one (21) calendar days unless the application is disapproved in writing.

(d) The Director of Public Works may extend the time allowed for processing of specific applications in order to allow adequate time for review, provided written notice is given to the applicant stipulating a date by which action will be taken. In the event no action is taken by the stipulated date, or unless the application is disapproved in writing, approval shall be automatic.

21.30.040 Standard Application Data. An application for a Grading Permit shall contain not less than the following information:

(1) Name and address of property owner;

(2) Identification of property;

(3) Narrative description and location sketch of proposed improvements or activity;

(4) Proposed start and completion dates for construction.

(5) Whether permit is for one or more phases, or for complete development of the property.

(6) Location sketch of significant watercourses traversing the property.

21.30.042 Special Application Data.

(a) When the Director of Public Works determines that the standard application data is insufficient to make a reasonable judgment about the impacts of proposed activities on surrounding property or the public drainage system, he or she may direct the applicant to submit special application data prior to further consideration of a Grading Permit application. Development affecting Special Drainage Use Areas are more likely to require special application data.

(b) Special application data may consist of:

(1) Drainage Plan prepared in accordance with the requirements of Chapter 21.35;

(2) Construction plans and specifications;

(3) Estimated quantities and cost of earthworks, grading, and drainage improvements;

(4) Evidence of plan approval by Alaska Department of Environmental Conservation, Alaska Department of Fish and Game, US Army Corps of Engineers, or other concerned public agencies and/or submittal of Alaska Department of Natural Resources Coastal Project Questionnaire.

21.30.046 Denial of Permit. The Director of Public Works shall not issue any grading permit when:

(1) In the determination of the Public Works Director the proposal shall lead to adverse flooding or sedimentation impacts;

(2) The applicant fails to provide complete and accurate application information required by other provisions of this chapter;

(3) The applicant fails to pay required permit processing fees;

(4) The applicant fails to agree to permit conditions which may be stipulated in accordance with Section 21.30.047 of this Chapter;

(5) Earlier phases of the same project approved under prior permits are not in compliance with permit conditions.

21.30.047 Permit Conditions. Whenever the Director of Public Works determines that proposed improvements are of such significance that incomplete or improper construction would have serious adverse impact on surrounding property as a result of erosion, flooding, or misrouting of storm water, he or she may require the following as a condition of the drainage permits:

(1) Bond or other security in accordance with Chapter 21.40;

(2) Liability insurance in with Chapter 21.40;

(3) Verification of construction conformance to the standards of Chapter 21.20 and to City approved construction plans and specifications in accordance with Section 21.30.060 of this Chapter;

(4) Documentation of size, location, and grades of "as constructed" drainage facilities.

21.30.050 Bonds and Insurance. The Director of Public Works is authorized to require property owners constructing drainage facilities to post security whenever the cost of proposed drainage improvements is estimated to exceed $50,000. Security shall be in the form and amount stipulated in Chapter 21.40 of this Title.

21.30.060 Inspection by City.

(a) The Director of Public Works, or a designated representative, is authorized to, and may inspect, any exterior premises in the City to verify data stated on drainage permit applications and compliance of new construction with permit conditions.

(b) After issuance of a grading permit the City shall be notified at the time any construction or alteration affecting drainage on the site shall begin and shall have the right to make periodic inspections during the construction or alteration to ensure that the requirements stated in the permit and elsewhere in this ordinance are met. If stipulated in the permit conditions the property owner or applicant must notify the City at least forty eight (48) hours prior to the back-filling or cover of any subsurface drainage control facilities so that a proper inspection can be made.

(c) Upon completion of the facilities an inspection will be conducted to determine that the drainage control facilities have been constructed in accordance with the plans, specifications submitted with the permit application.

(d) If inspections indicate that the facilities have been completed in accordance with the requirements of the permit, a final approval shall be given. Without this approval, or in the event of any deficiencies not being corrected, no occupancy or use of, or further construction on the property will be permitted until such time as the deficiencies are corrected. In the event the owner shall not make such corrections within 30 days, the City may take such corrective measures as may be necessary to make the system perform as required by the permit. All costs for corrective measures shall be borne by the property owner.

21.30.070 Suspension of Permit. The Director of Public Works may suspend or revoke a drainage permit when an applicant;

(1) Fails to comply with conditions of the permit within fourteen (14) calendar days of written notice of noncompliance;

(2) Application information is discovered to be fraudulent or incorrect subsequent to permit approval;

(3) Is in violation of other government permits applicable to improvements on the same property covered by the drainage permit;

(4) Fails to renew insurance coverage or replace other security which may be required under Chapter 21.40 of this Title.

21.30.075 Expiration of Permit. Every permit issued under the provisions of this Chapter shall expire at the end of the period of time set out in the permit. If the permittee is unable to complete the work within the specified time, he shall, prior to expiration of the permit, present in writing to the Director of Public Works, a request for an extension of time, setting forth therein the reasons for an extension of time. If, in the opinion of the Director of Public Works, such an extension is reasonable, he may grant additional time for the completion of the work.

21.30.080 Exemptions. A grading permit shall NOT be required for the following activities:

(1) Resurfacing of existing paved areas;

(2) Landscaping, gardening, roto-tilling or other residential land surface treatment unless it results in nuisance conditions as defined in Chapter 21.80 of this Title;

(3) Construction of on-lot driveways, drains, or other residential improvements which do not alter the quantity or location of storm drainage exiting the property, or adjoining properties.

21.30.081 Waivers. The Director of Public Works may waive minor technical deficiencies and waive permit requirements for specific applications when he or she finds that the proposed improvement will have no substantial adverse effect on storm drainage or surface water runoff.

21.30.085 Appeal Procedures.

(a) An appeal of the permit application requirements, conditions, denial, suspension, or revocation of a drainage permit, or of the determinations of the cost of corrective measures by the Director of Public Works, may be made by the applicant or permittee in writing to the City Manager, who shall respond with his or her written determination upholding or overruling the Director of Public Works within fourteen (14) calendar days of receipt. The City Manager may, in his or her discretion for good cause shown, grant a stay in whole or in part of the action taken by the Director of Public Works until the appeal is decided.

(b) The applicant or permittee may appeal the ruling of the City Manager directly to the City Council, upon filing a written request for a hearing with the City Clerk expressly setting forth the specific matters appealed, and the basis for the request.

(c) The Council shall hear the appeal at its next regular meeting after the appeal is filed. Only those matters specified in the notice of appeal shall be considered by the council. The council in its discretion may direct that the matter be heard wholly or in part on oral testimony or that other evidence be submitted.

(d) Upon consideration of the appeal, the City Council may affirm, modify, amend, vacate, or reverse any finding or action of the Director of Public Works, or it may remand the appeal to the Director of Public Works and require such further proceedings to be had as may be just under the circumstances. The City Council in its decision on appeal may provide and require such conditions and safeguards necessary to guarantee compliance by the permit holder with the intent and purposes of this Title.

(e) No appeals shall be considered unless filed within thirty (30) calendar days of issuance of the determination from which the appeal is sought.

21.30.090 Permit Processing Fees.

(a) The City shall levy such fees as are necessary to review and administer the grading permit for the specific improvement and the basic permit fee shall be twenty dollars ($20.00).

(b) The permit fee for projects requiring special data submittals in accordance with Section 21.30.042 of this Chapter shall be on the basis of the minimum fee plus direct costs incurred by the City including, but not limited to, the following:

1. Costs of engineering -review time
2. Costs for inspection time

(c) The Director of Public Works shall estimate the above costs and stipulate them in writing at the time applicants are advised of any special data submittal requirements.

(d) Should a property owner fail to obtain a grading permit and a permit is found by the Director of Public Works to be required after construction or other activity has begun the property owner shall be required to obtain a permit and permit fees shall be levied at twice the normal rate.

Chapter 21.35
DRAINAGE PLANS

Sections:

21.35.010 Drainage Plan Format.

(a) When required by other provisions of this Title, Drainage Plan submittals shall conform to the requirements of this Chapter.

(b) The Director of Public Works shall prepare standard format guidelines for applicants detailing requirements for drawing size, scale, and media, size and organization of engineering reports, and type and location of information to be shown on documents making up the Drainage Plan. Format guidelines shall be made available to permit applicants in written form at the time a Drainage Plan is requested.

21.35.020 Minimum Drainage Plan Content. Drainage plans shall contain not less than the following information:

(1) Parcel and ownership data;

(2) Description of drainage system and its existing drainage and water quality problems;

(32) Plan showing property boundaries and existing topography at sufficient scale and contour interval to indicate drainage ways, paved and graded areas, buildings, bridges, and culverts or other drainage structures;

(4) Plan showing proposed development features impacting drainage, including grading, ditching, bridges, culverts, paving, and buildings. Minimum data to be provided for culverts, ditches, or other drainage ways are cross-sectional dimensions and grades of inverts;

(5) Plans of existing and proposed conditions may be combined on the same drawings;

(6) Identification of amount of impervious area on the property both before and after the proposed development;

(7) Known data about soil types, depth of rock, vegetative cover on the property;

(8) Indication of the peak discharge and amount of surface water currently entering and leaving the subject property due to the design storm;

(9) Indication of the peak discharge and amount of runoff which will be generated due to the design storm within the subject property if development is allowed to proceed;

(10) Indication of the peak discharge and amount of surface water likely to enter the subject property as a result of future upstream property development, if other than current amounts. Computation shall assume maximum upstream development consistent with either existing zoning or development patterns proposed or projected in the Comprehensive Plan of the Ketchikan Gateway Borough, whichever is greater; (11) Computations to support information furnished in items (7), (8), (9) above.

(12) Computations to demonstrate that on site and off site open channels and pipe outlets are designed to provide a stable bed and banks at the design conditions.

(13) Computations to demonstrate that culverts and other pipe systems meet the design requirements of the Ketchikan Storm Drainage Control Standards and Guidelines.

(14) Computations shall be prepared by or under the supervision of a professional engineer;

(15) Details on proposed construction materials, inlet types, and drainage appurtenances if other than those stipulated in the Ketchikan Storm Drainage Control Standards and Guidelines or elsewhere in the Code.

<u>21.35.030 Special Requirements</u>.

(a) The Director of Public Works may require additional information when he/she finds that the submitted plans, specifications and other data are not sufficiently clear to allow a determination that the proposed work fully conforms to the design standards of Chapter 21.20, or if there is reasonable cause to believe that the proposed development will have a significant adverse drainage impact upon other properties. This information may consist of any or all of, but is not necessarily limited to, the following:

> (1) Where recorded or established water appropriation rights will be affected or significant rechanneling or changes in flow on downstream property will result:
>
> > a. A recorded agreement from all owners of adjoining property who may be affected by proposed development;
> >
> > b. A recorded waiver of claim from downstream or upstream property owners which could be adversely affected should the proposed stormwater discharge vary in location, velocity, or direction from that which previously existed;
>
> (2) If water is to be impounded during construction or as part of the final plan of the site development, inflow-outflow hydrographs plotted for design storms showing the impounded volume and maximum discharge;
>
> (3) A soils report prepared by a professional engineer which shall include data regarding the nature, distribution, and strength of existing soils, conclusions and recommendations for clearing and grading procedures including temporary and permanent erosion control measures,

and design criteria for corrective measures when necessary; together with opinions and recommendations covering adequacy of sites to be developed and the extent of significant effects of the site development due to erosion upon surrounding properties by the proposed clearing and grading. Recommendations included in the report shall be incorporated in the clearing and grading plans, specifications or supporting material;

(4) Construction plans and specifications for proposed grading and drainage improvements;

(5) Additional reports, if in the judgment of the Director of Public Works such information is deemed advisable, including but not limited to biological, wildlife, chemical, water quality, bacterial or other factors related to environmental impact.

21.35.040 Phased Development.

(a) Projects subject to this chapter which are to be developed in two or more phases must, insofar as possible, submit a drainage facility plan for, all phases of the project at the time of first submittal.

(b) The Director of Public Works shall determine on his review of any drainage facility plan for a project involving phased development:

(1) How much of the entire project the first phase plan must reasonably cover, and,

(2) When, in development of the entire project, the drainage facilities for each phase must be completed.

2.35.050 Waiver of Submittal Requirements. The Director of Public Works may waive specific drainage plan content requirements in cases where he/she determines that other information furnished by the applicant is sufficient to assess the adequacy of proposed drainage improvements and the drainage impacts on surrounding property of the proposed development.

Chapter 21.40
SECURITY

Sections:

21.40.010 Construction Bond. If required as a grading permit condition by the Director of Public Works, prior to commencing construction, the person constructing the facility shall post a construction bond in an amount sufficient to cover the cost of conforming said construction with the approved drainage plans.

21.40.020 Maintenance Bond.

(a) If required as a grading permit condition by the Director of Public Works, after satisfactory completion of the facilities and release of the construction bond by the City, the person constructing the facility shall commence a one (1)-year period of satisfactory maintenance of the facility. A cash bond to be used at the discretion of the Director of Public Works to correct deficiencies in said maintenance affecting public health, safety, and welfare must be posted and maintained throughout the one-year maintenance period.

(b) The amount of cash bond shall be determined by the Director of Public Works but shall not be less than one hundred percent of the estimated construction cost of the drainage facilities. In addition, a surety bond or cash bond to cover the cost of design defects or failures in workmanship of the facilities shall also be posted and maintained throughout the one-year maintenance period.

21.40.030 Umbrella Bond Permitted. Where persons have previously posted, or are required to post, other such bonds on the facility itself or on other construction relating to the facility, such person may, with the permission of the Director of Public Works and to the extent allowable by law, combine all such bonds into a single bond, provided that at no time shall the amount thus bonded be less than the total amount which would have been required in the form of separate bonds, and provided further that such a bond shall on its face clearly delineate those separate bonds which it is intended to replace.

21.40.040 Liability Policy. If required as a drainage permit condition by the Director of Public Works, the person constructing the facility shall maintain a liability policy in the amount of not less than one million dollars per individual, one million dollars per occurrence, and one million dollars property damage, which shall name the City and Ketchikan Public Utilities (KPU) as additional insured and which shall protect the City and KPU from any liability up to those amounts for any accident, negligence, failure of the facility, or any other liability whatsoever, relating to the construction or maintenance of the facility. Said liability policy shall be maintained for the duration of the facility by the owner of the facility, provided that, in the case of facilities assumed by the City for maintenance pursuant to Chapter 21.60 of this Title, said liability policy may be terminated when City maintenance responsibility commences.

21.40.050 Cash Escrow Accounts.

(a) The Director of Public Works may allow the permittee to establish security in lieu of bonds in the form of cash escrow account or an irrevocable letter of credit or other form of credit which may be acceptable to the City at its sole discretion, with his bank in an amount deemed by the Director to be sufficient to reimburse the City if it should become necessary for the City to enter the property for the purpose of correcting and/or eliminating hazardous conditions relating to soil stability and/or erosion, or to restore vegetation, and/or for other purposes authorized herein.

(b) In no case shall the security be less than the director's estimate of the cost of correcting or eliminating hazardous conditions that reasonably may occur, and/or of insuring compliance with the stipulations of the permit and the approved plans and specifications.

(c) Should the City, during the course of construction, find it necessary to expend the security to correct any work not in accordance with the approved plans and specifications, a stop work order shall be issued to the permittee on any additional work until the security is re-established by the permittee.

Chapter 21.50
MAINTENANCE REQUIREMENTS

21.50.010 Maintenance of Private Improvements.

(a) Unless the City specifically assumes maintenance responsibility as elsewhere provided in this Code, property owners shall be responsible for maintenance and repair of all ditches, drainage ways, culverts, and drainage appurtenances on their property.

(b) At a minimum, property owners are required to:

(1) Maintain the security of inlet screens and grates, and periodically clean inlets, silt traps and sediment boxes for any private inlet structures discharging into the public drainage system;

(2) Sweep or otherwise collect litter, leaves, or other debris from parking areas tributary to the public drainage system;

(3) Maintain foundation and under-drain systems, roof downspout systems and gutters to prevent overflows or leakage to the public sidewalks;

(4) Maintain driveway culverts clear of weeds or other debris, at all times, and of snow and ice during thawing conditions;

(5) Keep inlets clear of ice and snow during thawing conditions;

(6) Remove accumulated sediment from detention basins to maintain design storage capacity.

21.50.020 City Maintenance of New Construction.

(a) The City shall assume the maintenance of new storm drainage facilities per the requirements of Chapter 21.60.

(b) The burden of proof of compliance with permit conditions shall be with the developer. In the event the City does not accept facilities for maintenance, the developer shall be fully responsible for maintenance.

21.50.030 Notice of Non-Acceptance. The Director of Public Works shall notify the developer in writing of any refusal by the City to accept completed storm drainage facilities for maintenance, in whole or in part, stating the reasons for non-acceptance, and conditions for acceptance, prior to the expiration of the one year developer maintenance period, or else acceptance shall be automatic.

Chapter 21.60
EASEMENTS AND DEDICATIONS

Sections:

21.60.010 Easements Required. As a condition of issuance of a grading permit or annexation the City shall require dedication of easements or dedicated tracts for public or private construction of drainage systems that convey flows from an upstream property. Easements and dedicated tracts are intended to preserve natural watercourses or to provide sufficient access to allow periodic maintenance, repair, and reconstruction of drainage channels, conduits, and appurtenances. Easements or dedicated tracts are not required for drainage channels, conduit or appurtenances draining a single parcel such as roof, yard or footing drains.

21.60.020 Easement Requirements.

(a) The property owner shall provide the City with a certified as-built survey of the installed facilities performed by a registered land surveyor.

(b) Minimum easements or dedicated tracts for drainage facilities shall be:

(1) For open channels: channel width plus 15 feet from top of slope on one side and 5 feet from top of slope on opposite side;

(2) For pipes less than 60-inch diameter: 10 feet centered on pipe;

(3) For pipes greater than 60-inch diameter: 20 feet centered on pipe;

(4) Per Director of Public Works the required easement or dedicated tract width may be greater depending on depth or number of pipes.

(c) The City may require the property owner to provide a performance guarantee equal to one hundred percent of the construct cost adequate to assure that the facilities will perform satisfactorily for one year after completion of construction;

(d) Where feasible easements and dedicated tracts shall be adjacent and parallel to property lines and located completely within a single parcel or tract.

(e) In cases in which all or part of the drainage facilities are not accessible for maintenance purposes due to overlying structures or other causes, the City shall be held harmless by the grantor for damages which might occur due to failure of design or workmanship of those segments.

(e) The City reserves the right to reject dedications which would convey maintenance responsibility for grossly substandard drainage facilities, or which would provide more private than public benefit.

21.60.030 Maintenance Access.

(a) Maintenance access must be provided for all pipe inlets and outlets, manholes, catch basins, vaults, or other underground drainage facilities to be maintained by the City. Maintenance shall be through an access easement or dedicated tract. Drainage structures for conveyance without vehicular access must be in an open channel.

(b) A minimum 20-foot wide access easement or dedicated tract shall be provided to drainage facilities from a public street or right-of-way. Access easements shall be surfaced with a minimum 12-foot width of crushed rock, or other approved surface to allow year-round equipment access to the facility.

21.60.040 Retroactive Assumption of Maintenance.

(a) Except for drainage structures or appurtenances located within State right-of-way, or lateral ties of small roof, foundation or other drains providing private benefit, the City shall be responsible for maintenance of all drainage structures located within public dedicated rights-of-way or easements within the City Limits.

(b) Assumption of maintenance responsibility shall include facilities constructed prior to the effective date of this Chapter.

Chapter 21.70
EROSION AND SEDIMENT CONTROL

Sections:

21.70.010 Erosion and Sediment Control Required. Erosion and sediment control shall be required as a condition of a grading permit for all land disturbing activities such as clearing, grading, excavating and/or demolition that disturbs more than one acre of land. Property owners shall conduct their operations so as to expose the smallest practical area of soil to erosion for the least possible time during construction. Erosion control measures shall be undertaken from the time of beginning of clearing and maintained throughout the course of the project.

21.70.020 Erosion and Sediment Control Plans. For projects that disturb more than one acre of land, or are part of a common plan that disturbs more than one acre of land, property owners shall submit to the City and implement an Erosion and Sediment Control Plan as part of the requirements for a Grading Permit. Erosion and Sediment Control Plan shall meet the requirements of the Stormwater Pollution Prevention Plan as required by the Alaska Department of Environmental Conservation Construction General Permit.

21.70.030 Erosion and Sediment Control Measures.

(a) Control of erosion from the general clearing and grading operations as well as the cut and fill slopes shall be implemented according to procedures set forth in Chapter 21.20 to prevent damage by sedimentation to drainage facilities, streams, floodplains, surface waters, natural areas and property of others. Control of erosion shall be both permanent and temporary:

(1) Permanent. This control shall be considered and set forth in the original design of the project to provide erosion control following completion of construction.

(2) Temporary. This control is to be exercised by the clearing and grading contractor during the construction phase and prior to completion of the permanent erosion control facilities.

(b) The following are considered erosion and sediment control measures:

(1) Vegetation

(2) Mulch

(3) Natural or synthetic matting

(4) Riffles

(5) Impervious linings, including polyethylene and asphalt concrete

(6) Terraces, grassed waterways

(7) Drop structures, grade stabilization devices

(8) Storm drains

(9) Energy dissipation devices

(10) Debris basins

(11) Sedimentation ponds

(12) Filters

(c) Vegetation shall be restored or permanent control measures placed at the earliest possible date, with exposure of denuded areas limited to the shortest practical time on slopes with sufficient grade to allow scouring of soil. At the completion of the project all permanent erosion control measures shall be fully implemented and effective.

(d) During construction all temporary erosion control devices shall be maintained in fully operable and effective condition. Denuded areas of the project upon which further active construction is not being undertaken shall be planted or otherwise provided with a ground cover sufficient to restrain erosion within 30 working days of completion of grading.

(e) Onsite drainage shall be handled in such a way as to control erosion and to return waters to the natural drainage course free of sedimentation or other pollution. Drainage from areas above the developed site shall be temporarily diverted from the construction area to preclude erosion and sedimentation.

(f) Where drainage facilities discharge to natural drainage ways or watercourses, energy dissipation facilities shall be provided to prevent erosion and deterioration of the streambed or banks. Energy dissipation facilities shall be constructed of approved materials. Material such as broken concrete slabs, pipe, tires, scrap metal or debris is prohibited.

(g) No person shall discharge drainage waters from their project to any point or in any manner not approved by the City.

21.70.040 Suspension of Construction. During periods of seasonal high precipitation, the Director may prohibit specific clearing, grading, or excavation and filling activities within the City when he judges that adequate control of erosion is not practicable.

Chapter 21.80
STORMWATER QUALITY AND CONVEYANCE SYSTEM PROTECTION

Sections:

21.80.010 Prohibited Acts.

(a) It shall be prohibited and in violation of this Code and hereby proclaimed a public nuisance for any person to:

(1) Cause or permit litter, trash, rubbish, cut brush, tree trimmings, rocks, excavated materials, or debris to enter the public drainage system;

(2) Cause or permit liquid or water-carried pollutants to enter the public drainage system, including but not limited to oils and petroleum products, paints and paint thinners, flammable substances, pesticides, fertilizers, soaps, detergents, and washing wastes; substances with strong, offensive odors, sewage sludge, septic tank waste, and gas producing or corrosive substances;

(3) Cause or permit horses, cattle, or other domestic animals other than dogs or cats to enter any watercourses or wetlands that are part of the public drainage system. Stables, pastures, and other animal enclosures shall be drained so as to prevent polluted drainage waters from entering the public drainage system;

(4) Cause or permit grading, clearing, filling or other land surface changes to take place in such a way as to allow drainage from the property to carry detrimental amounts of suspended or dissolved matter into the public drainage system;

(5) Cause or permit to take place in the streams, watercourses, or wetlands that are part of the drainage system any work that would result in the 'transmission of detrimental amounts of sediment, pollutants, or other foreign substances into other parts of the public system;

(6) Discharge any waters which cause the temperature of receiving waters to reach levels which exceed Alaska Water Quality Standards;

(7) Obstruct or conceal the inlet to any public drainage appurtenance;

(8) Obstruct gutters, ditches, or other roadway channels obviously intended for the passage of storm water;

(9) Discharge storm water or subsurface drainage to the sanitary sewer system;

(10) Cause or permit rainwater, ice or snow to drain from the building or structure onto a public sidewalk, or to flow across the sidewalk;

(11) Construct real property improvements after the effective date of this Title in noncompliance with the permit requirements of Chapter 21.30 of this Code;

(12) Fail to maintain driveway culverts or other drainage works in violation of private maintenance requirements of Chapter 21.50 of this Code.

<u>21.80.020 Abatement</u>.

(a) The City may take immediate action to abate any nuisance specified in Section 21.80.010 which constitutes, in the judgment of the Director of Public Works, an immediate hazard to property or human life. The Director shall notify the property owner of any abatement action in writing by mail, telephone, messenger, and/or by posting on the property. All costs associated with this corrective action shall be borne by the property owner together with any penalties adjudged under Chapter 21.90 of this Code.

(b) The property owner shall be liable for all costs associated with the containment, cleanup, injury, death, or other liability or damage resulting from such discharge. The City may, without election and reserving all other rights, assess supplemental service charges in an amount equal to the City's direct and indirect costs, including without limitation liability to third parties, if any, and attorney's fees, against such owner or owners and against the premises from which discharge in violation of this chapter originates, and pursue all rights accorded by law in the recovery of such charges as supplemental hereunder.

Chapter 21.90
ENFORCEMENT AND PENALTIES

Sections:

21.90.010 Inspection. The City reserves the right to enter the grounds and exterior premises of private and public property from time to time to ascertain that all drainage facilities which impact the public drainage system are functioning.

21.90.020 Notice of Violation.

(a) Duly authorized officers and employees of the City shall have authority to issue citations on or off a job site charging a violation(s) of this chapter to any person(s) authorizing, directing or committing such violation(s). Said citations may, to the extent consistent with orders or directions of a court of competent jurisdiction, specify an amount of bail and a time by which such bail must be posted. A personal appearance at a trial or hearing is not required provided that a cash bail is posted and forfeited in the maximum amount of the fines prescribed in this section for the particular offenses(s) cited and provided that the person cited has not previously been convicted of a violation of this chapter or previously disposed of a citation there under by forfeiting bail.

(b) In the event violations of the provisions of this Title are found, the property owner shall make such corrections as are necessary within 15 calendar days of the date of notice by the City or as otherwise specified in the notice. In the event the property owner shall fail to make such corrections, the City may revoke the occupancy permit for the subject property, may charge the property owner with a misdemeanor punishable by fines, and may enter on to the subject property and take such corrective action as may be required to make the drainage facilities perform as required by the drainage permit. All costs for corrective measures and enforcement actions shall be borne by the property owner.

(c) In the event immediately hazardous conditions are found, and the property owner is unavailable, unable or unwilling to take immediate corrective action, the City may take summary abatement action in accordance with Section 21.80.020 of this Code.

21.90.030 Penalties.

(a) Violation of this Title as set forth in Section 21.80.010 is a misdemeanor. Each day during which any violation of or failure to comply with any of the provisions of this chapter is committed, continued or permitted constitutes a separate offense. Upon conviction of an offense, the violator shall be punished as follows:

(1) Upon first conviction of any offense, except the failure to obtain a permit required by Chapter 21.30, by a fine of $250;

(2) Upon first conviction for failure to obtain a permit required by Chapter 21.30, by a fine of $500;

(3) Upon second conviction, or any additional convictions thereafter, of a violation of this Title within any five year period, by a fine of $500 and, in addition, if the repeat offense includes a failure to obtain a permit required by this chapter, by imprisonment not exceeding thirty days.

21.90.040 Remedies Cumulative. Penalty or enforcement provisions provided herein shall not be exclusive, and the City may pursue any additional remedy or relief allowed by law in a response to a violation of this Title.

21.90.050 Reservation of Enforcement Rights. The failure or refusal of the City to enforce any provision of this ordinance, and as hereafter amended, shall not constitute a waiver or bar to prevent enforcement thereof against any person for a subsequent violation hereof, or for any other violation by any other person.

Section 2.

The effective date of this Ordinance shall be __________, 2011.

APPENDIX B.
PRECIPITATION FREQUENCY ANALYSIS

TECHNICAL MEMORANDUM

FINDINGS OF PRECIPITATION-FREQUENCY ANALYSES FOR THE SITKA ALASKA AREA

M.G. Schaefer Ph.D. P.E.

June 23, 2012

OVERVIEW

This technical memorandum provides a brief description of the findings of precipitation-frequency analyses that were conducted for the City and Borough of Sitka Alaska and nearby areas. The memorandum also includes a description of the data and procedures that were used in conducting the analyses. The following products were developed as part of this study.

- Precipitation-frequency relationships for the Sitka Rocky Gutierrez Airport and Sitka Magnetic Observatory for 24-hour precipitation maxima
- Generalized 24-hour precipitation-frequency relationship scalable to sites in the Sitka area
- Seasonality analysis of precipitation maxima at 24-hour duration
- Five scalable long-duration design storms developed from historical storms
- Intensity-Duration-Frequency (IDF) curves for durations from 5-min through 60-min
- Seasonality analysis of precipitation maxima at 1-hour duration
- Scalable short-duration, 2-hour synthetic design storm incorporating IDF characteristics

PRECIPITATION-FREQUENCY FOR 24-HOUR ANNUAL MAXIMA

An L-Moment regional frequency analysis (Hosking and Wallis[3]) was conducted to develop the precipitation-frequency relationship for 24-hour precipitation maxima for the Sitka area. Annual maxima data series were assembled for daily and 24-hour precipitation maxima (NOAA[9]) for the stations listed in Table 1. Daily annual maxima represent the largest daily precipitation amount measured in a given year where the measurements are taken once daily by an observer at a specified time each day, such as 10 AM at the NOAA Sitka Japonski Airport station. Twenty-four hour precipitation maxima are measured using a sliding 24-hour window of time for hourly data recorded at automated gages. All of these stations are located in coastal areas in the southern panhandle of Alaska or northwestern British Columbia and have similar topographical settings and climatological characteristics.

An L-moments regional precipitation-frequency analysis was conducted for stations with 25-years or more of record and the results of the analysis are listed in Table 2. These results are compared with results from a large regional study conducted by Schaefer[14] for the coastal region of southern British Columbia. Comparable regional measures of variability (L-Cv) and skewness (L-Skewness) are seen for the two study areas (Table 2) which further supports the findings for the regional analysis for the Sitka area.

Table 1 – Station Locations for Daily and 24-Hour Precipitation Annual Maxima Data used in Regional Frequency Analysis

STATION ID	STATION NAME	DATA TYPE	PERIOD OF RECORD	MEAN ANNUAL PRECIPITATION[10,11] (inches)	DATA SOURCE
50-0352	Annette Airport, AK	24-Hour	1949-2009	103	NCDC[8]
50-2785	Elfin Cove, AK	Daily	1975-2011	115	NCDC[7]
50-1334	Cape Spencer, AK	Daily	1950-1975	106	NCDC[7]
50-3475	Gustavus, AK	Daily	1950-2011	58	NCDC[7]
50-3605	Hidden Falls Hatchery, AK	Daily	1993-2011	129	NCDC[7]
50-3695	Hoonah, AK	Daily	1972-2011	81	NCDC[7]
50-4590	Ketchikan, AK	Daily	1911-2010	137	NCDC[7]
50-5519	Little Port Walter, AK	Daily	1950-2011	220	NCDC[7]
1065010	Mc Innes Island, BC	Daily	1954-2010	105	Environ Canada[1]
50-7141	Pelican, AK	Daily	1967-2011	145	NCDC[7]
50-7557	Port Alexander, AK	Daily	1950-2011	163	NCDC[7]
1066480	Prince Rupert, BC	Daily	1908-1962	94	Environ Canada[1]
1066481	Prince Rupert Airport, BC	24-Hour	1962-2010	101	Environ Canada[1]
50-8494	Sitka Japonski Airport, AK	Daily	1950-2011	94	NCDC[7]
50-8503	Sitka Magnetic Observatory, AK	Daily	1899-1990	99	NCDC[7]
50-9941	Yakutat Airport, AK	24-Hour	1950-2009	152	NCDC[7]

Table 2 – Results of Regional Frequency Analysis for Sitka Area and Comparison with Results for Coastal Areas of British Columbia

REGIONAL FREQUENCY ANALYSIS	STATIONS	STATION-YEARS OF RECORD	REGIONAL L-Cv	REGIONAL L-Skewness
Sitka Area, AK	14	725	0.154	0.187
Coastal Areas, BC	54	1988	0.146	0.164

The four-parameter Kappa distribution (Hosking and Wallis[4]) was identified in the regional study for southern British Columbia as the best-fit regional probability distribution. The four-parameter Kappa distribution was also found to be suitable for the Sitka study area. The inverse form of the Kappa distribution is:

$$q(F) = \xi + \frac{\alpha}{\kappa}\left\{1 - \left(\frac{1-F^h}{h}\right)^{\kappa}\right\} \quad (1)$$

where: $q(F)$ is the estimate of precipitation for a specified non-exceedance probability (F); ξ, α, κ, and h are location, scale and shape parameters respectively and are solved in terms of the station at-site mean and regional values of L-Cv and L-Skewness.

The recurrence interval (T, years) is commonly used in engineering applications as a measure of the desired service level for hydraulic structures and is computed as:

$$T = 1/(1-F) \quad (2)$$

After review of the results from the regional analyses shown in Table 2, it was decided to adopt the regional shape parameter *h* value from the study in southern British Columbia[14] and to use the regional values of L-Cv and L-Skewness from the regional analyses for sites in the Sitka study area. These results are shown in Tables 3a,b along with product-moment statistics. Review of the probability-plots of historical daily maxima data for the NOAA stations at the Sitka Japonski Airport (Sitka Rocky Gutierrez Airport) and Sitka Magnetic Observatory show good agreement with the shape of the regional probability distribution (Figures 1a,b, solid blue line). Adjustment of the statistics for daily maxima to that for 24-hour maxima (Weiss[19]) produces the predicted precipitation-frequency relationship for 24-hour maxima (Figures 1a,b, dashed red line).

Table 4 lists the estimates of 24-hour precipitation maxima for selected recurrence intervals. Precipitation estimates for the common events with 2-year and 5-year recurrence intervals have been adjusted to reflect conversion from an annual maxima series to partial duration series (Langbein[5]) as appropriate for common events.

Table 3a – Adopted Values of L-Moment and Corresponding Product-Moment Statistics for 24-Hour Precipitation Annual Maxima for the Sitka Study Area

L-MOMENTS			PRODUCT MOMENTS		
L-Cv	L-Skewness	L-Kurtosis	Coefficient of Variation	Coefficient of Skewness	Coefficient of Kurtosis
0.154	0.187	0.152	0.289	1.35	6.64

Table 3b – Four-Parameter Kappa Distribution Parameters for 24-Hour Precipitation Annual Maxima for the Sitka Study Area

4-PARAMETER KAPPA DISTRIBUTION PARAMETERS			
LOCATION (ξ)	SCALE (α)	SHAPE 1 (κ)	SHAPE 2 (h)
0.8753	0.2104	-0.0394	-0.05

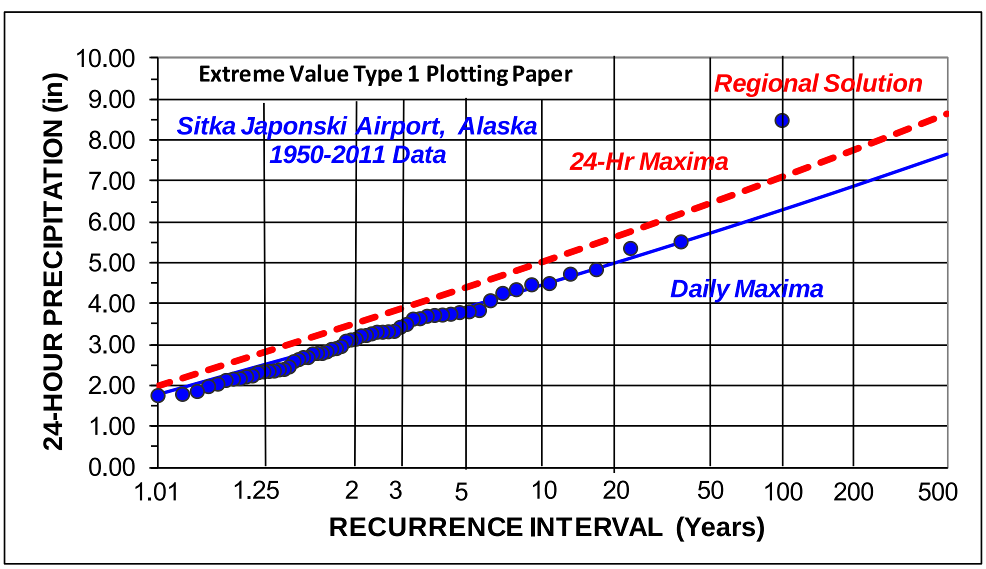

Figure 1a – Probability-Plot of Daily Precipitation Maxima for Sitka Japonski Airport Station and Precipitation-Frequency Relationship for 24-Hour Precipitation Maxima

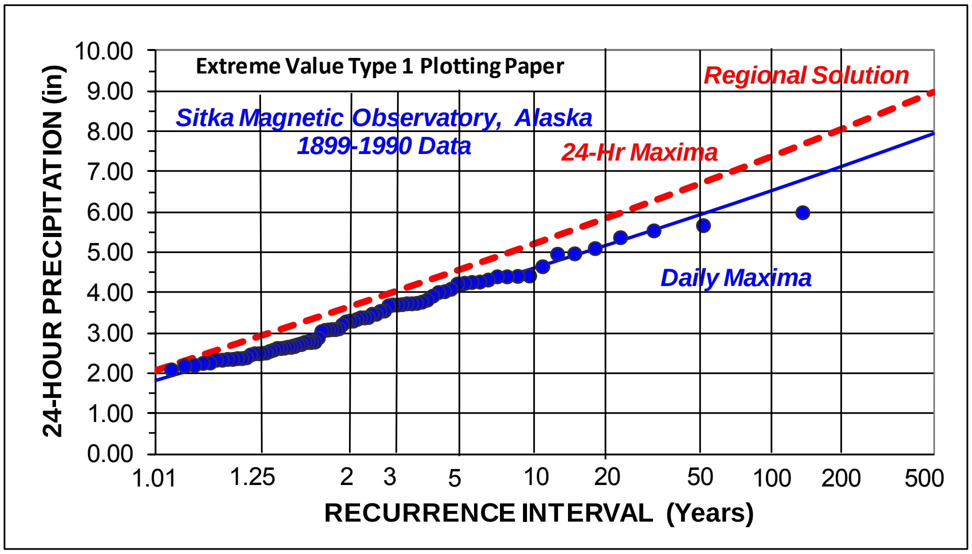

Figure 1b – Probability-Plot of Daily Precipitation Maxima for Sitka Magnetic Observatory and Precipitation-Frequency Relationship for 24-Hour Precipitation Maxima

Table 4 – Estimates of 24-Hour Precipitation Maxima for Selected Recurrence Intervals for the Sitka Rocky Gutierrez Airport (Sitka Japonski) and Sitka Magnetic Observatory

24-HOUR PRECIPITATION MAXIMA (inches)								
STATION	RECURRENCE INTERVAL (Years)							
	2	5	10	25	50	100	200	500
Sitka Rocky Gutierrez Airport	3.75	4.50	5.05	5.85	6.45	7.10	7.75	8.65
Sitka Magnetic Observatory	3.90	4.65	5.20	6.05	6.70	7.40	8.05	9.00

Generalized 24-Hour Precipitation-Frequency Estimates for Sites in Sitka Study

Precipitation-Frequency estimates for the 24-hour duration are also needed for sites within the City and Borough of Sitka (Baranof Island and southern portion of Chichagof Island) outside the downtown area. This can be accomplished by scaling the regional probability distribution by the 24-hour at-site mean for the site of interest, where the at-site mean is the mean of the annual maxima data series for the NOAA station (site). Table 5 lists 24-hour at-site means for NOAA precipitation stations in or near the City and Borough of Sitka.

The 24-hour at-site mean for a given location can be estimated from a 2nd order polynomial regression for 24-hour at-site mean values observed at NOAA precipitation stations using PRISM values of mean annual precipitation[11] as the explanatory variable (Equation 3, Figure 2). A gridded dataset of mean annual precipitation for Alaska can be obtained through the PRISM Climate Group at Oregon State University[11] and used to estimate the mean annual precipitation for a selected site. A color-shaded map of mean annual precipitation developed by the PRISM Climate Group is shown in Figure 3 and the gridded dataset of mean annual precipitation is included as a deliverable.

Table 5 – Listing of 24-Hour At-Site Means for NOAA Stations Within or Near the City and Borough of Sitka

STATION ID	STATION NAME	PERIOD OF RECORD	24-HOUR AT-SITE MEAN (in)
50-2785	Elfin Cove, AK	1975-2011	4.05
50-1334	Cape Spencer, AK	1950-1975	3.52
50-3695	Hoonah, AK	1972-2011	2.60
50-5519	Little Port Walter, AK	1950-2011	9.17
50-7141	Pelican, AK	1967-2011	5.64
50-7557	Port Alexander, AK	1950-2011	5.99
50-8494	Sitka Japonski Airport, AK	1950-2011	3.67
50-8503	Sitka Magnetic Observatory, AK	1899-1990	3.81

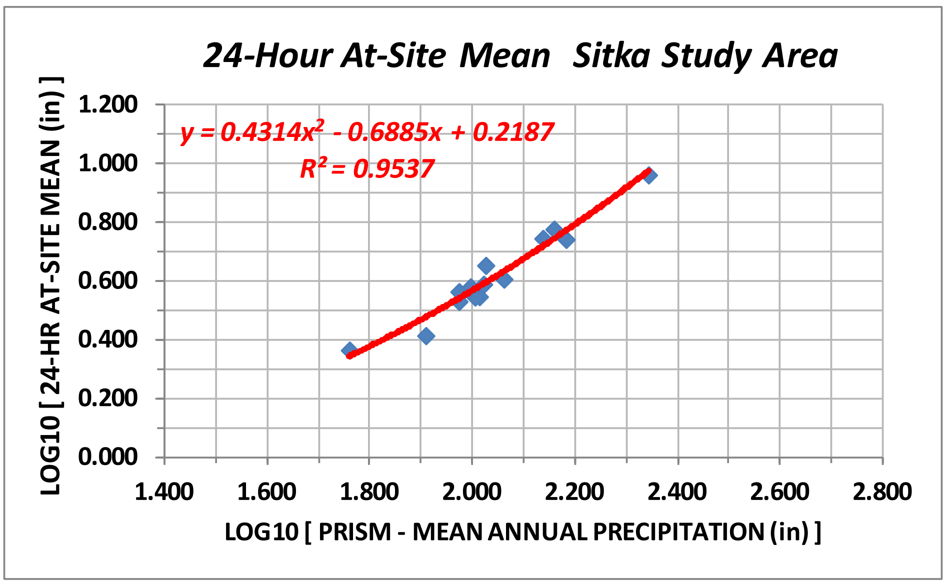

Figure 2 – Polynomial Regression for 24-Hour At-Site Means Using PRISM Values of Mean Annual Precipitation as the Explanatory Variable

$$At\text{-}Site\ Mean_{24} = 10\wedge(0.2187 - 0.6885 * MAP_{L10} + 0.4314 * MAP_{L10} * MAP_{L10}) \qquad (3)$$

where: *At-Site Mean*$_{24}$ is the estimate of the 24-hour at-site mean (inches); and MAP_{L10} is the base 10 logarithm of the value of mean annual precipitation (inches) for the site of interest obtained from the PRISM mean annual precipitation gridded dataset for Alaska.

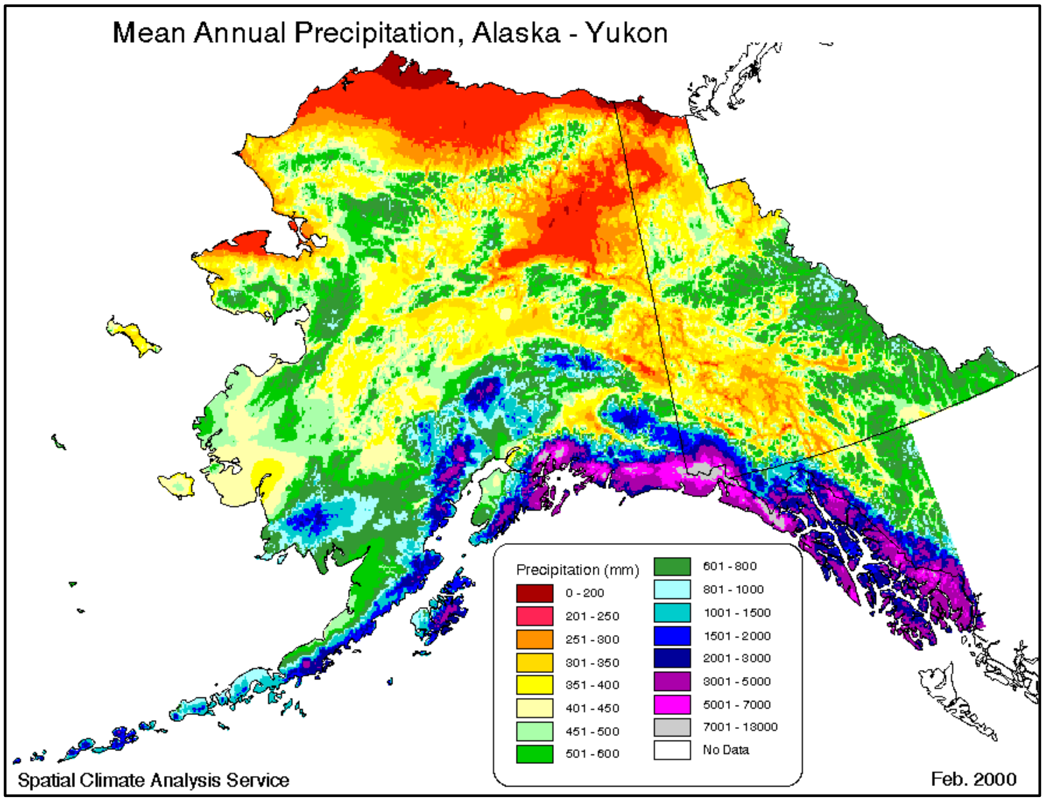

Figure 3 – Color Shaded Map of Mean Annual Precipitation for Alaska
Developed by PRISM Climate Group, Oregon State University

Estimation of the 24-hour precipitation-frequency relationship for a given site is computed as follows:

1. Determine the mean annual precipitation (inches) for the site of interest using ArcGIS or other spatial mapping software using the PRISM gridded dataset of mean annual precipitation
2. Estimate the 24-hour at-site mean (inches) using Equation 3 and the value of mean annual precipitation obtained from Step 1
3. Estimate the precipitation-frequency relationship for the selected site by using the 24-hour at-site mean from Step 2 to scale (multiply) the regional precipitation-frequency (Equation 1) using the regional distribution parameters listed in Table 3b.

An Excel spreadsheet is included as a deliverable which does all of the computations described above after the PRISM value of mean annual precipitation is determined.

Seasonality of Occurrence for 24-Hour Precipitation Annual Maxima for Sitka

24-hour precipitation annual maxima along the southern coast of Alaska are typically produced by well-organized storm systems that commonly produce precipitation with low to moderate intensities that persist for several days. Figure 4 depicts the monthly distribution of the dates of the daily annual maxima for the Sitka study area for the 1910-2011 period. The majority of daily maxima are seen to occur within the August through February period with September-October clearly showing the highest frequency of daily maxima. The seasonality histogram is often useful in assessing representative antecedent watershed conditions to be used in rainfall-runoff modeling.

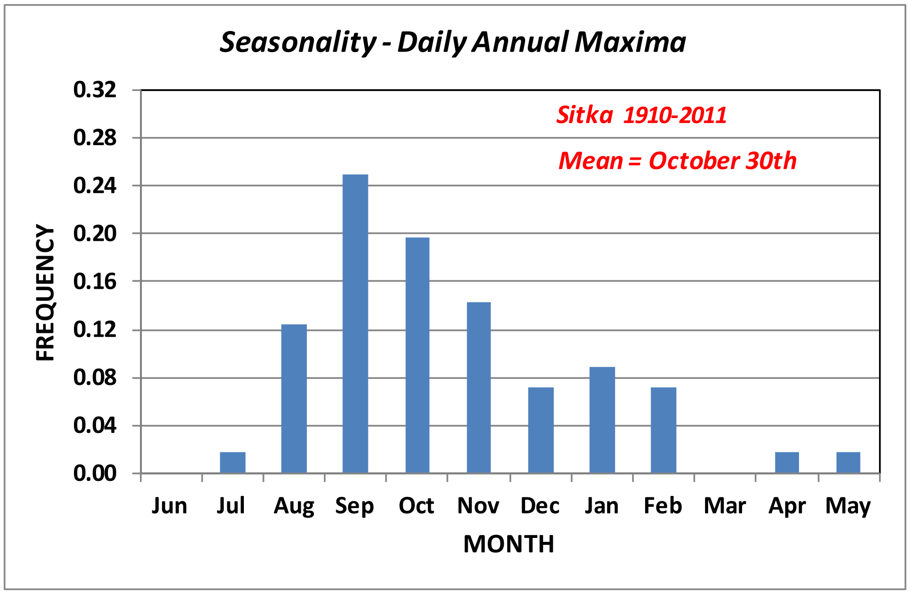

Figure 4 – Seasonality of Occurrence for Daily Precipitation Annual Maxima for Sitka Alaska Area

SCALABLE LONG-DURATION DESIGN STORMS

Long-duration design storms applicable to the Sitka area were developed using historical storms recorded at the Yakutat and Annette Airports in Alaska and at the Quillayute Airport in Washington. The Yakutat and Annette Airport stations represent the closest hourly recording precipitation gages that are representative of the storm patterns at Sitka. A synthetic design storm was not developed due to an insufficient number of storms to obtain representative statistics on storm characteristics. Alternatively, scaling of long-duration historical storms provides a practical solution to providing hyetographs for use in rainfall-runoff modeling of natural watersheds and partially urbanized watersheds.

Five scalable long-duration historical storms have been developed using the two storms with the largest 24-hour maxima in the historical record at the Yakutat and Annette Airports and a fifth large storm recorded on the coast in northern Washington that is considered representative of the storm characteristics to be expected in the Sitka area. The precipitation ordinates are obtained by scaling (multiplying) the historical incremental precipitation amounts by the user-specified 24-hour precipitation maxima for the desired recurrence interval. The 24-hour precipitation maxima can be obtained from Table 4 for sites near downtown Sitka or from the generalized procedures described above for sites elsewhere in the Borough.

The original storms were recorded at hourly intervals and the design storms were created on 10-minute intervals to allow higher resolution of runoff hydrographs. Precipitation intensities in all hourly increments, except the hour with the greatest 1-hour precipitation, have uniform intensities across the hourly interval. Precipitation intensities for the largest hourly precipitation increment were obtained by disaggregation to 10-minutes to provide higher resolution of the runoff peak discharge. Disaggregation was accomplished using findings of analyses of inter-duration storm characteristics conducted in Washington State (Schaefer[13,17]).

Figures 5a,b,c,d,e depict examples of long-duration design storms scaled to a 50-year recurrence interval at the 24-hour duration. Excel workbooks are included as deliverables for automatically scaling and plotting the long-duration design storms for the five historical storms.

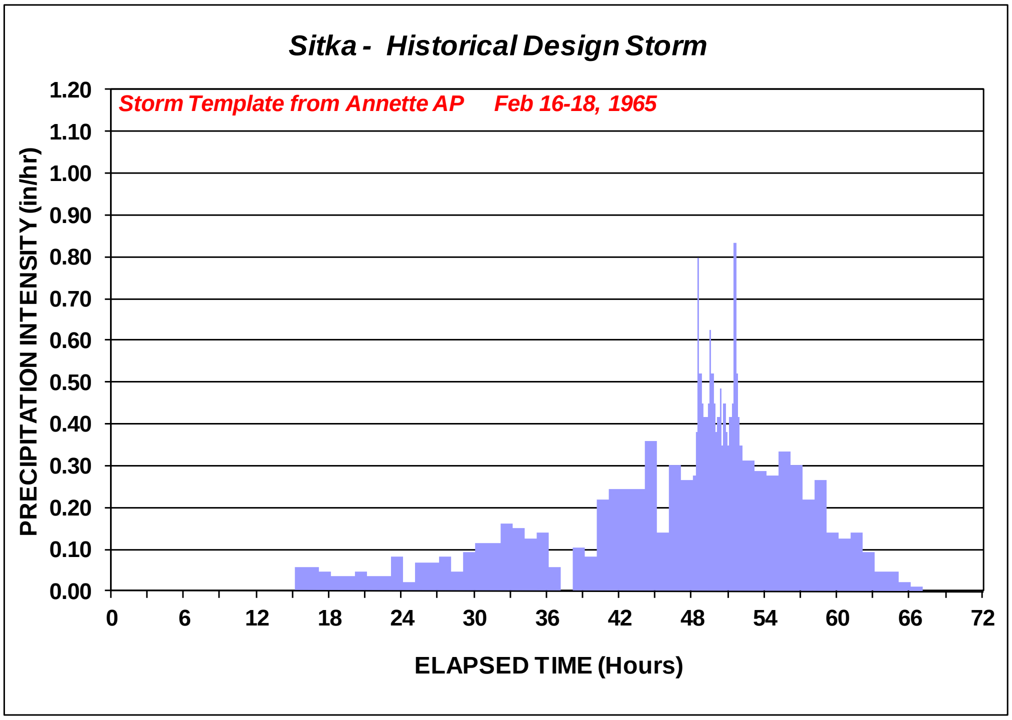

Figure 5a – Example Sitka Long-Duration Design Storm for 50-Year Recurrence Interval
for 24-Hour Precipitation=6.45-inches, Total Precipitation=8.35-inches
Historical Storm Originally Recorded at Annette Airport Alaska, Feb 16-18, 1965

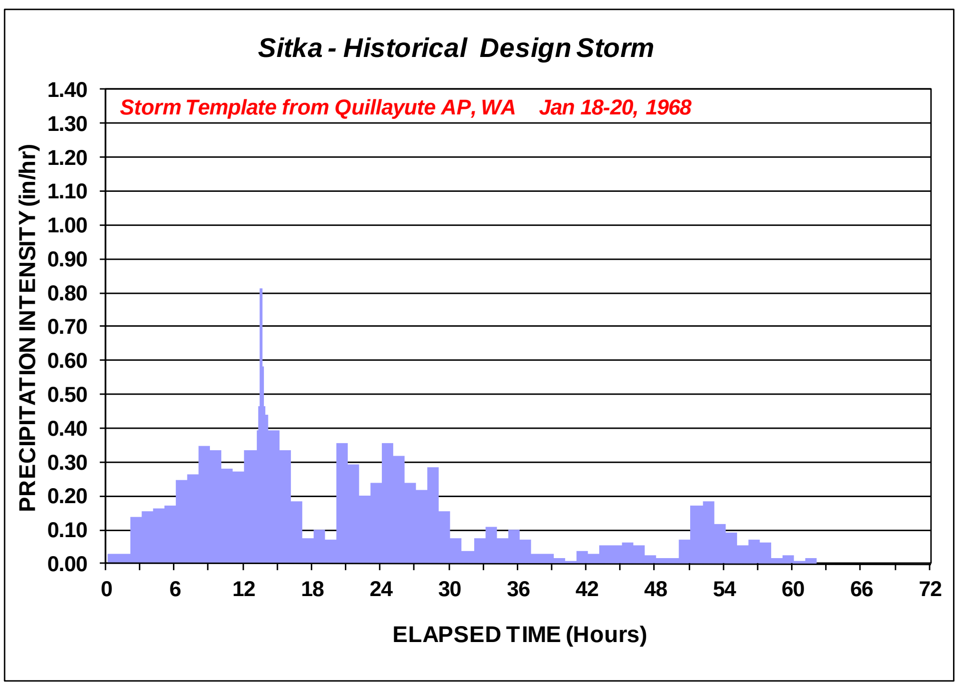

Figure 5b – Example Sitka Long-Duration Design Storm for 50-Year Recurrence Interval
for 24-Hour Precipitation=6.45-inches, Total Precipitation=8.99-inches
Historical Storm Originally Recorded at Quillayute Airport Washington, Jan 18-20, 1968

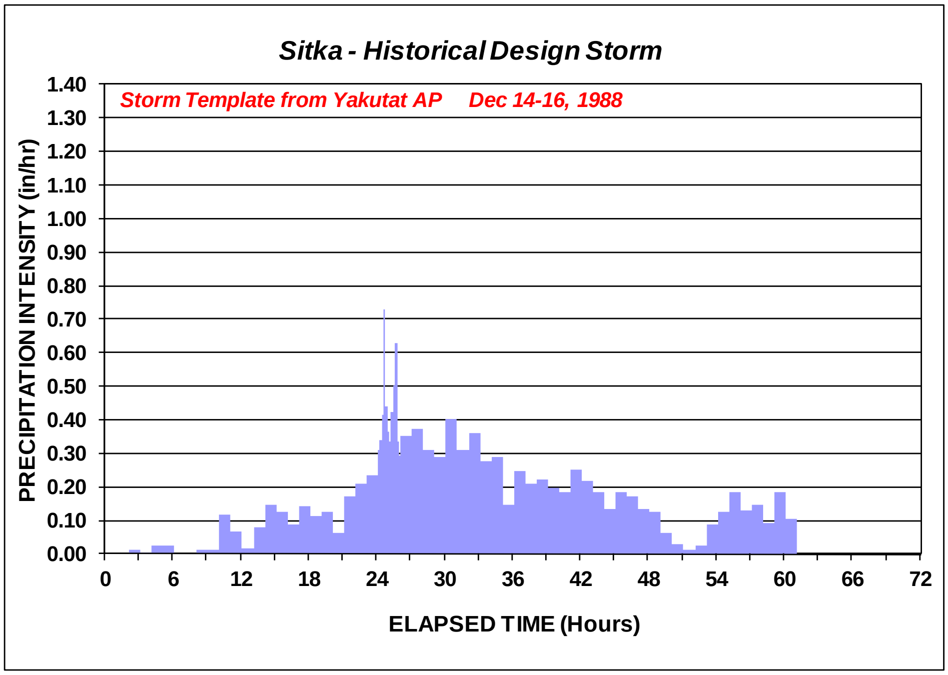

Figure 5c – Example Sitka Long-Duration Design Storm for 50-Year Recurrence Interval
for 24-Hour Precipitation=6.45-inches, Total Precipitation=9.42-inches
Historical Storm Originally Recorded at Yakutat Airport Alaska, Dec 14-16, 1988

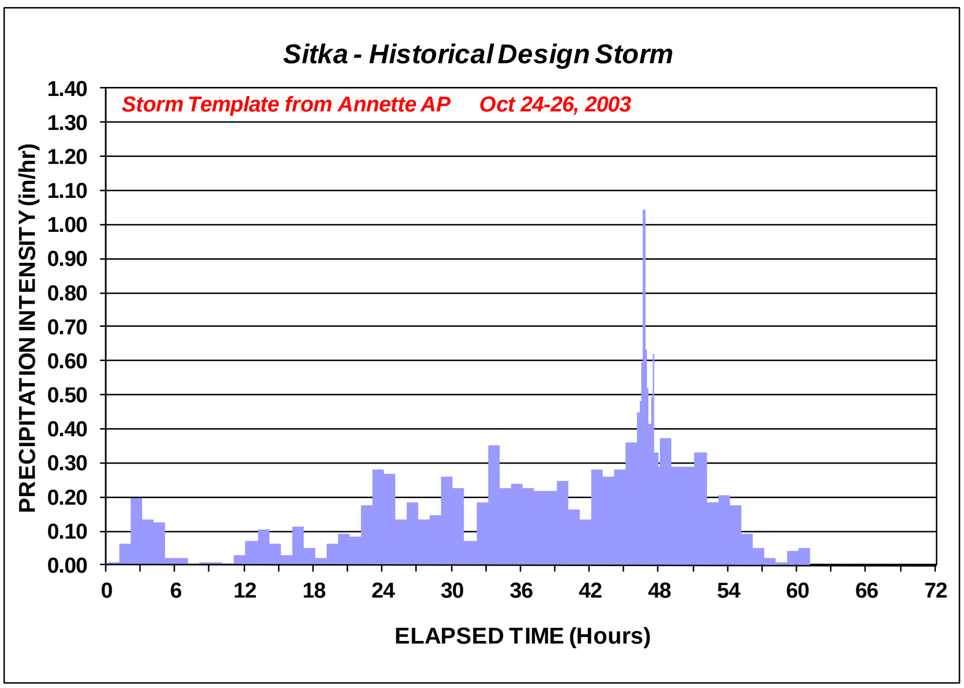

Figure 5d – Example Sitka Long-Duration Design Storm for 50-Year Recurrence Interval
for 24-Hour Precipitation=6.45-inches, Total Precipitation=9.74-inches
Historical Storm Originally Recorded at Annette Airport Alaska, Oct 24-26, 2003

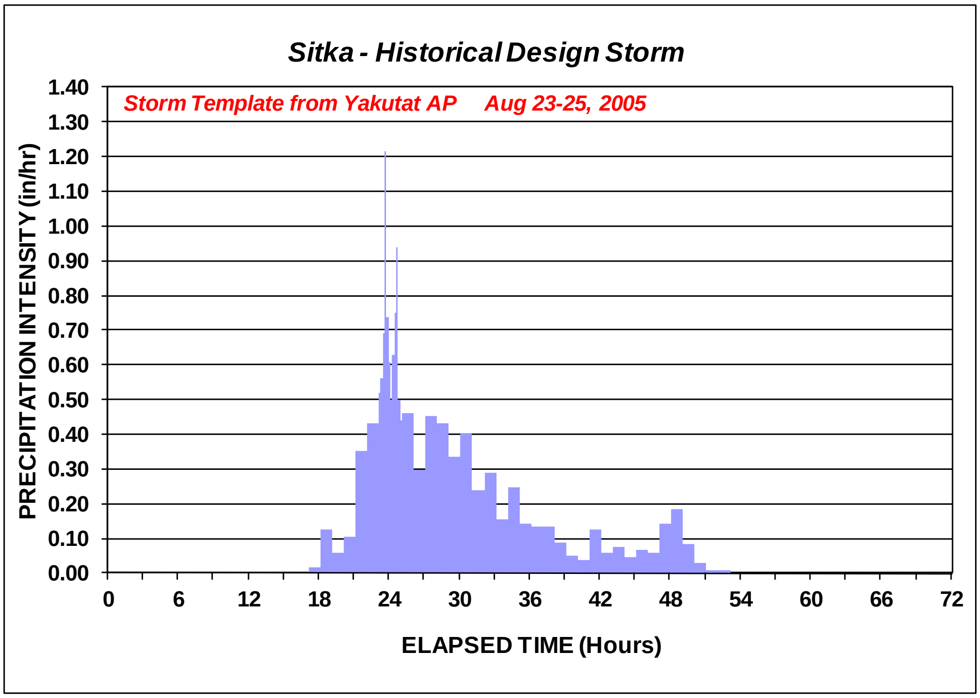

Figure 5e – Example Sitka Long-Duration Design Storm for 50-Year Recurrence Interval
for 24-Hour Precipitation=6.45-inches, Total Precipitation=7.22-inches
Historical Storm Originally Recorded at Yakutat Airport Alaska, Aug 23-25, 2005

It should be noted that convective activity and resultant precipitation intensities in long-duration storms is less than that for the isolated convective cells that produce the short-duration high intensities reflected in Intensity-Duration-Frequency (IDF) curves. A comparison of precipitation intensities for the long-duration design storms (Figures 5a,b,c,d,e) with intensities for the short-duration design storm (described later in the TM) will show maximum intensities to be markedly lower in the long-duration storms.

In application for watershed modeling, all five long-duration design storms and the short-duration design storm should be used to determine the controlling event for design of a hydraulic structure.

INTENSITY-DURATION-FREQUENCY CURVES

Development of Intensity-Duration-Frequency (IDF) curves was based on transposition of findings from other precipitation-frequency studies to the Sitka area. This was necessary because there are no long-term records of hourly or sub-hourly precipitation for Sitka. However, precipitation data are available from climatologically similar areas in Alaska and British Columbia and were used in assessing the precipitation-frequency characteristics for Sitka. Table 6 lists the types of data available for the locations used in the analyses.

Table 6 – Locations and Data Types Used in IDF Precipitation Analyses

DATA TYPE	LOCATION	PERIOD OF RECORD	DATA SOURCE
1-Hr, 2-Hr	Annette Airport, AK	1949-2009	NCDC[8]
1-Hr, 2-Hr	Prince Rupert, BC	1970-1999	Environment Canada[1]
5-min through 60-min	Prince Rupert, BC	1970-1999	Environment Canada[1]
5-min through 60-min	Tofino, BC	1970-2005	Environment Canada[1]
5-min through 60-min	Pitt Polder, BC	1965-2005	Environment Canada[1]
5-min through 60-min	Vancouver, BC	1953-2005	Environment Canada[1]
5-min through 60-min	Seattle, WA	1965-2003	Seattle Public Utilities[16]

The IDF curves for the Sitka area were developed as follows:

1. The findings of an analysis of 1-hour and 2-hour precipitation annual maxima at stations listed in Table 6 were used to estimate the 1-hour and 2-hour at-site mean values of the annual maxima series for the Sitka area.
2. The findings from the IDF analysis for Prince Rupert BC and Seattle WA in conjunction with the 1-hour mean value for Sitka obtained from Step 1 were used to produce precipitation-frequency estimates for durations from 5-minutes through 60-minutes.

Mean Values for 1-Hour and 2-Hour Durations for the Sitka Area

Annual maxima data series were assembled for durations of 1-hour and 2-hours for the stations listed in Table 7 and mean values (at-site means) were computed. Regression relationships were developed for 1-hour and 2-hour at-site mean values using the station 24-hour at-site mean as the explanatory variable (Figures 6a,b). This allowed estimation of the 1-hour and 2-hour at-site mean values for the Sitka area based on the 24-hour at-site mean of 3.67-inches for the NOAA Sitka Japonski Airport station (Table 8).

Table 7 – Stations Used in Analysis of 1-Hour and 2-Hour Annual Maxima for Estimation of 1-Hour and 2-Hour At-Site Mean Values for Sitka Area

STATION ID	STATION	MEAN ANNUAL PRECIPITATION[10,11] (inches)	1-HOUR AT-SITE MEAN (in)	2-HOUR AT-SITE MEAN (in)	24-HOUR AT-SITE MEAN (in)
50-0352	Annette Airport, AK	103	0.59	0.85	3.53
1054500	Langara, BC	74	0.43	0.66	2.22
1066481	Prince Rupert Airport, BC	101	0.53	0.82	3.52
1038205	Tofino, BC	130	0.72	1.22	5.20
50-4590	Vancouver Airport, BC	46	0.46	0.63	2.13
50-9941	Yakutat Airport, AK	152	0.73	1.10	5.53

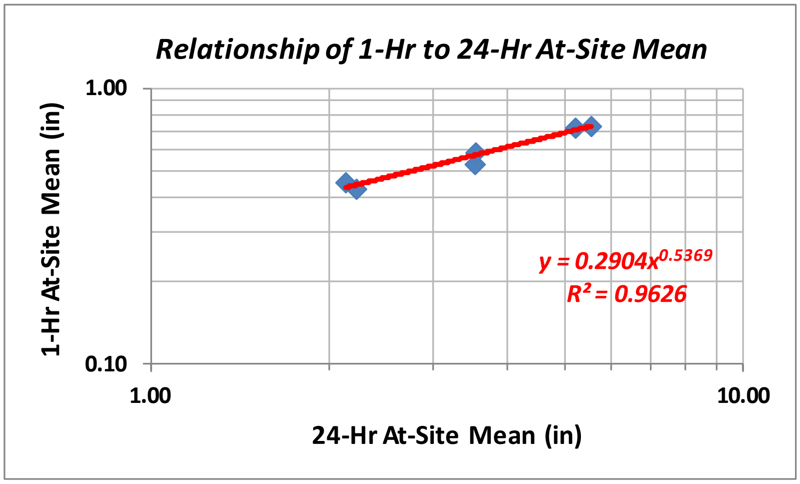

Figure 6a – Relationship Between 1-Hour and 24-Hour At-Site Means for Selected Coastal Locations in Alaska and British Columbia

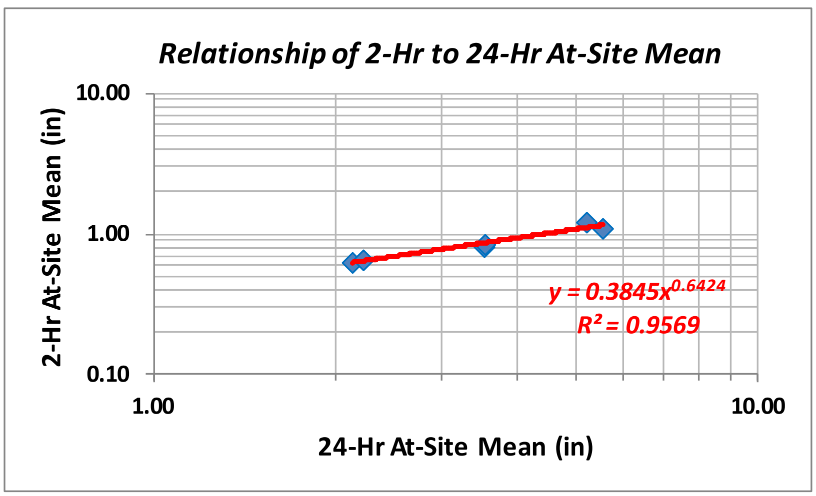

Figure 6b – Relationship Between 2-Hour and 24-Hour At-Site Means for Selected Coastal Locations in Alaska and British Columbia

Table 8 – Estimated Mean Values for 1-Hour and 2-Hour Precipitation Annual Maxima for the Sitka Area

ESTIMATED MEAN VALUES OF PRECIPITATION ANNUAL MAXIMA DATA SERIES		
LOCATION	1-HOUR DURATION	2-HOUR DURATION
Prince Rupert, BC	0.53-inches	0.82-inches
Sitka Japonski Airport, AK	0.58-inches	0.89-inches

Behavior of Short-Duration Precipitation-Frequency Characteristics

Annual maxima data series were assembled for durations of 1-hour and 2-hours for the stations at the Annette and Yakutat Airports Alaska for the period from 1949-2009 and for 60-minute maxima for Prince Rupert BC for the period from 1970-1999. Probability-plots were produced for each duration (Figures 7a,b,c,d,e,f). It was found that the precipitation-frequency relationships were well-described by the regional distribution parameters (Figures 7a,b,c,d,e,f solid blue line) applicable to the Seattle area in the Puget Sound Lowlands of Washington (Schaefer et al[15]). The findings from the study for Seattle Washington were used for comparison because they are based on an extensive 17-gage network of precipitation stations, recording on a 5-minute interval which produced high-quality datasets with 40-years of record.

The 1-hour and 2-hour maxima for the Alaska stations are based on fixed interval readings taken at the end-of-hour. Accordingly, an adjustment is made to the statistics from these datasets to reflect the desired values for continuous measurements where the maxima would have been determined for a moving 60-minute or 120-minute window of time. The adjustments are 1.13 and 1.04 for the 60-minute and 120-minute durations, respectively (Weiss[19]) and the desired precipitation-frequency relationships for 60-minutes and 120-minutes are shown by the dashed red-line in Figures 7a,b,d,e.

The adequacy of the Seattle precipitation-frequency curves for use in the Sitka area is not as surprising as first might be thought. Precipitation maxima for very short durations (less than 15-minutes) along the Pacific Coast are produced by convective storm cells. Convective cells are typically short-lived in duration, localized in areal extent, and the effects of increased precipitation from orographic lifting are minor for short durations. As a result, the IDF characteristics for very short durations are not dramatically different for lowlands, coastal, or mountain areas in similar climatic settings. In addition, precipitation intensities in convective cells are greatest in warmer climates where there is typically a higher level of atmospheric moisture. These factors result in the situation that the magnitude of convection and resultant precipitation intensities tend to be greatest in coastal areas in the warmer climate of California and intensities are more muted for locations further north towards Seattle, WA and the Alaska panhandle where the offshore waters are cooler.

In summary, the shapes of the precipitation-frequency curves for short-durations in Seattle WA are very similar to the shapes of the precipitation-frequency curves for sites listed in Table 7. It is reasonable to conclude that the shapes of the precipitation-frequency relationships for the Sitka area will be similar to that for the other coastal sites listed in Table 7. It should be noted that the goodness-of-fit to historical data (Figures 7a,b,c,d,e,f) is evaluated by the fit of the body of the data and not the largest value(s) which are subject to higher sampling variability.

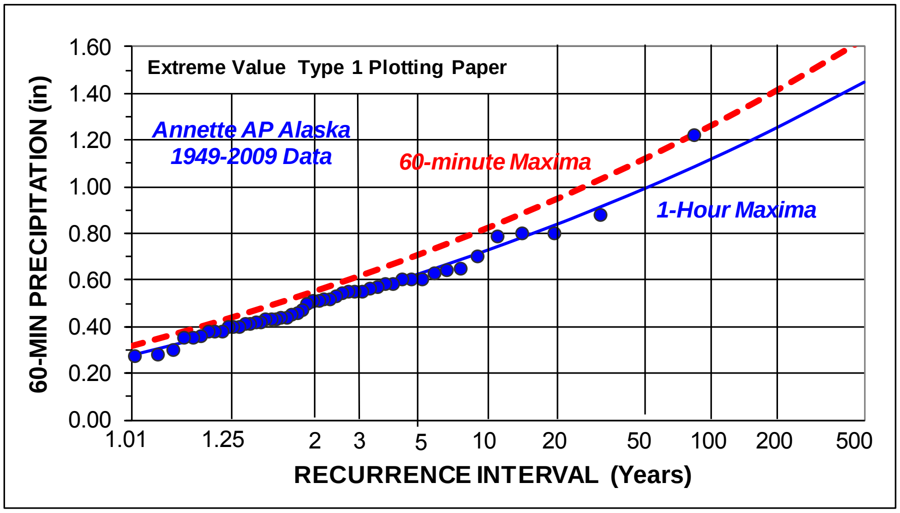

Figure 7a – Probability-Plot of 1-Hour Precipitation Annual Maxima for Annette Airport, Alaska

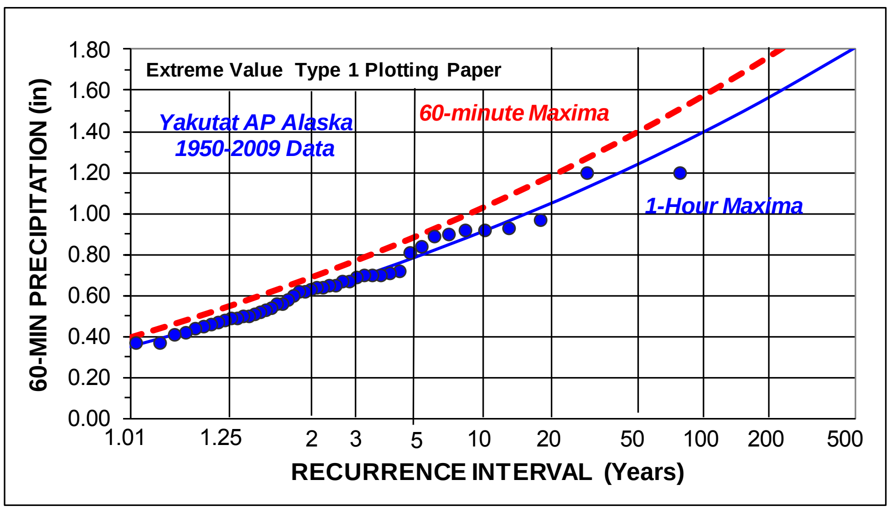

Figure 7b – Probability-Plot of 1-Hour Precipitation Annual Maxima for Yakutat Airport, Alaska

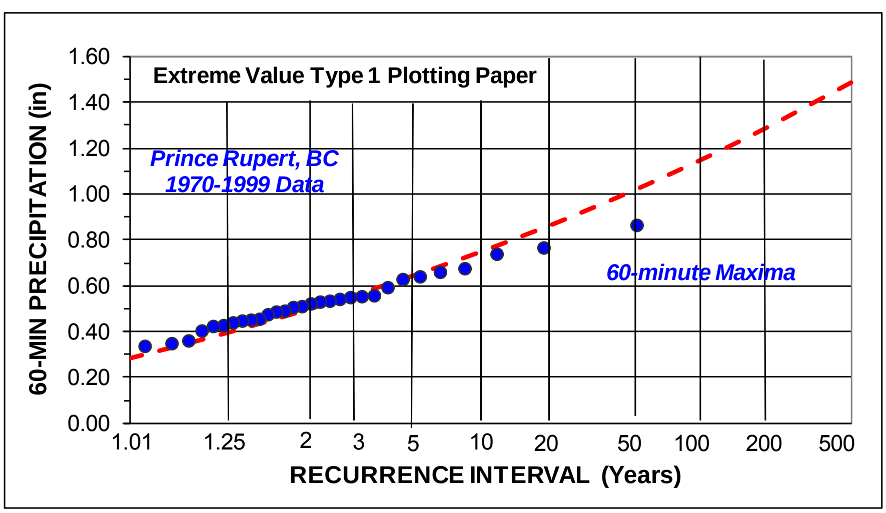

Figure 7c – Probability-Plot of 60-Minute Precipitation Annual Maxima for Prince Rupert, BC

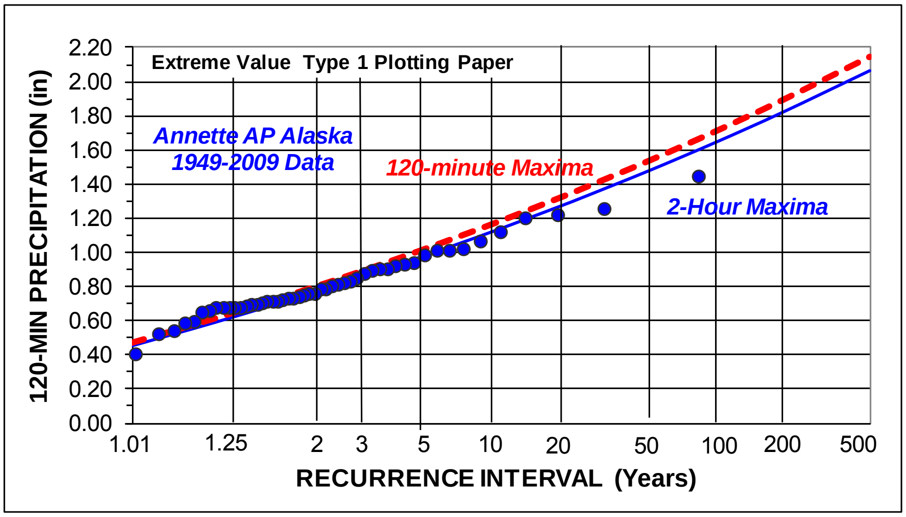

Figure 7d – Probability-Plot of 2-Hour Precipitation Annual Maxima for Annette Airport, Alaska

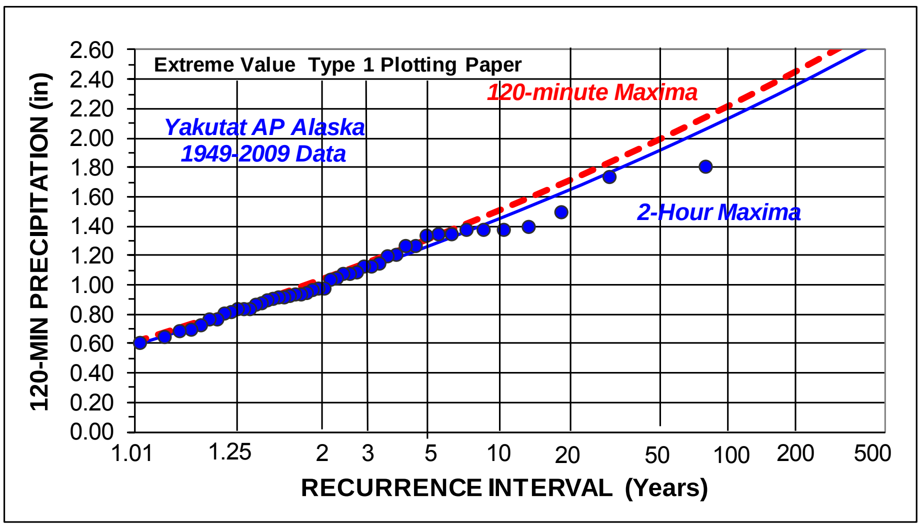

Figure 7e – Probability-Plot of 2-Hour Precipitation Annual Maxima for Yakutat Airport, Alaska

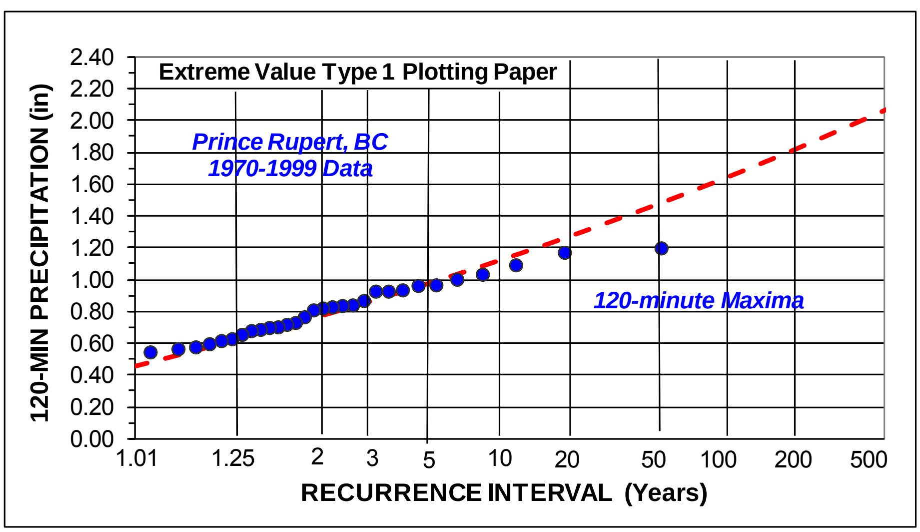

Figure 7f – Probability-Plot of 120-Minute Precipitation Annual Maxima for Prince Rupert, BC

Transposition of IDF Curves from Prince Rupert, BC to Sitka, AK

Environment Canada[1] have developed Intensity-Duration-Frequency (IDF) curves for Prince Rupert, BC based on annual maxima data for the period from 1970-1999. Adjustments were made to the precipitation-frequency values for the 5, 10, 15 and 30-minute durations to transpose the IDF curves from Prince Rupert, BC to the Sitka area. This was accomplished in three steps. First, probability-plots were constructed of the annual maxima data at Prince Rupert for durations of 5, 10, 15, 30 and 60-minutes. Next, the regional probability distribution parameters from the Seattle IDF study were used to describe the precipitation-frequency relationship for the various durations. For example, Figures 8a,b compare the relationships for the 5-minute and 60-minute durations, respectively. Lastly, the difference between the precipitation-frequency estimates for the 60-minute duration at Prince Rupert and the Sitka area (Figure 9) were uniformly adjusted by duration (5-min, 10-min, etc) as a proportion of the 60-minute amount to increase the precipitation amounts to match Sitka (Japonski Airport) at the 60-minute duration. This approach reflects the judgment that the basic form of the IDF curves is essentially the same at Prince Rupert and the Sitka area. The resultant precipitation-frequency estimates for the IDF curves are shown in Figure 9 and listed in Tables 9a,b.

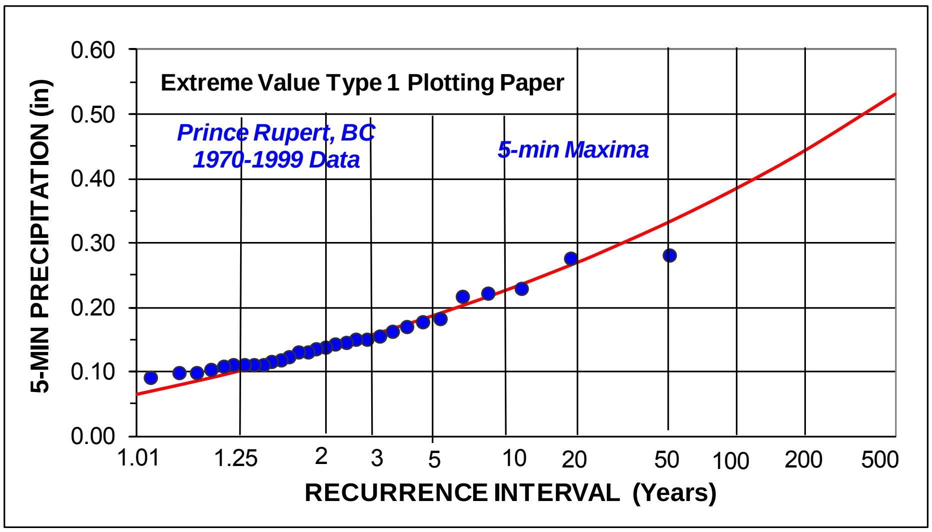

Figure 8a – Probability-Plot of 5-Minute Precipitation Annual Maxima for Prince Rupert, BC

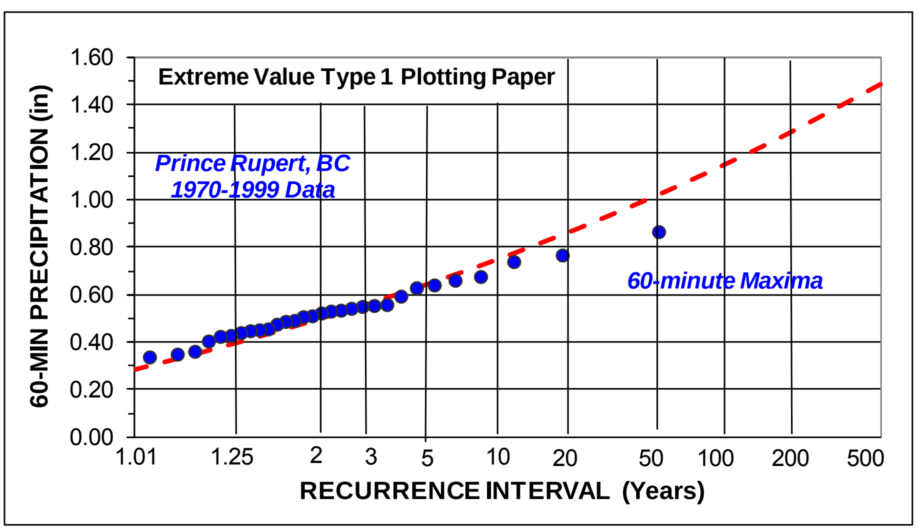

Figure 8b – Probability-Plot of 60-Minute Precipitation Annual Maxima for Prince Rupert, BC

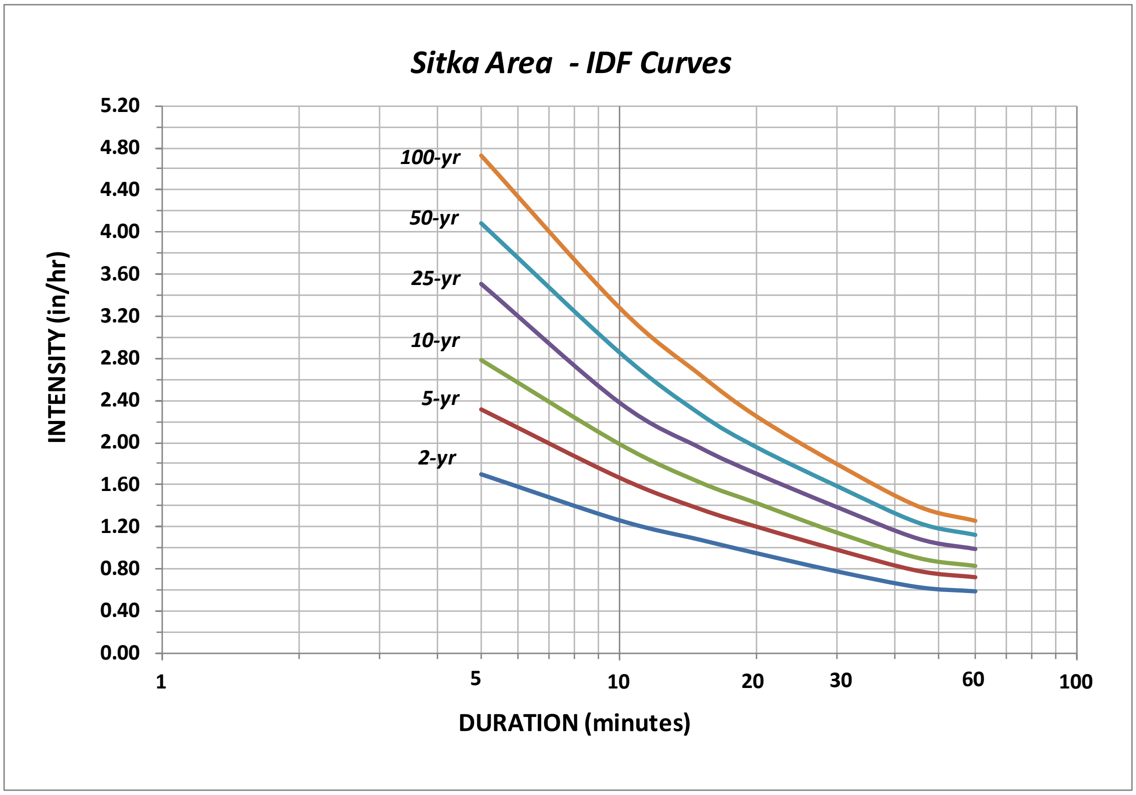

Figure 9 – Intensity-Duration-Frequency Curves for Sitka Alaska Area

Table 9a – Precipitation Intensities for IDF Relationship for Sitka Alaska Area

DURATION (minutes)	RECURRENCE INTERVAL (Years)					
	2	5	10	25	50	100
5	1.70	2.32	2.78	3.50	4.08	4.73
10	1.27	1.67	1.99	2.38	2.86	3.29
15	1.08	1.37	1.62	1.95	2.27	2.65
20	0.95	1.20	1.42	1.70	1.95	2.25
30	0.78	0.98	1.14	1.38	1.58	1.80
45	0.63	0.78	0.90	1.08	1.23	1.40
60	0.59	0.72	0.82	0.99	1.12	1.26
	PRECIPITATION INTENSITY (in/hr)					

Table 9b – Precipitation Depths for IDF Relationship for Sitka Alaska Area

DURATION (minutes)	RECURRENCE INTERVAL (Years)					
	2	5	10	25	50	100
5	0.14	0.20	0.23	0.29	0.34	0.39
10	0.21	0.28	0.33	0.40	0.48	0.55
15	0.27	0.34	0.41	0.49	0.57	0.66
20	0.32	0.40	0.47	0.57	0.65	0.75
30	0.39	0.49	0.57	0.69	0.79	0.90
45	0.47	0.59	0.67	0.81	0.93	1.05
60	0.59	0.72	0.82	0.99	1.12	1.26
	PRECIPITATION DEPTH (inches)					

Seasonality of Occurrence for 1-Hour Precipitation Annual Maxima

The seasonality of short-duration precipitation for the Sitka area was assessed by examining the seasonality characteristics of 1-hour precipitation annual maxima at the Annette and Yakutat Airports. Figure 10 depicts the monthly distribution of the dates of the 1-hour annual maxima for Annette and Yakutat Airport for the period from 1949-2009. Seasonality is similar to that for the 24-hour annual maxima (Figure 2) except there is a greater tendency for 1-hour maxima to occur in the warmer months of August through October with September showing the highest frequency of 1-hour maxima. The seasonality histogram should be useful in assessing representative runoff coefficients for pervious areas in use of the rational equation along with IDF curves.

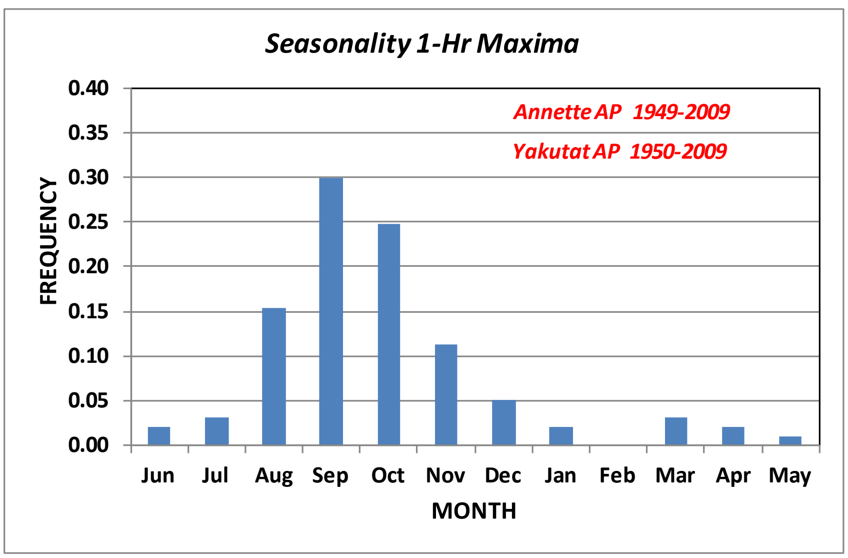

Figure 10 – Seasonality of Occurrence for 1-Hour Precipitation Annual Maxima at Annette Airport Alaska

SCALABLE SHORT-DURATION DESIGN STORMS

There will be instances where a hyetograph is needed for sizing of conveyance facilities in small urbanized basins using a rainfall-runoff model. A synthetic short-duration design storm was assembled (Figure 11) using the incremental precipitation amounts obtained from successive subtraction of IDF curve values (Table 9b) and nesting the shorter durations within the longer durations. This design storm is scalable by multiplication using user-specified 60-minute precipitation amounts for selected recurrence intervals (see yellow highlighted row in Table 9b). Figure 11 depicts the Sitka design hyetograph for a 50-year recurrence interval. An Excel workbook is included as a deliverable for automatically scaling and plotting short-duration design storms.

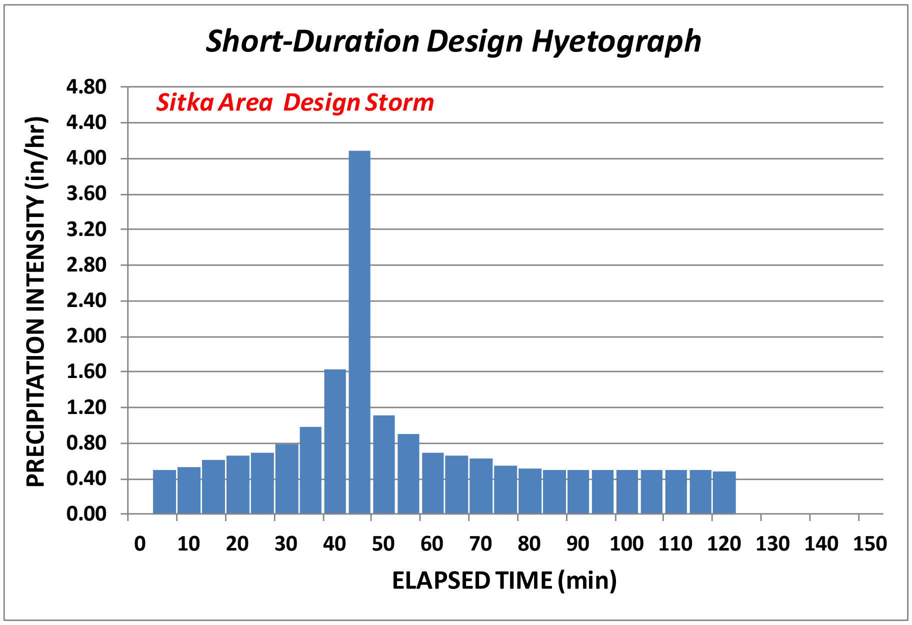

Figure 11 – Example Sitka Area Short-Duration Design Hyetograph for 50-Year Recurrence Interval for 1-Hour Precipitation=1.12-inches and Total Precipitation=1.62-inches

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APPENDIX C.
FEATURE ATTRIBUTES TO BE COLLECTED FOR POINTS (CATCH BASINS, PIPE INLETS/OUTLETS, AND DITCH POINTS)

APPENDIX C
FEATURE ATTRIBUTES TO BE COLLECTED FOR POINTS (CATCH BASINS, PIPE INLETS/OUTLETS, AND DITCH POINTS)

The following feature attributes are to be collected during the inventory and included in the geo-database deliverable.

Asset Code	Code Attributes	Field Type	Field Width	Alias	Attribute Selection or Numeric Entry	Geodatabase Domain	Explanatory Description
Drain Point							
Ditch Flow Point	GPSID	Long Integer		GPSID	Auto Numbered from GPS		Auto Numbered ID assigned by the GPS
	ASSET_ID	Text	18	Asset ID	Unique ID Created by TT		Feature Identification Number (See Asset_ID_Codes Worksheet for Alphanumeric Asset ID Schema)
	SUBTYPE	Short Integer		Point Subtype	1 = Drain Point		
					2 = Ditch Flow Point		
					3 = Outfall		
					4 = Infiltration Point		
	ELEVATION	Double		Invert Elevation	GPS Elevation		Invert Elevation of Drain or Flow Point
	TYPE	Text	8	Point Type	DRAIN	Drain_Swale_Point_Type	Inlet/Outlet
					TYPICAL		Ditch/Swale Interval Shot
					BEGIN		Ditch/Swale Start
					END		Ditch/Swale End
					INFILTR		Infiltration Point
					DISCH		Outfall to Open Water
	FLOW	Text	4	Point Flow Direction	IN	Ditch_Swale_Flow_Direction	Flows from Ditch/Swale into a Pipe
					OUT		Flows out from Pipe
					FLOW		Flow Point
					END		Endpoint of Flow (at Infiltration Point or End Cap)
	COMMENT1	Text	220				Special comments, condition, material, or special maintenance needs.
	SVY_DATE	Long Integer		Survey Date			Date of CB Survey
	SOURCE	Text	12	Data Source			Creator of the data point
	ACCURACY	Text	8	Data Accuracy	SURVEY	Accuracy	Describes if point was collected using survey grade equipment or digitized "heads up."
					MANUAL		
	MODIFIED_BY	Text	24	Modified By			Person who last modified attribute data
	MODIFIED_DATE	Long Integer		Modification Date			Date of last modification

Catch Basins/Inlets/Outlets/Outfalls/Ditch Flow Feature Class Attributes							
Asset Code	Code Attributes	Field Type	Field Width	Alias	Attribute Selection or Numeric Entry	Geodatabase Domain	Explanatory Description
CB							NEZ at the center of the lid of a storm structure.
	GPSID	Long Integer		GPSID	Auto Numbered from GPS		Auto Numbered ID assigned by the GPS
	ASSET_ID	Text	18	Asset ID	Unique ID Created by TT		Feature Identification Number (See Asset_ID_Codes Worksheet for Alphanumeric Asset ID Schema)
	SUBTYPE	Short Integer		CB Subtype	1 = Type 1		Geodatabase subtype field that organizes catch basins into basic categories
					2 = Type 2		
					3 = CB Other		
	LID_ELEVATION	Double		Lid Elevation			Elevation of CB Lid
	COVER	Text	12	CB Cover Type	RECT VANED	CB_Cover	Rectangular vaned or grated cover.
					RECT SOLID		Rectangular solid cover.
					RECT HOODED		Through curb inlet with a vaned or grated cover.
					RND SOLID		Round solid cover.
					RND VANED		Round vaned or grated cover.
					OTHER LID		Other lid type, see comments, or lid is missing.
					UNK		Cover Type Unknown
	TYPE	Text	16	CB Type	TYPE 1	CB_Type	Rectangular storm structure.
					TYPE 2		Round storm structure.
					CB OTHER		Other CB Type
					UNK		CB Type Unknown
	MATERIAL	Text	8	CB Material	CONC	CB_Material	Concrete
					CMP		Corrugated metal pipe structure.
					HDPE		High density poly-ethylene (includes corrugated) flexible black plastic.
					PVC		PolyVinyl-chloride (white, green, or black) rigid plastic.
					WOOD		Wood stave structure.
					BRICK		Brick and mortar.
					OTHER		See comment field for notes.
					UNK		Not Able to Assess
	CONDITION	Text	6	CB Condition	GOOD	Condition	Good Condition
					FAIR		Fair Condition
					POOR		Poor Condition
					UNK		Condition Not Assessed
	SILT	Double		Silt Depth (ft)			Measured sediment depth at bottom of structure in feet. Default is zero (0) feet.
	MAINTENANCE	Text	16	Maintenance Required	NONE	CB_Maintenance	Default selection
					COVER		Cover is cracked/damaged, missing, or has fallen into structure.
					ROOT INTRUSION		Roots growing into structure through cracks or voids in structure wall.
					SOIL INTRUSION		Soil entering through cracks or voids in structure wall.
					GROUTING		No grout around pipes, (or beneath rim).
					OIL/CHEM		Significant oil or chemical residue present.
					VACTOR		Review silt depth measurement and/or pipe silt estimates.
					SILT SOCK		Silt sock installed.
					LADDER		Ladder has fallen from hangers, is damaged, or is not installed (for deep structures).
					PVMT LIP		Raised lip of pavement around cover or rim.
					VEGETATION		Access to structure is hampered by overgrowth of vegetation or shrubs.
					OTHER		See comment field for notes.
					UNK		Maintenance Requirements Not Assessed

Catch Basin Attributes continued.

Asset Code	Code Attributes	Field Type	Field Width	Alias	Attribute Selection or Numeric Entry	Geodatabase Domain	Explanatory Description
X = Pipe In Number (1-5)	PINX_DIAMETER	Short Integer		Pipe In X Diameter	0		Pipe diameter in inches. Zero (0) inches diameter reserved for not-determined
					3		
					4		
					6		
					8		
					10		
					12		
					15		
					18		
					24		
					36		
	PINX_MATERIAL	Text	14	Pipe In X Material	CONC	Material	Concrete pipe.
					CMP		Corrugated metal pipe (aluminum or galvanized steel).
					HDPE		High density poly-ethylene (includes corrugated) flexible black plastic pipe.
					PVC		Polyvinyl-chloride (white, green, or black) rigid plastic pipe.
					DUCTILE IRON		Ductile iron pipe.
					STEEL		Steel pipe.
					CONC PERF		Concrete pipe, perforated.
					CMP PERF		Corrugated Metal Pipe, perforated.
					HDPE PERF		High density poly-ethylene (includes corrugated) flexible black plastic pipe, perforated.
					PVC PERF		Polyvinyl-chloride (white, green, or black) rigid plastic pipe, perforated.
					UNK		Not discernable from surface observation.
					CONC BOX		Rectangular concrete box culvert for drainage/creek crossing. Comment width x height and 3 or 4 sided.
					WOOD BOX		Rectangular wood box culvert for drainage/creek crossing. Comment width x height and 3 or 4 sided.
					CMP ARCH		Large arched CMP culvert for drainage/creek crossing. Comment width x height.
					GRASS		Grass or other low growing vegetation (Ditch or Swale Only).
					ROCK		Gravel or quarry spall lined ditch (Ditch or Swale Only).
	PINX_ELEVATION	Double		Pipe In X Elevation			Invert Elevation of Pipe In X
	PT_DIAMETER	Short Integer		Pipe Out Diameter	see PINX_DIAMETER		
	PT_MATERIAL	Text	14	Pipe Out Material	see PINX_MATERIAL	Material	
	PT_ELEVATION	Double		Pipe Out Elevation			Invert Elevation of Pipe Out
	SVY_DATE	Long Integer		Survey Date			Date of CB Survey
	SOURCE	Text	12	Data Source			Creator of the data point
	ACCURACY	Text	8	Data Accuracy	SURVEY	Accuracy	Describes if point was collected using survey grade equipment or digitized "heads up."
					MANUAL		
	MODIFIED_BY	Text	24	Modified By			Person who last modified feature and/or attribute data
	MODIFIED_DATE	Long Integer		Modification Date			Date of last feature and/or attribute data modification

APPENDIX D. FEATURE ATTRIBUTES TO BE COLLECTED FOR LINES (PIPES, CULVERTS, AND DITCHES)

APPENDIX D
FEATURE ATTRIBUTES TO BE COLLECTED FOR LINES (PIPES, CULVERTS, AND DITCHES)

The following feature attributes are to be collected during the inventory and included in the Geodatabase deliverable.

Pipe/Culvert/Ditch Feature Class Attributes							
Asset Class	**Code Attributes**	**Field Type**	**Field Width**	**Alias**	**Attribute Selection or Numeric Entry**	**Data Domain**	**Explanatory Description**
PIPE, CULVERT, DITCH ATTRIBUTES	X_GPSID	Long Integer		From/To Point GPSID	Auto Numbered by GPS for Line Start/End Point		To/From GPSID (May be a CB, IE, or FL)
X = FR or TO	X_ASSET_ID	Text	18	From/To Point Asset_ID	Asset_ID of Line Start/End Point		To/From Asset_ID (May be a CB, IE, or FL)
FR = FROM END TO = TO END	ASSET_ID	Text	18	Asset ID	Unique ID Created by TT		Feature Identification Number (See Asset_ID_Codes Worksheet for Alphanumeric Asset ID Schema)
	SUBTYPE	Short Integer		Line Subtype	1 = Pipe		Geodatabase Subtype for line types
					2 = Culvert		
					3 = Ditch		
	X_ELEVATION	Double		From/To Pipe Elevation			Invert Elevation
	X_DIAMETER	Short		From/To Pipe Diameter	0	Pipe_Diameter	Pipe diameter in inches. Zero (0) inches diameter reserved for not-determined
					3		
					4		
					6		
					8		
					10		
					12		
					15		
					18		
					24		
					36		
					N/A		No Pipe
	X_MATERIAL	Text	14	From/To Pipe Material	CONC	Material	Concrete pipe.
					CMP		Corrugated metal pipe (aluminum or galvanized steel).
					HDPE		High density poly-ethylene (includes corrugated) flexible black plastic pipe.
					PVC		Polyvinyl-chloride (white, green, or black) rigid plastic pipe.
					DUCTILE IRON		Ductile iron pipe.
					STEEL		Steel pipe.
					CONC PERF		Concrete pipe, perforated.
					CMP PERF		Corrugated Metal Pipe, perforated.
					HDPE PERF		High density poly-ethylene (includes corrugated) flexible black plastic pipe, perforated.
					PVC PERF		Polyvinyl-chloride (white, green, or black) rigid plastic pipe, perforated.
					UNKNOWN		Not discernable from surface observation.
					CONC BOX		Rectangular concrete box culvert for drainage/creek crossing. Comment width x height and 3 or 4 sided.
					WOOD BOX		Rectangular wood box culvert for drainage/creek crossing. Comment width x height and 3 or 4 sided.
					CMP ARCH		Large arched CMP culvert for drainage/creek crossing. Comment width x height.
					GRASS		Grass or other low growing vegetation (Ditch or Swale Only).
					ROCK		Gravel or quarry spall lined ditch (Ditch or Swale Only).
					OTHER		See note in comment field.
	X_SILT	Text	10	From/To Pipe Siltation	SILT 0%	Pipe_Silt	Pipe silt percentage, none of the diameter is silted.
					SILT 25%		Pipe silt percentage, one-quarter of the diameter is silted.
					SILT 50%		Pipe silt percentage, one-half of the diameter is silted.
					SILT 75%		Pipe silt percentage, three-quarters of the diameter is silted.
					SILT 100%		Pipe silt percentage, all of the diameter is silted.
					N/A		No PIPE
	X_CONDITION	Text	6	From/To Pipe Condition	GOOD	Condition	New or recently maintained pipe, ditch, or swale.
					FAIR		Stable or gradual changes in pipe, ditch, or swale profile, side slopes, and depth (grassy vegetation is good).
					POOR		Poor or widely varying pipe, ditch, or swale profile, side slopes, depth, vegetation, or combinations thereof.
					UNK		Missing Data

Pipe/Culvert/Ditch Attributes continued.

Asset Code	Code Attributes	Field Type	Field Width	Alias	Attribute Selection or Numeric Entry	Geodatabase Domain	Explanatory Description
	X_MAINTENANCE	Text	16	From/To Pipe Maintenance Required	NONE	Maintenance	Default, no significant maintenance needs noted.
					BROKEN PIPE		Broken or bent pipe causing significant blockage.
					OIL/CHEM		Significant oil or chemical residue present.
					JET PIPE		Review pipe silt estimate.
					TRASH		Trash in pipe causing significant blockage.
					CLEANING NEEDED		Ditch/Swale Cleaning
					REPAIR EROSION		Ditch/Swale Erosion
					REPAIR BARE		Ditch/Swale Bare Soil
					REMOVE TRASH		Ditch/Swale Trash
					REPAIR CHECK DAM		Ditch/Swale Check Dam Repair
					ENCROACHMENT		Ditch/Swale Encroachment
					OTHER		See comment field for special notes.
					UNK		Missing Data
	X_COMMENT	Text	220	From/To Pipe Comment		free text field	Special comments, condition, material, or special maintenance needs. Clarify if for CB, POT, or PINn.
	SVY_DATE	Long Integer		Survey Date			Date of End Point Survey
	SOURCE	Text	12	Data Source			Creator of the data point
	ACCURACY	Text	8	Data Accuracy	SURVEY	Accuracy	Describes if point was collected using survey grade equipment or digitized "heads up."
					MANUAL		
	MODIFIED_BY	Text	24	Modified By			Person who last modified attribute data
[redacted]							

APPENDIX E.
CAPITAL IMPROVEMENT PROJECT DESCRIPTIONS

APPENDIX E
CAPITAL IMPROVEMENT PROJECT DESCRIPTIONS

Barracks Street and Lincoln Street Drainage System Realignment

Problem Description

An 18-inch high-density polyethylene (HDPE) pipe leaves a catch basin at the intersection of Barracks Street and Lincoln Street and passes under a building at 200 Lincoln Street. The condition or material of the pipe under the building is unknown. The pipe is an older corrugated metal pipe (CMP) and in the worst case scenario is in poor condition and could collapse and damage or flood the building. Upstream of Lincoln Street, this pipe system drains Barracks, Seward, and Observatory Streets as well as Marine Street north as far as Erler Street. Downstream of 200 Lincoln Street, the pipe joins the piped drainage system of a parking lot adjacent to Harbor Road. The drainage system outfalls to Crescent Bay through a 24-inch HDPE pipe across Harbor Drive. Sitka staff report that the pipe can be accessed through a manhole in the basement of 200 Lincoln Street.

A separate drainage system 200 feet to the west drains Katlian and Lincoln Streets. This system starts as a 12-inch CMP at the intersection of Lincoln Street and Katlian Street, and outfalls through a 22-inch CMP at the southwest corner of Totem Square.

Figure E-1. Looking south on Barracks Street towards Lincoln Street.

Figure E-2. Looking west on Lincoln Street from Barracks Street.

Proposed Solution

The drainage pipe under 200 Lincoln Street should be located and inspected for condition through access at 200 Lincoln Street and with CCTV.

The proposed solution is to install a new 18- to 30-inch corrugated plastic pipe (CPP) along Lincoln Street to drain to the west to meet the existing drainage system along Lincoln Street and to abandon the existing pipe under 200 Lincoln Street by filling the pipe with controlled density fill.

Alternatively, the drainage system could be diverted to the east, turning southeast along Maksoutoff Street, and partially replace the drainage system along Lincoln Street. However, this route would be longer and would require more traffic control to cross Harbor Drive.

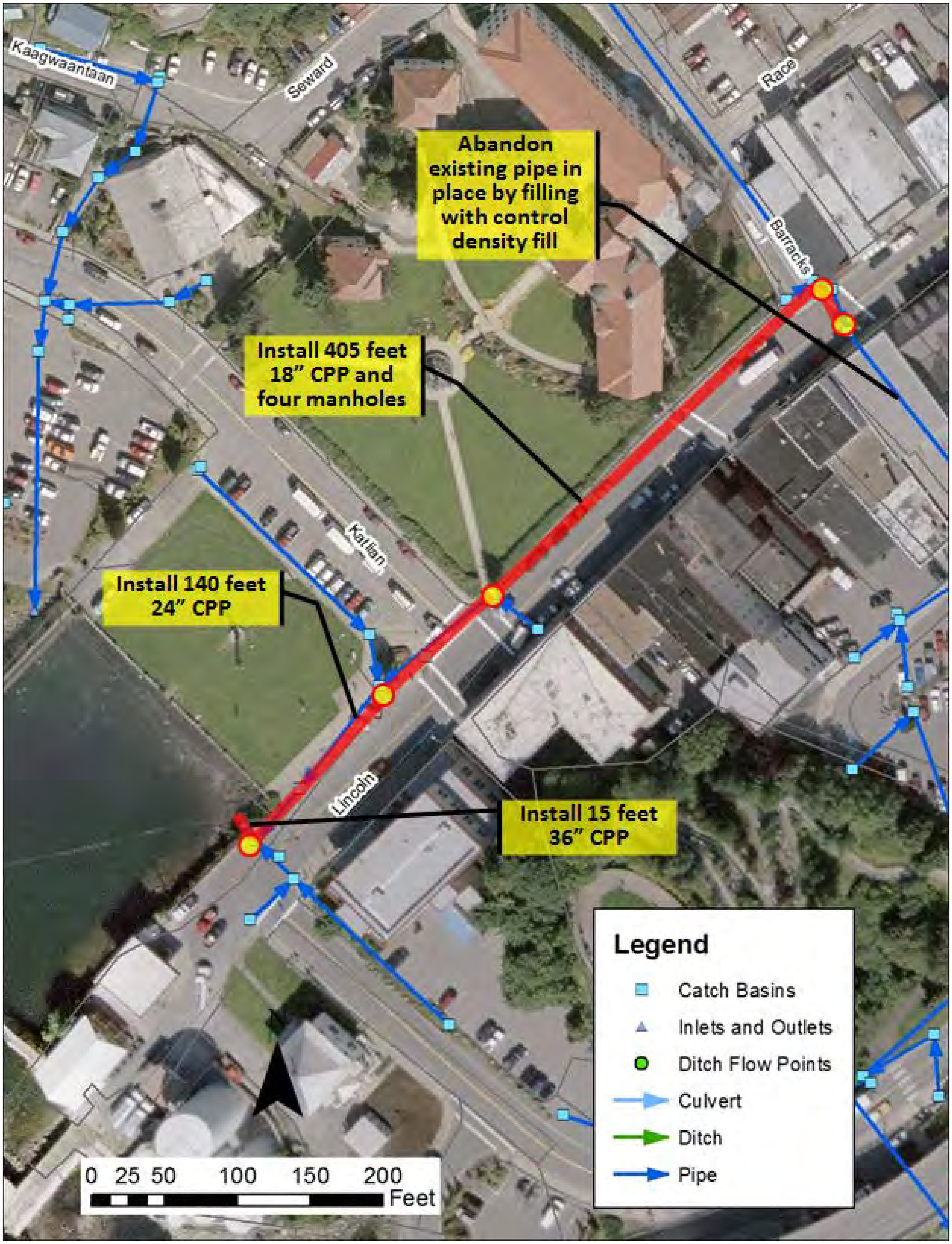

Figure E-3. Barracks Street proposed solution.

Cost Estimate

PLANNING LEVEL CONSTRUCTION COST OPINION				
PROJECT: **Barracks St and Lincoln St Drainage Realignment**			BY:	**JT**
DESCRIPTION: **Realign drainage system to avoid route under building**			CHECKED BY:	
DRAINAGE AREA: **Downtown**			DATE:	**11-Jun-13**
BID ITEM	**QUANTITY**	**UNIT**	**UNIT PRICE**	**AMOUNT**
12-INCH DIAM CPP	35	LF	$80	$ 2,800
18-INCH DIAM CPP	405	LF	$90	$ 36,450
24-INCH DIAM CPP	140	LF	$110	$ 15,400
30-INCH DIAM CPP	15	LF	$140	$ 2,100
STORM DRAIN MANHOLE TYPE 1	6	EA	$4,500	$ 27,000
SAWCUT & REMOVE PAVEMENT	331	SF	$9	$ 2,975
ASPHALT PAVEMENT REPAIR	2,975	SF	$9	$ 26,775
			Subtotal	$ 113,500
DEWATERING	3%			$ 3,405
EROSION & SEDIMENTATION CONTROL	5%			$ 5,675
TRAFFIC CONTROL	3%			$ 3,405
CONTINGENCY	30%			$ 34,050
			Subtotal	$ 160,035
MOBILIZATION (GENERAL REQUIREMENT)	10%			$ 16,004
	Construction Subtotal (Rounded)			$ 176,000
SURVEY/EASEMENTS/ROW ACQUISITION	25%			$ 44,000
ENGINEERING/LEGAL/ADMIN	25%			$ 44,000
CONSTRUCTION MANAGEMENT	10%			$ 17,600
PERMITTING	10%			$ 17,600
2013 Dollars	**Total Estimated Project Cost (Rounded)**			**$ 299,000**

Notes:

1. The above cost opinion is in 2013 dollars and does not include future escalation, financing, land acquisition, or O&M costs.
2. The order-of-magnitude cost opinion has been prepared for guidance in project evaluation from the information available at the time of preparation and for the assumptions stated. The final costs of the project will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope and schedule, and other variable factors. As a result, the final project costs will vary from those presented above. Because of these factors, funding needs for individual projects must be scrutinized prior to establishing the final project budgets.

Tlingit Way - Install New Drainage System

Problem Description

Tlingit Way is a small dead end street with six houses accessed from Marine Street. Tlingit Way currently has no piped drainage system. Drainage at the northwest end of the street appears to flow to a low spot on Tlingit Way and flows west between 307 and 311 Tlingit Way towards the hill slope near Kaagwaantaan Street. The east side of Tlingit Way flows towards Marine Street. An 18-inch-diameter CMP pipe drainage system begins at the intersection of Marine Street and Tlingit Way and flows southeast along Marine Street. This drainage system outfalls to Crescent Bay under Harbor Drive.

Figure E-4. Looking north on Tlingit Way towards cul-de-sac.

Proposed Solution

The proposed solution is to extend the drainage system on Marine Street to collect surface drainage on Tlingit Way. The existing Marine Street drainage system to the intersection of Marine Street and Seward Avenue has a drainage area of 7.6 acres. The proposed new drainage area that would be added to this system is 1 acre. The post-project 100-year recurrence interval peak flow rate was estimated at 8.5 cubic feet per second (cfs) while the added 1 acre is estimated at 2.1 cfs. Because of the relatively steep slope depth of the existing pipe system, the system should have adequate inlet capacity and pipe flow capacity for the additional flow.

The proposed solution includes:

- Install new 12-inch CPP and two catch basins along Tlingit Way.
- Install a new manhole on Marine Street at the intersection with Tlingit Way and extend new pipe to Marine Street.

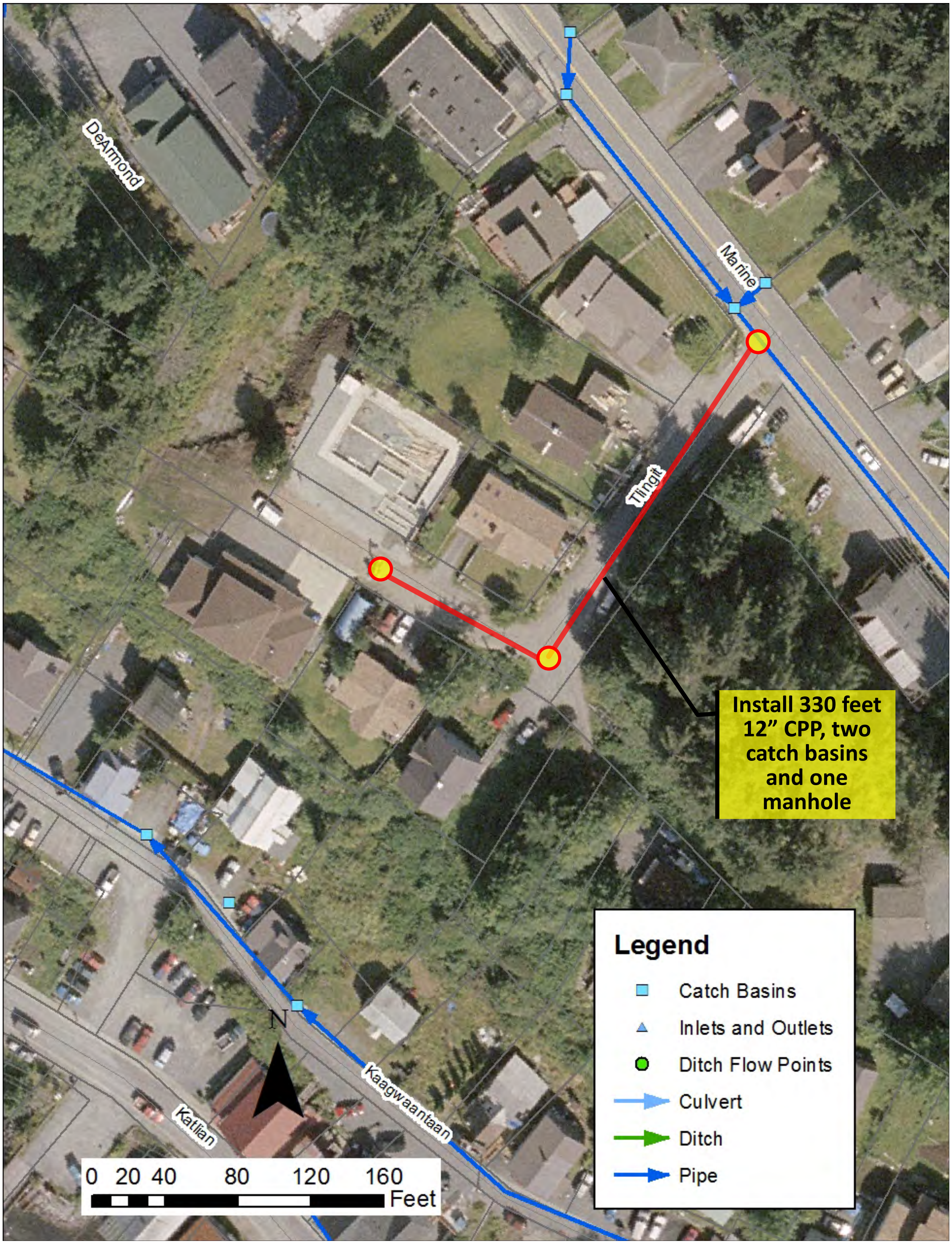

Figure E-5. Tlingit Way proposed solution.

Cost Estimate

PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: Tlingit St - New Drainage System
DESCRIPTION: Install 12-inch CPP with catch basins
DRAINAGE AREA: Downtown

BY: JT
CHECKED BY:
DATE: 11-Jun-13

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
12-INCH DIAM CPP	330	LF	$80	$ 26,400
CATCH BASIN TYPE 1	2	EA	$3,000	$ 6,000
STORM DRAIN MANHOLE TYPE 1	1	EA	$4,500	$ 4,500
SAWCUT & REMOVE PAVEMENT	183	SF	$9	$ 1,650
ASPHALT PAVEMENT REPAIR	1,650	SF	$9	$ 14,850
			Subtotal	$ 53,400
DEWATERING	3%			$ 1,602
EROSION & SEDIMENTATION CONTROL	5%			$ 2,670
TRAFFIC CONTROL	3%			$ 1,602
CONTINGENCY	30%			$ 16,020
			Subtotal	$ 75,294
MOBILIZATION (GENERAL REQUIREMENT)	10%			$ 7,529
			Construction Subtotal (Rounded)	$ 83,000
SURVEY/EASEMENTS/ROW ACQUISITION	25%			$ 20,750
ENGINEERING/LEGAL/ADMIN	25%			$ 20,750
CONSTRUCTION MANAGEMENT	10%			$ 8,300
PERMITTING	10%			$ 8,300
2013 Dollars			**Total Estimated Project Cost (Rounded)**	**$141,000**

Notes:

1. The above cost opinion is in 2013 dollars and does not include future escalation, financing, land acquisition, or O&M costs.
2. The order-of-magnitude cost opinion has been prepared for guidance in project evaluation from the information available at the time of preparation and for the assumptions stated. The final costs of the project will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope and schedule, and other variable factors. As a result, the final project costs will vary from those presented above. Because of these factors, funding needs for individual projects must be scrutinized prior to establishing the final project budgets.

Merrill Street Drainage Improvements

Problem Description

The pipe system draining the east end of Merrill Street flows between 618 and 620 Merrill Street through a City easement and private property between 617 and 619 DeGroff Street and joins a piped drainage system on DeGroff Street. This drainage system eventually joins the drainage system on Baranoff Street and outfalls to Crescent Harbor.

This system was reported to be causing flooding problems in the backyards of the houses from 613 to 619 DeGroff Street. The pipe system is relatively shallow (less than 2 feet deep) and low gradient, but appeared to be in working condition with no visible blockages or signs of flooding during the site visit. A resident at 615 DeGroff Street reported drainage issues in the backyards of 615 and 613 DeGroff Street. It appears unlikely that water comes from the municipal drainage system leading from Merrill Street to DeGroff Street or from the drainage from the Merrill Street road surface. Water may be coming from groundwater or roof drainage and appeared to be a private drainage issue.

Figure E-6. Looking south between 620 and 618 Merrill Street from Merrill Street.

Figure E-7. Looking north between 617 and 619 DeGroff Street from DeGroff Street.

Figure E-8. Merrill Street and DeGroff Street drainage system.

Proposed Solution

The drainage problem in this area appears to be a private drainage issue on private property; the municipal drainage system in the area appears to be working properly. New pipe could be installed by private property owners on private property to convey flows to a catch basin inlet located in the front yard of 613 DeGroff Street. This catch basin leads to an inlet located at the curb line along DeGroff Street.

Viking Way and Valhalla Drive Drainage Improvements

Problem Description

Viking Way and Valhalla Drive are two short, very steep streets with CMP drainage ditches in poor condition. CMP driveway culverts on the east side of Valhalla Drive are crushed and blocked. The ditch on the east side of Valhalla Drive overflows, and drainage sheet flows across Valhalla Drive towards the south side of Viking Way. A series of short ditch sections and 12-inch CMP culverts convey drainage along the south side of Viking Way. Drainage is then conveyed through a 12-inch CMP pipe south along the driveway at 102 Viking Way. This pipe has holes exposed at the surface and is in danger of collapsing. This pipe outfalls to a steep, open channel that leads to a ditch system along Halibut Point Road (HPR). An Alaska Department of Transportation and Public Facilities (ADOT&PF) culvert conveys flows across HPR approximately 500 feet west of Viking Way and outfalls to saltwater. The drainage basin is largely forest land east of Valhalla Drive.

Close to HPR, Viking Way turns sharply to the north and descends steeply to HPR. Road surface drainage along Viking Way north of the turn drains to a separate drainage basin to the north. According to Sitka staff, the pipes in the drainage system to the north are under capacity and more flow should not be diverted to this system.

A topographic and as-built survey of the area was conducted in May 2011. A preliminary design drawing was developed in AutoCAD by City staff in 2011, but progress on this project was stopped due to lack of funding.

Figure E-9. Looking north on Valhalla Drive from Viking Way.

Figure E-10. Looking west on Viking Way from Valhalla Drive.

Proposed Solution

Peak flows for the existing conditions, 100-year recurrence interval event to the drainage system at the intersection of Viking Way and Valhalla Drive were estimated at 4.6 cfs. A 12-inch-diameter pipe size was selected for this site provided that at least 2 feet of cover could be provided at pipe inlets. The proposed project includes:

- Install new curb and gutter on west side of Valhalla Drive north and south of Viking Way to direct flows to new catch basin inlets.
- Install new catch basin inlets at the northwest and southwest corners of the intersection of Viking Way and Valhalla Drive.
- Install new 12-inch CPP pipe along the south side of Viking Way. A new manhole structure would be installed at the top of the steep slope, and new pipe would be installed on the ground surface and outfall at the base of the slope to a ditch along HPR. CMP on private property along the driveway at 102 Viking Way should be excavated and removed.
- Install rock energy dissipater at pipe outlet.

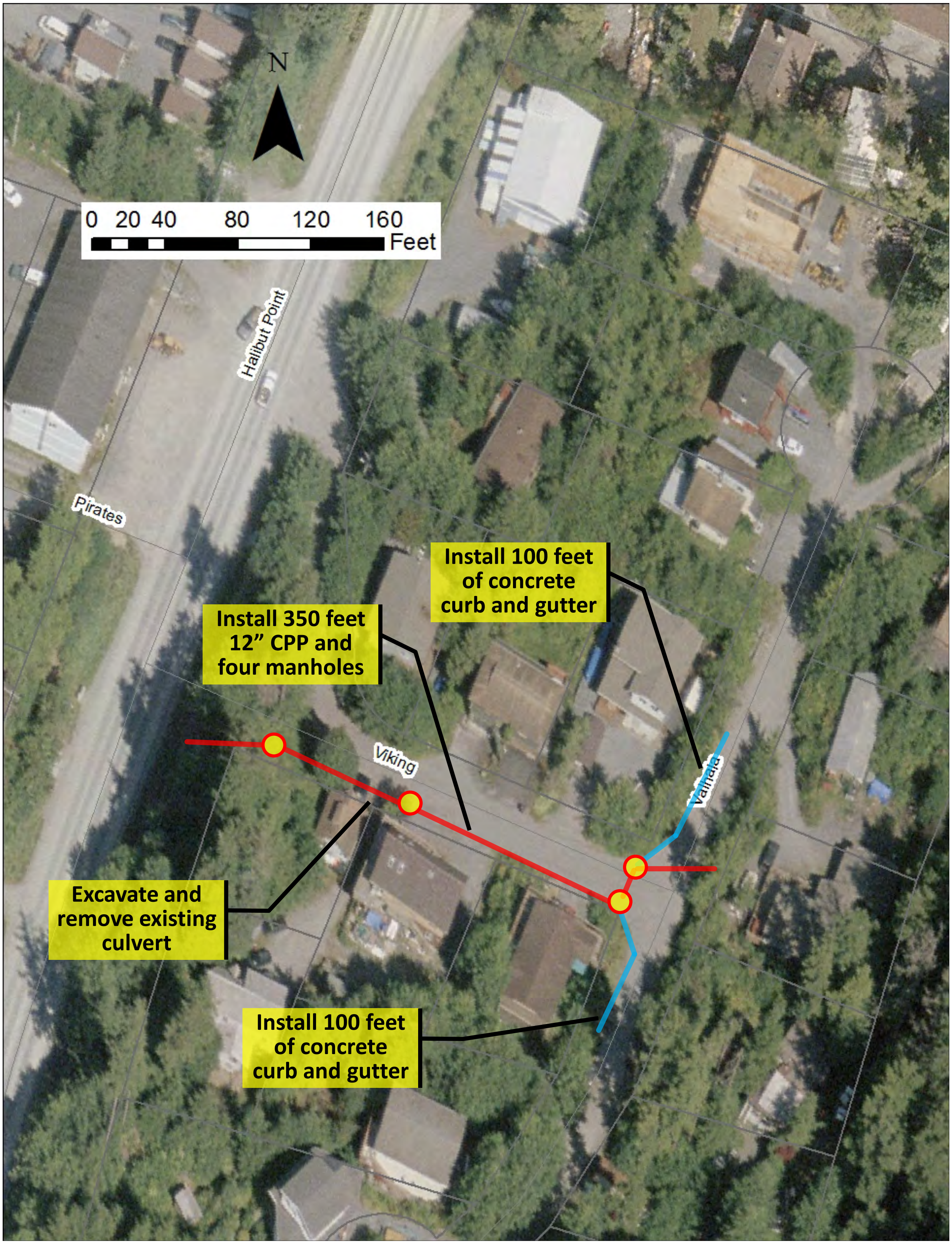

Figure E-11. Viking Way and Valhalla Drive proposed project.

Cost Estimate

PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: Viking Way and Valhalla Drive Drainage Improvements — **BY:** JT
DESCRIPTION: Install 12-inch CPP and manhole inlets — **CHECKED BY:**
DRAINAGE AREA: Granite Creek — **DATE:** 20-May-13

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
12-INCH DIAM CPP	350	LF	$80	$ 28,000
STORM DRAIN MANHOLE TYPE 1	4	EA	$4,500	$ 18,000
INSTALL CURB AND GUTTER	200	LF	$45	$ 9,000
MAN ROCK	5	CY	$200	$ 1,000
CSTC	25	CY	$45	$ 1,125
SAWCUT & REMOVE PAVEMENT	78	SF	$9	$ 700
ASPHALT PAVEMENT REPAIR	700	SF	$9	$ 6,300
			Subtotal	$ 64,125
DEWATERING	3%			$ 1,924
EROSION & SEDIMENTATION CONTROL	5%			$ 3,206
TRAFFIC CONTROL	3%			$ 1,924
CONTINGENCY	30%			$ 19,238
			Subtotal	$ 90,416
MOBILIZATION (GENERAL REQUIREMENT)	10%			$ 9,042
	Construction Subtotal (Rounded)			$ 99,000
SURVEY/EASEMENTS/ROW ACQUISITION	25%			$ 24,750
ENGINEERING/LEGAL/ADMIN	25%			$ 24,750
CONSTRUCTION MANAGEMENT	10%			$ 9,900
PERMITTING	10%			$ 9,900
2013 Dollars	**Total Estimated Project Cost (Rounded)**			**$168,000**

Notes:

1. The above cost opinion is in 2013 dollars and does not include future escalation, financing, land acquisition, or O&M costs.
2. The order-of-magnitude cost opinion has been prepared for guidance in project evaluation from the information available at the time of preparation and for the assumptions stated. The final costs of the project will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope and schedule, and other variable factors. As a result, the final project costs will vary from those presented above. Because of these factors, funding needs for individual projects must be scrutinized prior to establishing the final project budgets.

Granite Creek Road Detention and Retention Pond Improvements

Problem Description

According to City staff, stormwater detention/retention ponds on the north and south sides of Granite Creek Road approximately 200 feet east of HPR were constructed in the early 2000s to control sediment loading to Granite Creek. Granite Creek was placed on the Section 303(d) list of impaired water bodies for sediment and turbidity in 1996, and a Total Maximum Daily Load water quality cleanup plan was issued for Granite Creek in September 2002. In 2012 Granite Creek was still on the Category 4a list but not on the Category 5 list, indicating that water quality conditions have improved but that the water body is still impaired.

On the north side of Granite Creek Road, the detention features consist of approximately 200 linear feet of oversized roadside ditch approximately 2 to 3 feet wide with a maximum depth of 3 to 4 feet. The ditches drain east and west to a low spot in the middle, and flows are conveyed under Granite Creek Road to Granite Creek through a 36-inch-diameter CMP. The ditch is separated into discrete 50- to 100-foot-long cells by riprap dams perforated by short segments of 12-inch-diameter HDPE pipe. Ditch banks were largely unvegetated and showed large amounts of accumulated sand. As shown in Figure E-8, on April 23, 2013, these ditches had about 1 foot of standing water. The drainage basin contributing to the ditch system extends up the hill side to the north and is approximately 30 acres. A pond feature on the golf course controls over half of the drainage area.

On the south side of the road are two small detention ponds adjacent to the road edge. One pond consists of an excavated depression approximately 15 feet in diameter with a rock and soil dam with a 12-inch-diameter HDPE outlet pipe. On April 23, 2013, this pond was dry. The ponds on the south side of the road appear to receive drainage only from half of the Granite Creek Road surface for about 500 feet.

Figure E-12. Looking west on Granite Creek Road towards Sea Mountain Golf Course.

Figure E-13. Stormwater detention structure on south side of Granite Creek Road.

Proposed Solution

The ponds in the area appear to be largely operating as designed but could be improved through minor changes and maintenance. The ditches on the north side of the road are likely undersized and would provide water quality treatment only for small storm events. However, there is little available room to expand storage. Accumulated sediment on road edges could be swept, and accumulated sediment in ditches could be excavated to provide additional storage volume. The 12-inch-diameter outlet pipes will provide little stormwater storage. In order to better utilize the available storage, they could be replaced with smaller diameter outlet pipes and a stabilized overflow weir. In addition, the weir material could be replaced with permeable sand and riprap that would filter the stored water and allow the ditch to drain between storms and increase available storage. The total cost of these grading and pipe changes is estimated at $20,000.

Figure E-14. Granite Creek Road proposed solution.

Shotgun Alley/Rands Drive/Winchester Way Drainage System

Problem Description

The lack of drainage infrastructure along Shotgun Alley, Rands Drive, and Winchester Way directs drainage flows towards the house at 102 Winchester Way. A resident at 102 Winchester Way reported tracking storm drainage from her house up to Sawmill Creek Road. Drainage from the west side of Shotgun Alley drains south through a ditch on the west side of Shotgun Alley. A culvert crossing Shotgun Alley from the east to the west about 200 feet south of Sawmill Creek Road may divert some of the drainage flows. The ditchline turns west along the north side of Rands Drive. City records show that a culvert crosses Rands Drive immediately west of Shotgun Alley, but this culvert could not be located during site visits. The ditch on the north side of Rands Drive has no pipe outlet and would overflow to a ditch on the south side of Rands Drive. This ditch flows west on Rands Drive and turns south on the east side of Winchester Way. High flows could overtop the ditch and continue west to the cul-de-sac of Rands Drive. The ditch directing water southward on the east side of Winchester Way is shallow and has no pipe outlet. The ditch along Winchester Way also receives drainage from a swale flowing from private property to the east and from the driveway to 104 Winchester Way. The ditch would overflow west across Winchester Way and flow to the gravel private driveway at 102 Winchester Way. Currently, flows along the driveway are directed at the front of the house at 102 Winchester Way.

Delineation of the watershed to 102 Winchester Way resulted in a total basin area of 4.2 acres, including approximately 20 percent impervious surface. Hydrologic modeling resulted in estimated peak flows of 3.18 and 2.49 cfs for the existing conditions, 100-year and 25-year recurrence interval events.

Figure E-15. Looking west on Rands Drive from Shotgun Alley.

Figure E-16. Looking south on Winchester Way from Rands Drive.

Figure E-17. Looking west along private driveway at 102 Winchester Way.

Proposed Solution

Drainage infrastructure was sized to accommodate the existing conditions, 100-year recurrence interval peak flow using uniform flow assumption for ditch conveyance and inlet control assumption for pipe size. Because of the steep slopes in the area, the system is unlikely to have any backwater conditions. Ditches should have at least 1 foot bottom width, 1.5:1 side slopes, and be at least 1 foot deep and deeper at bends and pipe inlets. Ditch banks should be revegetated with grass to resist erosion and provide water quality treatment.

The proposed solution includes:

- Investigate the culvert crossing Rands Drive west of Shotgun Alley and clean out if the culvert is found.
- Install a 12-inch-diameter CPP culvert across Rands Drive west of Shotgun Alley.
- Expand the ditch system along the south side of Rands Drive and the east side of Winchester Way; install erosion control fabric and plant the ditch banks with grass.
- Install a 12-inch CPP beginning at an inlet on the east side of Winchester Way across Winchester Way.
- Install a catch basin inlet on the west side of Winchester Way adjacent to the driveway at 102 Winchester Way.
- Install a manhole at the change in grade at the western edge of the property at 102 Winchester Way.
- Extend the 12-inch CPP pipe across the property to outfall at the shoreline at the base of the slope.

The proposed solution elements are all located within the public right of way except for pipe and a manhole on property at 102 Winchester Way. Installing drainage infrastructure would require a construction easement, and a permanent maintenance easement should also be obtained. The property owner appeared amenable to granting an easement during a discussion on April 23, 2013.

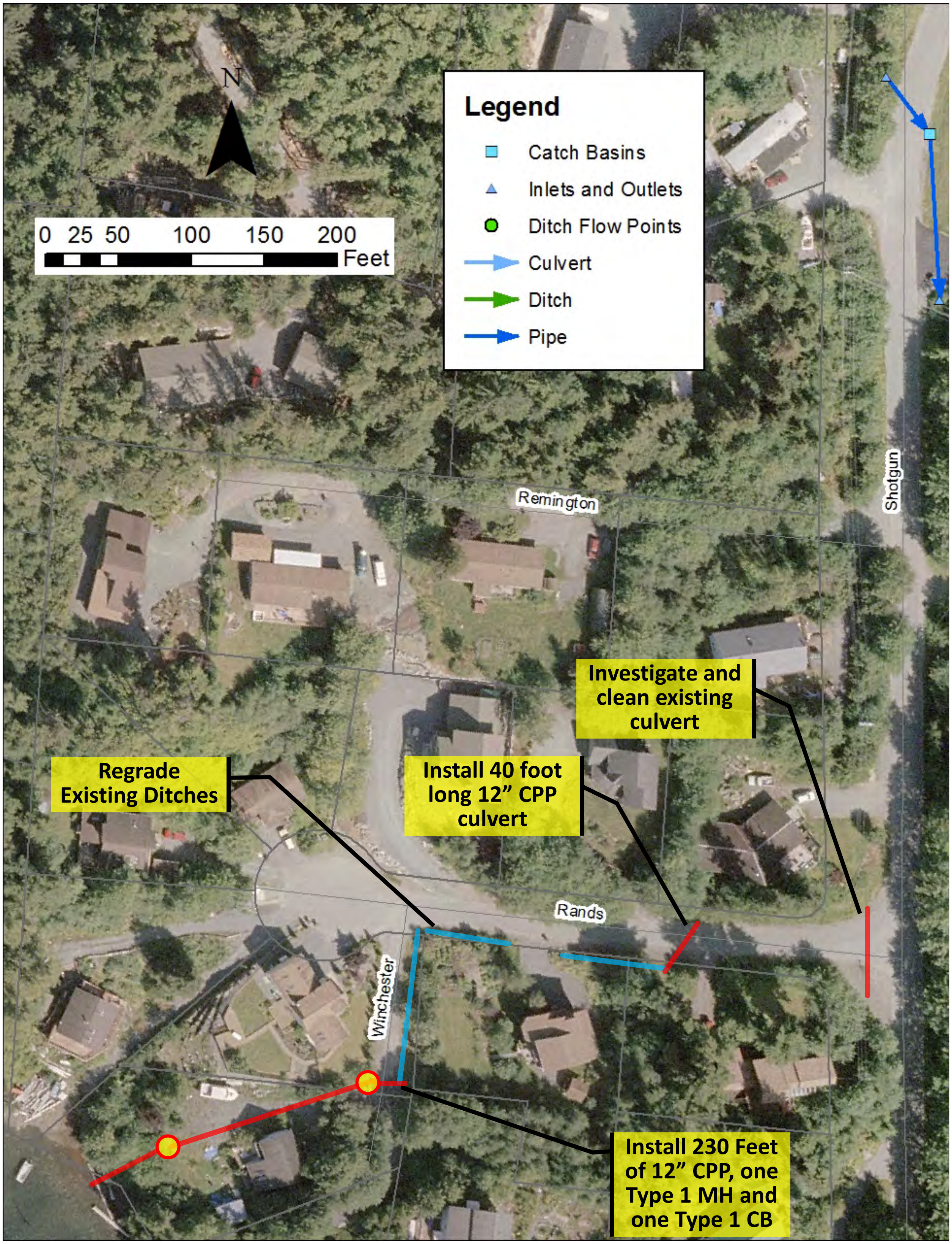

Figure E-18. Shotgun Alley proposed solution.

Cost Estimate

PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: **Shotgun Alley and Rands Drive Drainage System** **BY:** **JT**
DESCRIPTION: **Install 12-inch CPP and improve existing ditches** **CHECKED BY:**
DRAINAGE AREA: **Jamestown Bay/Thimbleberry Bay** **DATE:** **11-Jun-13**

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
12-INCH DIAM CPP	270	LF	$80	$ 21,600
CATCH BASIN TYPE 1	1	EA	$3,000	$ 3,000
STORM DRAIN MANHOLE TYPE 1	1	EA	$4,500	$ 4,500
MAN ROCK	10	CY	$200	$ 2,000
CSTC	15	CY	$45	$ 667
EXCAVATION	15	CY	$20	$ 296
SEEDING	110	SY	$3	$ 330
TOPSOIL	12	CY	$60	$ 741
SAWCUT & REMOVE PAVEMENT	22	SF	$9	$ 200
ASPHALT PAVEMENT REPAIR	200	SF	$9	$ 1,800
			Subtotal	$ 35,134
DEWATERING	3%			$ 1,054
EROSION & SEDIMENTATION CONTROL	5%			$ 1,757
TRAFFIC CONTROL	3%			$ 1,054
CONTINGENCY	30%			$ 10,540
			Subtotal	$ 49,539
MOBILIZATION (GENERAL REQUIREMENT)	10%			$ 4,954
			Construction Subtotal (Rounded)	$ 54,000
SURVEY/EASEMENTS/ROW ACQUISITION	25%			$ 13,500
ENGINEERING/LEGAL/ADMIN	25%			$ 13,500
CONSTRUCTION MANAGEMENT	10%			$ 5,400
PERMITTING	10%			$ 5,400
2013 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 92,000**

Notes:

1. The above cost opinion is in 2013 dollars and does not include future escalation, financing, land acquisition, or O&M costs.
2. The order-of-magnitude cost opinion has been prepared for guidance in project evaluation from the information available at the time of preparation and for the assumptions stated. The final costs of the project will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope and schedule, and other

Lake Street Storm Drain Crossing

Problem Description

Flows from a small creek enter a 42-inch CMP east of Lake Street at a right of way between 700 and 618 Lake Street. The invert of the pipe at the inlet and outlet is severely corroded and is in danger of collapsing or of having the pipe bed and backfill material wash away.

The pipe inlet is fitted with a metal trash rack that appears in good condition with no accumulated debris. The pipe appears to make a 20-degree bend to the south below the driveway at 701 Lake Street without manhole access. Downstream of the bend, the pipe alignment is about 15 feet from the edge of the house at 701 Lake Street. The 42-inch CMP outfalls to a small open channel at 703 Lake Street and flows approximately 100 feet to Swan Lake. The invert pipe at the outlet is also extremely corroded.

The 42-inch pipe is approximately 4 to 5 feet deep across Lake Street. The road surface above the pipe shows no sign of subsidence. Sewer and water pipelines run along Lake Street but the invert and alignment of these lines were not researched. In this area Lake Street is drained by several catch basin inlets connected to an 18-inch-diameter CMP. The 18-inch CMP system crosses but does not appear to connect to the 42-inch pipe system. This pipe outfalls to Swan Lake approximately 500 feet east of the 42-inch crossing.

During a site visit on April 23, 2013, the flow through the pipe was approximately 0.5 cfs. Flows in the 42-inch pipe are reported by City staff to be constant through the year. The property owner at 703 Lake Street reports that water has recently started to discharge from the ground near the foundation at the rear of their house after storm events. Water was not flowing from the foundation during the site visit on April 23, 2013. The property owner believes the water is coming from the corroded 42-inch CMP. According to the homeowner, who walked the pipe, the pipe is corroded along the entire length. Because the 42-inch pipe invert is low compared to the house foundation and flows from the foundation are not constant, it appears unlikely that the flows from the foundation come from the 42-inch CMP.

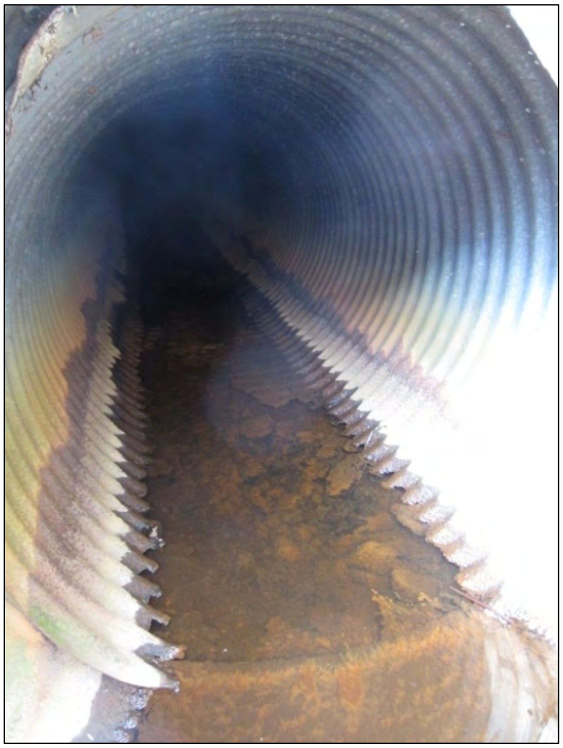

Figure E-19. Looking downstream at 42-inch CMP pipe inlet upstream of Lake Street.

Figure E-20. Looking west (downstream) along pipe alignment across Lake Street from east of Lake Street.

Figure E-21. Looking east (upstream) at the 42-inch CMP outlet on private property west of Lake Street.

Proposed Solution

The peak flow rate for the 100-year recurrence interval flow rate for the existing conditions was estimated at 11.8 cfs. The total drainage area is 74 acres, of which 52 acres are forested. Because the pipe and outlet channel slope to Swan Lake is relatively steep, it is assumed that the pipe size would be determined by the inlet capacity. Assuming the current land use does not change and assuming inlet control, the existing pipe has excess capacity and could be replaced with a much smaller pipe.

The proposed solution is to replace the pipe by slip lining it with a smaller 30-inch-diameter CPP. A 30-inch CPP has an outside diameter of about 36 inches and should be able to be installed in a 42-inch CMP. HDPE pipe without outside corrugations would give more space or a larger diameter but would be more expensive to install due to the more complicated butt-fused pipe joints. Prior to further design, the inlet and outlet pipes need to be surveyed and the pipe alignment inspected to check if the pipe is buckled, rendering slip lining impossible. Before slip lining, the pipe may need to be cleared of excessive debris. An access hole would be dug at the vertex of the pipe at the driveway to 701 Lake Street. Pipe sections would be pushed and/or pulled from the inlet and outlet towards the access hole. The annular space between the pipes would be filled with controlled density fill. A manhole would be constructed at the access hole after the pipe installation. During construction, flows in the open channel could be pumped over Lake Street or to the piped drainage system on Lake Street. Flow diversion may require fish exclusion. The upstream end of the pipe should be fitted with a trash rack. Construction would take place partially on private property so a construction and permanent easement should be secured.

Other trenchless pipe installation options such as cured in place pipe would require specialized equipment, and the mobilization costs to Sitka and competitiveness of bids may make these options cost prohibitive. Open cut pipe installation is also possible. The most inexpensive construction would be to close the road entirely for the construction period of approximately 2 weeks. Existing storm, sewer, and water utilities would need to be secured or diverted during construction. Open cut installation may still be cost competitive and may be less risky than slip lining.

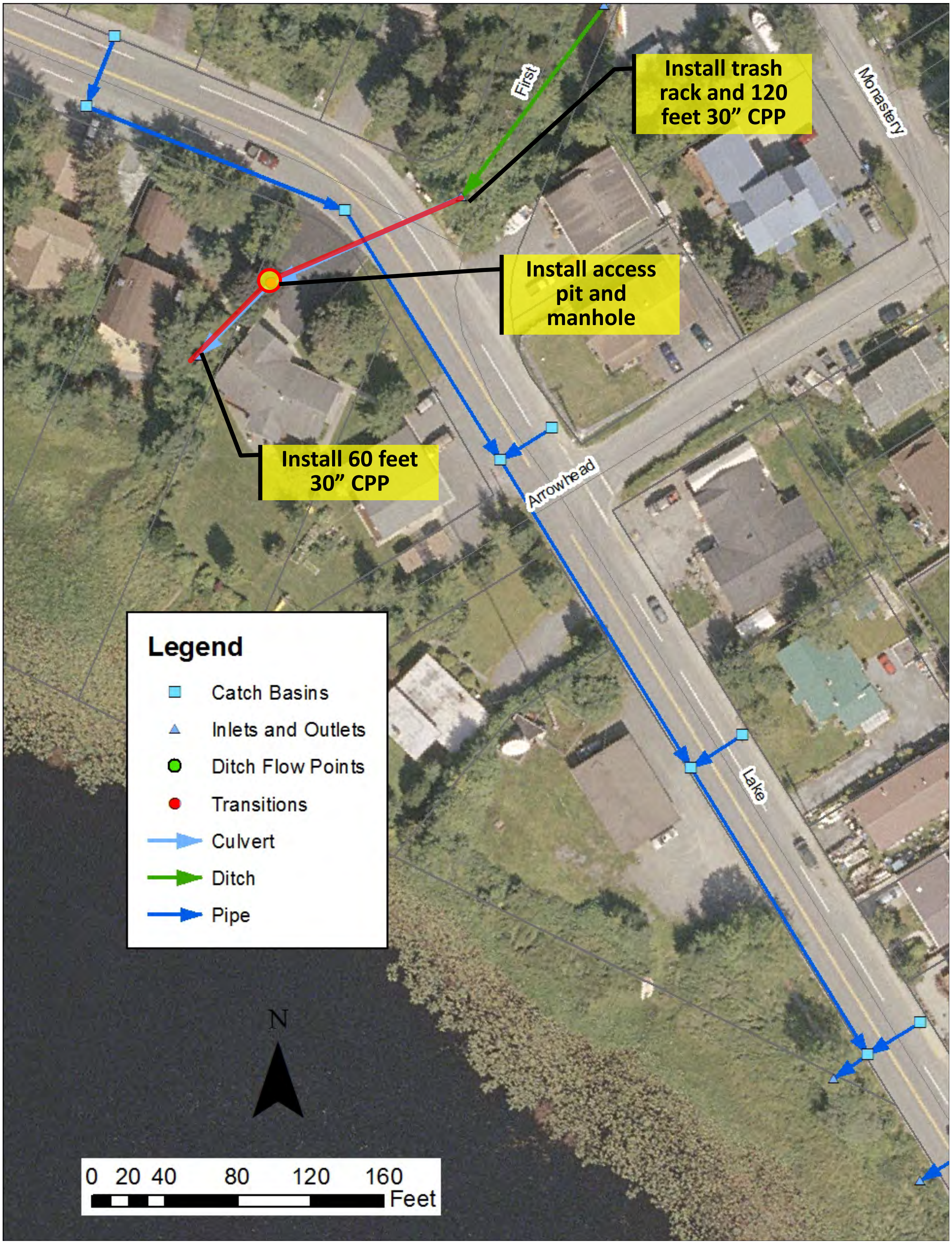

Figure E-22. Lake Street proposed project.

Cost Estimate

PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: **Storm Drain Crossing Lake St at 703 Lake Street** **BY:** **JT**
DESCRIPTION: **Install 36-inch PE and Manhole** **CHECKED BY:** **GG**
DRAINAGE AREA: **Swan Lake** **DATE:** **29-May-13**

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
30-INCH DIAM CPP	180	LF	$60	$ 10,800
INSTALL CPP	1	LS	$50,000	$ 50,000
STORM DRAIN MANHOLE TYPE 1	1	EA	$4,500	$ 4,500
TRASH RACK	1	EA	$5,000	$ 5,000
SAWCUT & REMOVE PAVEMENT	11	SF	$9	$ 100
ASPHALT PAVEMENT REPAIR	100	SF	$9	$ 900
			Subtotal	$ 71,300
DEWATERING	3%			$ 2,139
EROSION & SEDIMENTATION CONTROL	5%			$ 3,565
TRAFFIC CONTROL	3%			$ 2,139
CONTINGENCY	30%			$ 21,390
			Subtotal	$ 100,533
MOBILIZATION (GENERAL REQUIREMENT)	10%			$ 10,053
			Construction Subtotal (Rounded)	$ 111,000
SURVEY/EASEMENTS/ROW ACQUISITION	25%			$ 27,750
ENGINEERING/LEGAL/ADMIN	25%			$ 27,750
CONSTRUCTION MANAGEMENT	10%			$ 11,100
PERMITTING	10%			$ 11,100
2013 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 189,000**

Notes:

1. The above cost opinion is in 2013 dollars and does not include future escalation, financing, land acquisition, or O&M costs.
2. The order-of-magnitude cost opinion has been prepared for guidance in project evaluation from the information available at the time of preparation and for the assumptions stated. The final costs of the project will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope and schedule, and other variable factors. As a result, the final project costs will vary from those presented above. Because of these factors, funding needs for individual projects must be scrutinized prior to establishing the final project budgets.

Davidoff Street Drainage System to HPR

Problem Description

The invert of a 24-inch CMP culvert system on the south side of Davidoff Street is corroded and has exposed the bedding material. This pipe system primarily conveys drainage from a ditch and pipe drainage system along Charteris Street north of Edgecumbe Drive. This pipe system also collects drainage from Davidoff Street through a ditch and gutter along the south side of Davidoff Street. Drainage flows from Edgecumbe Drive enter a 24-inch CMP adjacent to a mobile home at 1602 Charteris Street. The CMP crosses Davidoff Street and enters a CMP riser manhole located in the driveway of 1603 Davidoff Street. Flows are conveyed through two non-standard manholes on private property at 1603 and 1605 Davidoff Street and outfall on private property on a riprap slope uphill from HPR. An HDPE culvert behind the sidewalk on HPR conveys flows across HPR and outfalls to saltwater. The CMP through 1603 and 1605 Davidoff Street is severely degraded at the pipe invert. The pipe also shows some buckling and rusting at the pipe crown.

Figure E-23. Poor condition CMP manhole riser at 1601 Davidoff Street.

Figure E-24. Erosion of CMP invert at culvert inlet near 1602 Davidoff Street.

Figure E-25. Looking west on Davidoff Street from Charteris Street.

Proposed Solution

The proposed solution is to install new CPP within the right of way and to abandon in place the existing pipe system and manholes by filling them with controlled density fill. The new system would outfall to the ditch on the north side of HPR. The existing drainage collection system on Davidoff Street near HPR would be left in place.

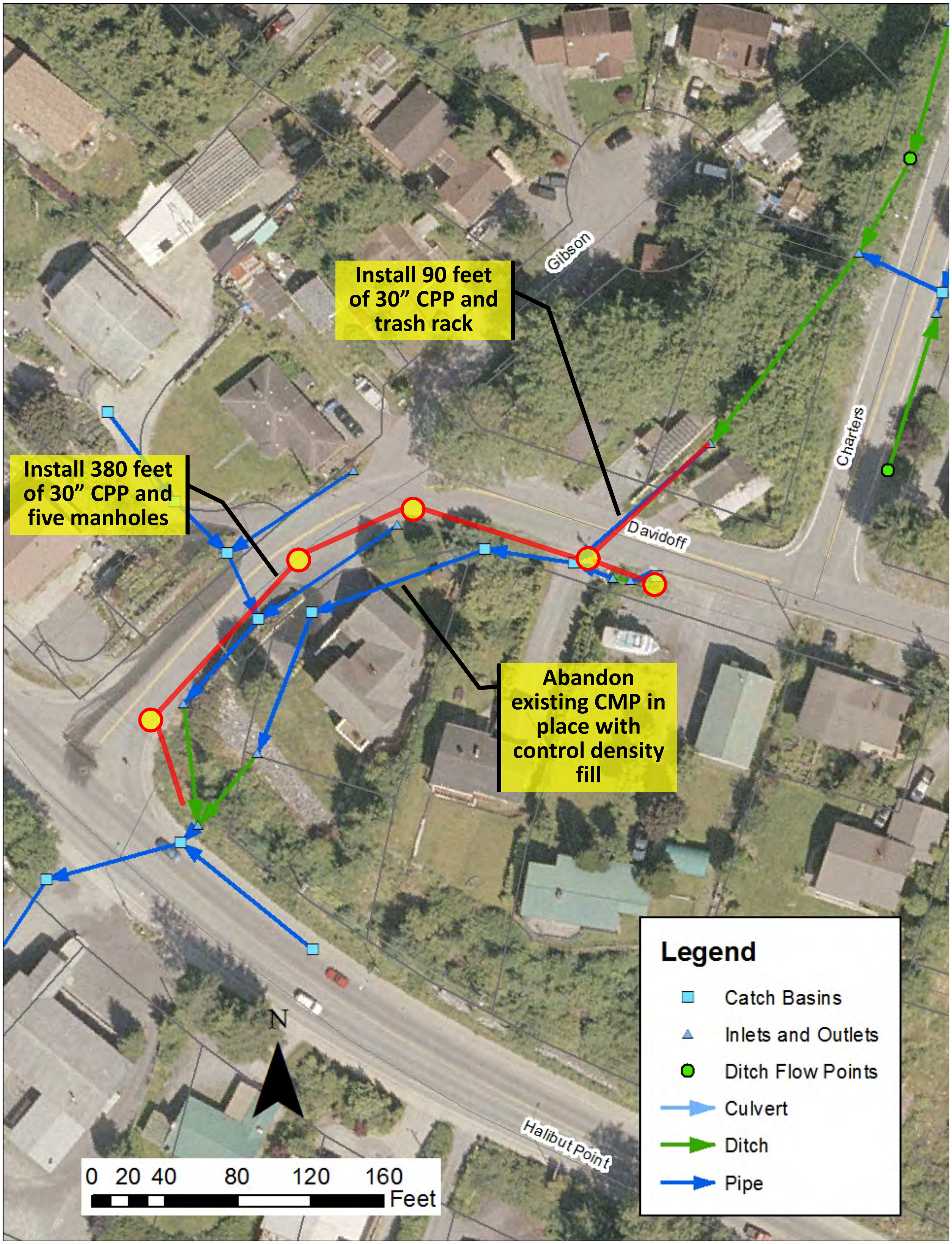

Figure E-26. Davidoff Street and Charteris Street proposed project.

Cost Estimate

PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: Davidoff St Drainage System | **BY:** JT
DESCRIPTION: Install 30-inch CPP and Manholes | **CHECKED BY:**
DRAINAGE AREA: Edgecumbe | **DATE:** 10-Jun-13

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
30-INCH DIAM CPP	470	LF	$80	$ 37,600
STORM DRAIN MANHOLE TYPE 1	5	EA	$4,500	$ 22,500
SAWCUT & REMOVE PAVEMENT	261	SF	$9	$ 2,350
ASPHALT PAVEMENT REPAIR	2,350	SF	$9	$ 21,150
CONTROLLED DENSITY FILL	80	CY	$140	$ 11,200
MAN ROCK	5	CY	$200	$ 1,000
TRASH RACK	1	EA	$5,000	$ 5,000
			Subtotal	$ 100,800
DEWATERING	3%			$ 3,024
EROSION & SEDIMENTATION CONTROL	5%			$ 5,040
TRAFFIC CONTROL	3%			$ 3,024
CONTINGENCY	30%			$ 30,240
			Subtotal	$ 142,128
MOBILIZATION (GENERAL REQUIREMENT)	10%			$ 14,213
			Construction Subtotal (Rounded)	$ 156,000
SURVEY/EASEMENTS/ROW ACQUISITION	25%			$ 39,000
ENGINEERING/LEGAL/ADMIN	25%			$ 39,000
CONSTRUCTION MANAGEMENT	10%			$ 15,600
PERMITTING	10%			$ 15,600
2013 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 265,000**

Notes:

1. The above cost opinion is in 2013 dollars and does not include future escalation, financing, land acquisition, or O&M costs.
2. The order-of-magnitude cost opinion has been prepared for guidance in project evaluation from the information available at the time of preparation and for the assumptions stated. The final costs of the project w ill depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope and schedule, and other variable factors. As a result, the final project costs w ill vary from those presented above. Because of these factors, funding needs for individual projects must be scrutinized prior to establishing the final project budgets.

Edgecumbe Drive Storm Drain Crossings

Problem Description

A 30-inch CMP pipe inlet adjacent to 306 Charteris Street has a deteriorated invert. The pipe conveys surface flows from along Charteris Street across Edgecumbe Drive. The pipe likely is deteriorated along its entire length and may be in danger of collapse. The pipe system predates the Edgecumbe Road construction conducted in 1983. This pipe joins two CMPs crossing Charteris Street from the west at underground tees with no surface access. The inventory of pipe condition at manholes farther downstream shows the pipe is in fair condition; however, it is likely that the culvert invert is in poor condition at other locations. The pipe system outfalls to an open channel west of Charteris Street through a 24-inch-diameter CMP.

Other similar CMP culverts crossing Edgecumbe Road were investigated but were found to be in good condition, including culverts at Mills Street, Kostrometinoff Street, and west of Kashevaroff Street.

A 36-inch-diameter CMP culvert conveys flows from a surface channel adjacent to the Keet Gooshi Elementary School. At the inlet the pipe appears to have been paved with concrete; however, from the inventory it does not appear that the concrete paving continues for the entire length of the pipe system. Inventory of the manholes farther downstream shows the pipe is in fair condition; however, it is likely that this pipe could be in poor condition. Upstream sections of the pipe are CMP but between Edgecumbe and HPR the pipe transitions to HDPE or concrete. This pipe system crosses Edgecumbe Drive without connecting to the drainage system along Edgecumbe Drive. It joins the drainage system draining HPR at the intersection of Kashevaroff Street and HPR and outfalls to saltwater across HPR.

Figure E-27. Erosion of CMP invert at 306 Charteris Street.

Proposed Solution

The condition of pipe inverts should be further investigated for the two pipe systems along Charteris Street and Kashvaroff Street through manhole access and by television. Peak flow rates for the 100-year recurrence interval storm were estimated at 32 cfs. Using inlet control to size the pipes, the existing 30-inch diameter should be adequate.

The proposed solution here assumes the pipe along Charteris Street needs to be replaced. The proposed solution includes:

- Install 30-inch-diameter CPP from inlet on Charteris Street to outfall on west side of Charteris Street.
- Install manholes at the intersection of Charteris Street and Edgecumbe Drive.
- Install manhole north of Charteris Street and install 24-inch CPP culvert to intercept drainage on ditch on west side of Charteris Street.
- Install manhole south of Charteris Street to collect pipe drainage from east side of Charteris Street.
- Install 30-inch CPP to outfall to open channel of west side of Charteris Street.

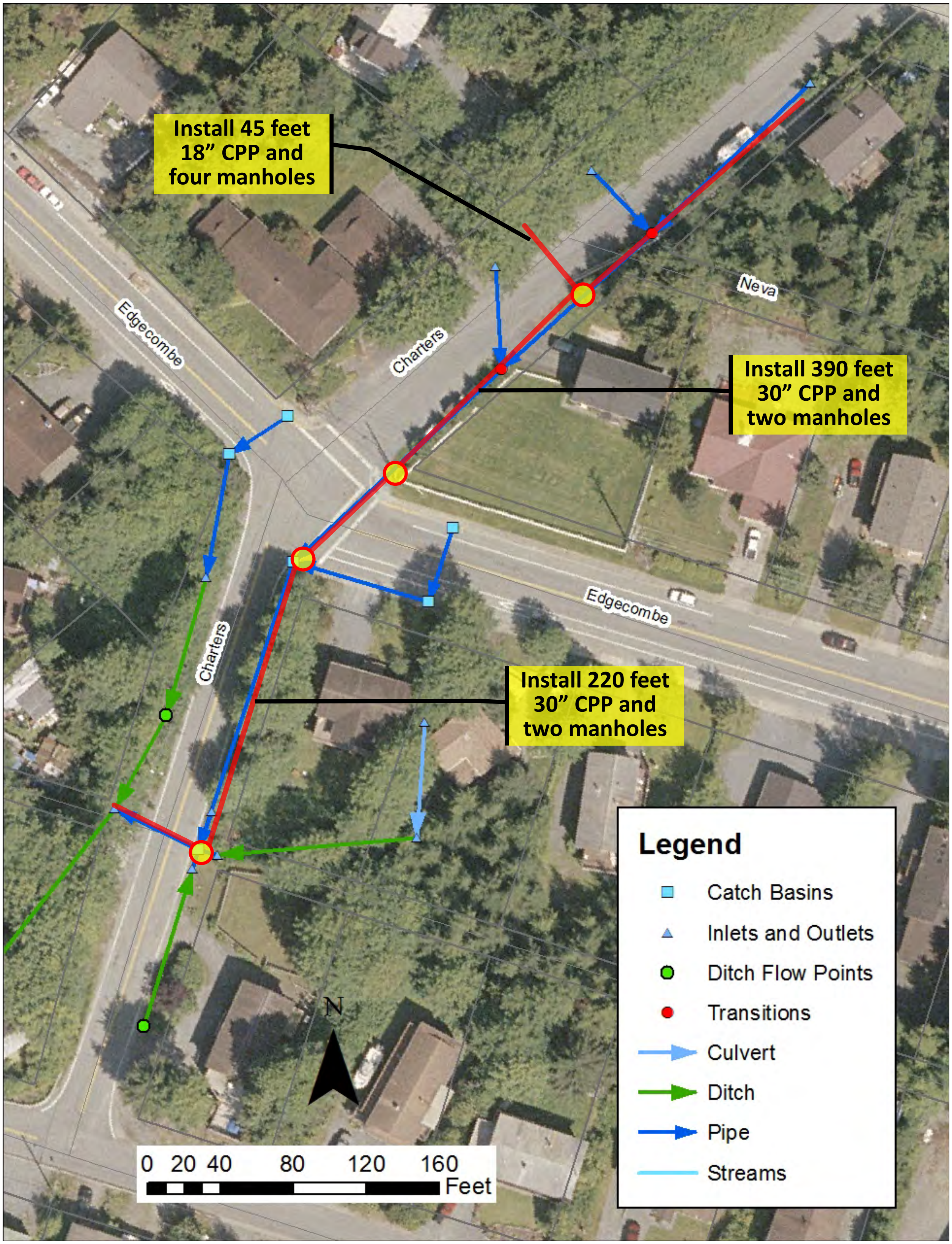

Figure E-28. Edgecumbe Drive and Charteris Street proposed solution.

Cost Estimate

PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: Edgecumbe Drive Storm Drain Crossing - Charteris Street
DESCRIPTION: Install 30-inch CPP and manholes
DRAINAGE AREA: Edgecumbe
BY: JT
CHECKED BY:
DATE: 29-May-13

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
18-INCH DIAM CPP	45	LF	$90	$ 4,050
30-INCH DIAM CPP	610	LF	$140	$ 85,400
STORM DRAIN MANHOLE TYPE 1	4	EA	$4,500	$ 18,000
MAN ROCK	5	CY	$200	$ 1,000
SAWCUT & REMOVE PAVEMENT	364	SF	$9	$ 3,275
ASPHALT PAVEMENT REPAIR	3,275	SF	$9	$ 29,475
			Subtotal	$ 141,200
DEWATERING	3%			$ 4,236
EROSION & SEDIMENTATION CONTROL	5%			$ 7,060
TRAFFIC CONTROL	3%			$ 4,236
CONTINGENCY	30%			$ 42,360
			Subtotal	$ 199,092
MOBILIZATION (GENERAL REQUIREMENT)	10%			$ 19,909
	Construction Subtotal (Rounded)			$ 219,000
SURVEY/EASEMENTS/ROW ACQUISITION	25%			$ 54,750
ENGINEERING/LEGAL/ADMIN	25%			$ 54,750
CONSTRUCTION MANAGEMENT	10%			$ 21,900
PERMITTING	10%			$ 21,900
2013 Dollars	**Total Estimated Project Cost (Rounded)**			**$ 372,000**

Notes:

1. The above cost opinion is in 2013 dollars and does not include future escalation, financing, land acquisition, or O&M costs.
2. The order-of-magnitude cost opinion has been prepared for guidance in project evaluation from the information available at the time of preparation and for the assumptions stated. The final costs of the project will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope and schedule, and other variable factors. As a result, the final project costs will vary from those presented above. Because of these factors, funding needs for individual projects must be scrutinized prior to establishing the final project budgets.

Hillside Subdivision Drainage System

Problem Description

The Hillside subdivision (Kiksadi Court, Vitsakri Road, and Chirikov Street) was built in approximately 2006. The drainage system consists of ditches, large-diameter HDPE driveway and road culverts, and HDPE tightline pipes. Road and ditch slopes in the area are typically 10 to 15 percent while one section on Kiksadi Court is 33 percent. The road surface in the subdivision is a fine gravel material. Ditch banks are generally steep and are constructed from small-diameter aggregate material. The drainage basin contributing to Hillside is forested but extremely steep.

During large storm events, the ditch banks erode and eroded material blocks culvert entrances leading to flooding. During a storm event on January 11, 2009, the ditch at the intersection of Vitskari Street and Kiksadi Court overtopped, partially unearthing the culvert crossing of Kiksadi Court due to the misalignment of the culvert in relation to the ditch line.

Figure E-29. Looking west on Kiksadi Court towards Vitskari Street.

Proposed Solution

Peak flow rates for the 100- and 25-year recurrence interval events were estimated for two ditch sections, one on the north-south section in the northwest corner of Kiksadi Court with a slope of 21 percent and another on the east-west lower section of Kiksadi Court with a slope of 11 percent. Flow rates ranged from 11.5 to 4.25 cfs. Peak velocities in the ditch were estimated to range from 11.3 to 6.6 feet per second.

Design standards for ditches in Sitka have not been set but ditches should at least be designed to convey the 25-year flow rate without erosion. Ditches should be designed with site-specific flow rates, slopes, and channel geometry using design guidance such as the ADOT&PF Drainage Manual (2005) and the Federal Highway Administration Hydraulic Engineering Circular 11 or 15 (FHWA 1989, 2005). In general, ditches with expected velocities of 5 feet or greater should be constructed with bed material with a median diameter of approximately 8 inches, while velocities of greater than 8 feet per second will require bed material with a median diameter of 16 inches. The existing ditch material is considerably smaller and would be expected to erode during peak flow events.

Check dams constructed of large-diameter riprap would moderate slopes, increase channel roughness, reduce flow velocities, and trap mobilized material. Where feasible, the upper ditch banks could be regraded and planted with turf grass. Paving the roadway surface will also decrease the sediment loading to the ditches. Misaligned culverts such as the culvert at the southwest corner of the Kiksadi Court loop should be reinstalled to align with the upstream and downstream ditch to help prevent ditch overtopping. Culvert outfalls should also be designed with outfall protection to prevent erosion.

Sitka should develop and adopt drainage design standards to address hydrologic and hydraulic modeling, sizing of pipes, design of street crossings, and open channel drainage design.

The proposed solution here involves relining ditches with larger bed material and installing check dams at 100-foot intervals. The proposed solution assumed that approximately 2,100 feet of ditches in the area would need to be relined.

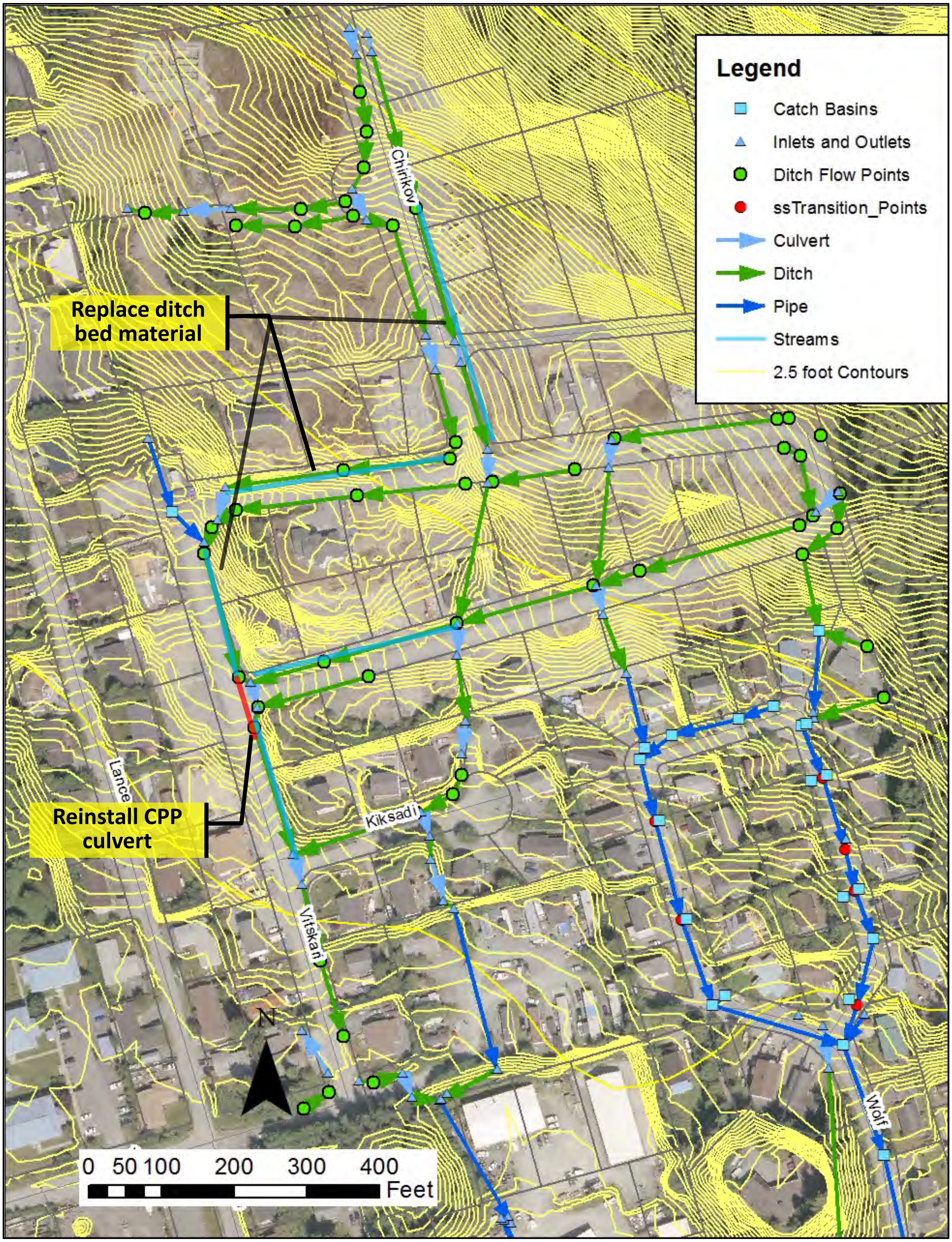

Figure E-30. Hillside subdivision proposed solution.

Cost Estimate

PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: Hillside Subdivision Drainage System	**BY:** JT
DESCRIPTION: Reline Ditches with Riprap	**CHECKED BY:**
DRAINAGE AREA: Jamestown Bay - Thimbleberry Bay	**DATE:** 20-May-13

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
RELINE DITCH WITH RIPRAP	2,130	LF	$20	$ 42,600
INSTALL CHECK DAM	20	EA	$200	$ 4,000
REINSTALL CULVERT	1	LS	$2,000	$ 2,000
			Subtotal	$ 48,600
DEWATERING	3%			$ 1,458
EROSION & SEDIMENTATION CONTROL	5%			$ 2,430
TRAFFIC CONTROL	3%			$ 1,458
CONTINGENCY	30%			$ 14,580
			Subtotal	$ 68,526
MOBILIZATION (GENERAL REQUIREMENT)	10%			$ 6,853
	Construction Subtotal (Rounded)			$ 75,000
SURVEY/EASEMENTS/ROW ACQUISITION	25%			$ 18,750
ENGINEERING/LEGAL/ADMIN	25%			$ 18,750
CONSTRUCTION MANAGEMENT	10%			$ 7,500
PERMITTING	10%			$ 7,500
2013 Dollars	**Total Estimated Project Cost (Rounded)**			**$128,000**

Notes:

1. The above cost opinion is in 2013 dollars and does not include future escalation, financing, land acquisition, or O&M costs.
2. The order-of-magnitude cost opinion has been prepared for guidance in project evaluation from the information available at the time of preparation and for the assumptions stated. The final costs of the project will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope and schedule, and other variable factors. As a result, the final project costs will vary from those presented above. Because of these factors, funding needs for individual projects must be scrutinized prior to establishing the final project budgets.

Hollywood Way Drainage

Problem Description

Hollywood Way has no pipe drainage infrastructure between Sawmill Creek Boulevard and DeGroff Street. The northern third of the road in the block sheet flows towards catch basins at the corner of Hollywood Way and DeGroff Street. At mid-block, the road is slightly higher than adjacent parking lots, resulting in surface ponding. Drainage from the southern two-thirds of the road otherwise sheet flow south to catch basins near the intersection of Hollywood Way and Sawmill Creek Boulevard.

An 18-inch-diameter CMP drainage pipe runs west along Sawmill Creek Boulevard with catch basins 22 feet east and 42 feet west of the intersection of Hollywood Way and Sawmill Creek Boulevard. This drainage system joins the 60-inch CMP pipe at Lake Street and outfalls to Crescent Bay adjacent to Centennial Hall. The Sawmill Creek Boulevard drainage system is owned and operated by ADOT&PF and that agency would need to be involved in the design.

City staff recently completed a concept design for a grant application for new water and sewer pipelines from DeGroff Street to the middle of the block on Hollywood Way.

Figure E-31. Looking north on Hollywood Way from north of Sawmill Creek Boulevard.

Figure E-32. Looking south on Hollywood Way towards Sawmill Creek Boulevard.

Proposed Solution

The proposed solution includes:

- Install catch basin inlet with a stub out to the west to allow for future connection.
- Extend 12-inch CPP to Sawmill Creek Boulevard.
- Install new manhole on Sawmill Creek Boulevard.

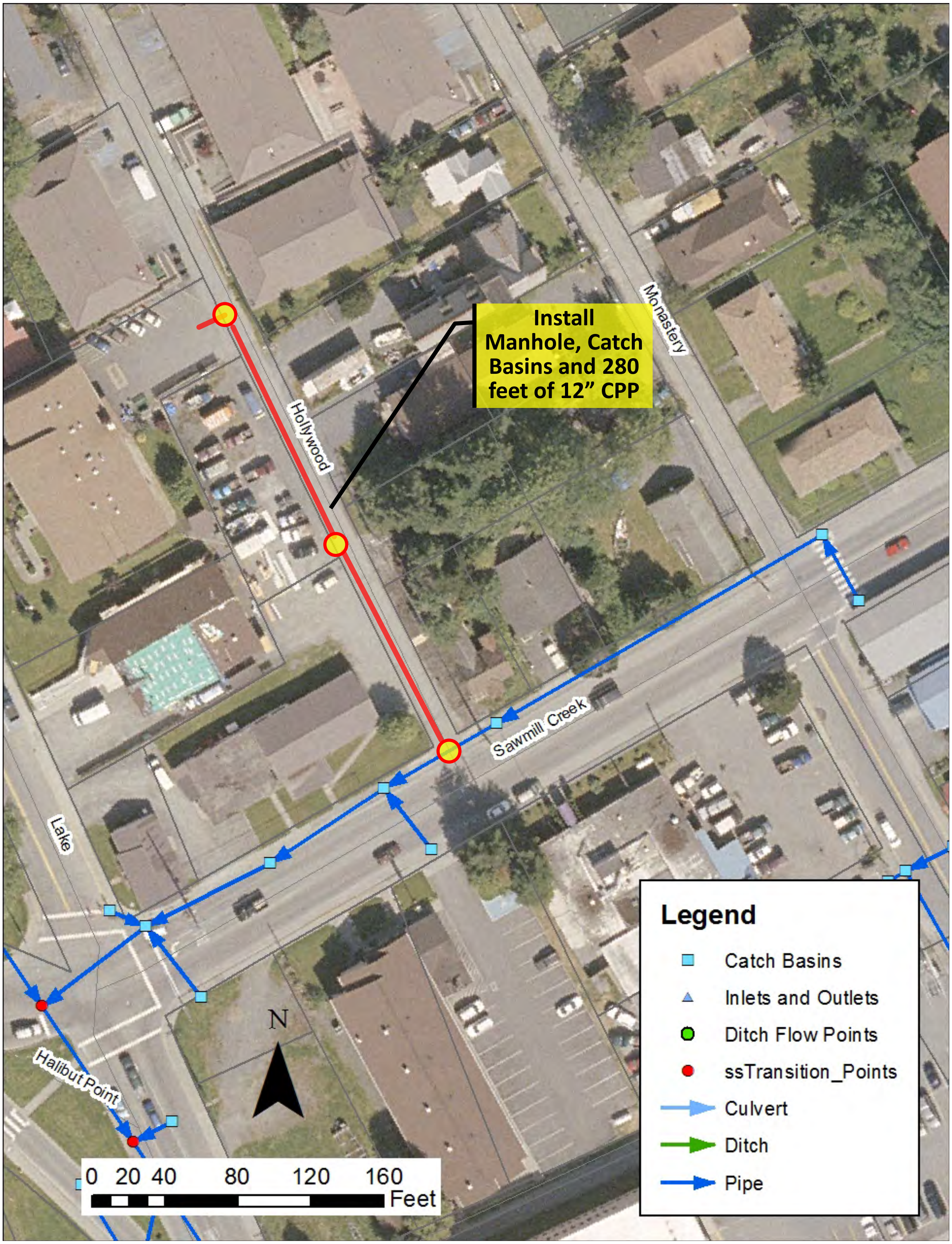

Figure E-33. Hollywood Way proposed solution.

Cost Estimate

PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT:	**Hollywood Way Drainage**		**BY:**	**JT**
DESCRIPTION:	**Install 12-inch CPP and catch basins**		**CHECKED BY:**	
DRAINAGE AREA:	**Downtown**		**DATE:**	**20-May-13**

BID ITEM	**QUANTITY**	**UNIT**	**UNIT PRICE**	**AMOUNT**
12-INCH DIAM CPP	280	LF	$80	$ 22,400
STORM DRAIN MANHOLE TYPE 1	1	EA	$4,500	$ 4,500
CATCH BASIN TYPE 1	2	EA	$3,000	$ 6,000
SAWCUT & REMOVE PAVEMENT	156	SF	$9	$ 1,400
ASPHALT PAVEMENT REPAIR	1,400	SF	$9	$ 12,600
			Subtotal	$ 46,900
DEWATERING	3%			$ 1,407
EROSION & SEDIMENTATION CONTROL	5%			$ 2,345
TRAFFIC CONTROL	3%			$ 1,407
CONTINGENCY	30%			$ 14,070
			Subtotal	$ 66,129
MOBILIZATION (GENERAL REQUIREMENT)	10%			$ 6,613
			Construction Subtotal (Rounded)	$ 73,000
SURVEY/EASEMENTS/ROW ACQUISITION	25%			$ 18,250
ENGINEERING/LEGAL/ADMIN	25%			$ 18,250
CONSTRUCTION MANAGEMENT	10%			$ 7,300
PERMITTING	10%			$ 7,300
2013 Dollars			**Total Estimated Project Cost (Rounded)**	**$124,000**

Notes:

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Peterson Avenue Culvert Crossing

Problem Description

The pipe invert, metal apron, and wingwalls at the inlet and outlet of a 125-foot-long, 60-inch-diameter CMP crossing Peterson Avenue are in poor condition. Deterioration of the culvert inlet may allow the culvert bed and backfill material to be washed away. In addition, the structural strength of the pipe relies on continuous pipe material around the circumference. Erosion of the invert will greatly reduce the strength of the pipe and could lead to collapse.

Two 12-inch-diameter CMP drainage systems draining Petersen Avenue north and south of the culvert tee into the culvert without surface access. The culvert has approximately 10 feet of cover over the pipe at the centerline of Peterson Road. The culvert conveys flows from an unnamed stream that drains approximately 410 acres. Downstream of the Peterson Avenue culvert, the stream flows through approximately 1,000 feet of open channel and is conveyed across HPR and private property through a 66-inch CMP to saltwater.

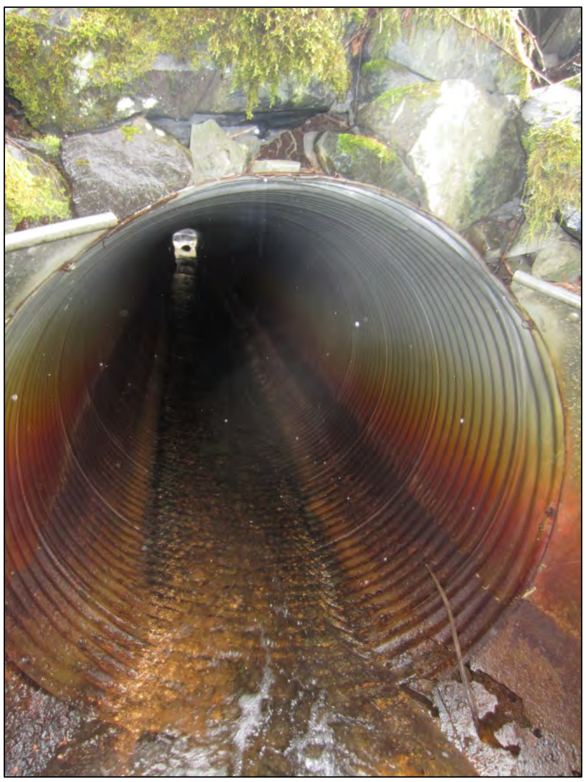

Figure E-34. Looking downstream at inlet of 60-inch CMP crossing Peterson Avenue.

Figure E-35. Looking upstream at inlet of 60-inch CMP crossing Peterson Avenue.

Proposed Solution

The condition of the invert through the culvert should be determined to assess the extent of deterioration. If the structural integrity of the pipe has not been compromised, the life of the culvert may be extended by 10 to 20 years by paving the culvert invert with reinforced concrete (see Figure E-35). Paving would not stop rusting but would protect the pipe invert from abrasion. If the invert of the pipe has been significantly weakened, additional metal could be welded to the pipe invert to increase strength prior to paving with reinforced concrete. Design recommendations for both methods can be found in Federal Highway Administration manuals (FHWA 1995). The proposed project assumes that the culvert invert is still structurally sound.

The existing pipe could be replaced with a concrete box culvert. Open cut replacement would most cost effectively require the entire road to be out of service during the construction period of about 2 weeks. Existing sewer and water utilities along Peterson Street would need to be protected during excavation and the 12-inch-diameter storm drains would need to be rerouted. Total construction cost for this option is estimated at $427,000.

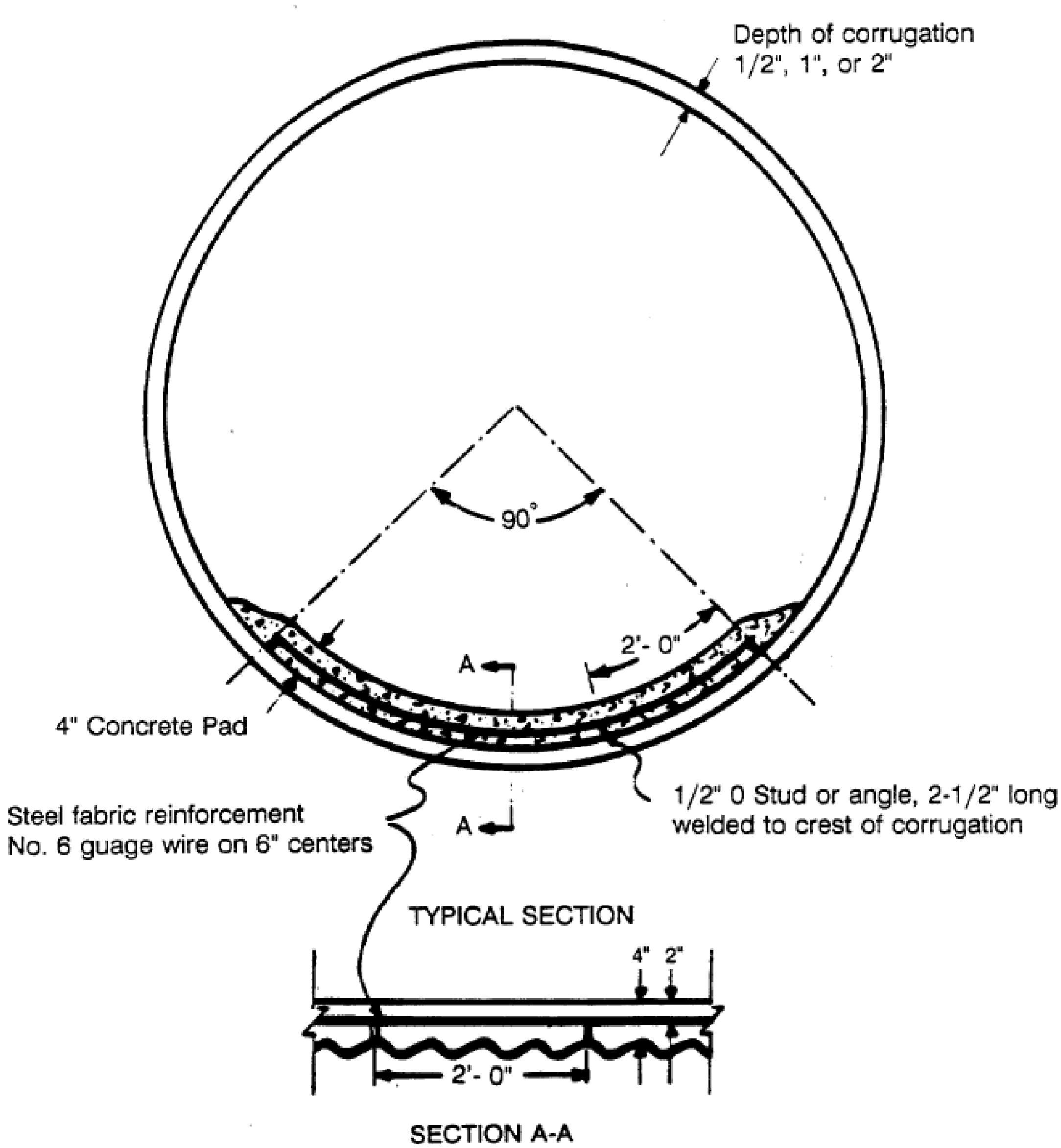

Figure E-36. Reinforced concrete invert paving for corrugated metal pipes (FHWA 1995).

Figure E-37. Peterson Avenue proposed solution.

Cost Estimate

PLANNING LEVEL CONSTRUCTION COST OPINION				
PROJECT: Peterson Ave Culvert Crossing			BY:	JT
DESCRIPTION: Pave 60-inch CMP invert			CHECKED BY:	GG
DRAINAGE AREA: Edgecumbe			DATE:	10-Jun-13
BID ITEM	**QUANTITY**	**UNIT**	**UNIT PRICE**	**AMOUNT**
REPLACE UPSTREAM METAL WINGWALL AND APRON	1	LS	$7,000	$ 7,000
PLACE METAL REINFORCING	1	LS	$20,000	$ 20,000
PLACE CONCRETE	6	CY	$1,000	$ 6,111
			Subtotal	$ 33,111
DEWATERING	3%			$ 993
EROSION & SEDIMENTATION CONTROL	5%			$ 1,656
TRAFFIC CONTROL	3%			$ 993
CONTINGENCY	30%			$ 9,933
			Subtotal	$ 46,687
MOBILIZATION (GENERAL REQUIREMENT)	10%			$ 4,669
			Construction Subtotal (Rounded)	$ 51,000
SURVEY/EASEMENTS/ROW ACQUISITION	25%			$ 12,750
ENGINEERING/LEGAL/ADMIN	25%			$ 12,750
CONSTRUCTION MANAGEMENT	10%			$ 5,100
PERMITTING	10%			$ 5,100
2013 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 87,000**

Notes:

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References

ADOT&PF (Alaska Department of Transportation and Public Facilities). 1995. Alaska Highway Drainage Manual. Juneau, AK.

FHWA (Federal Highway Administration). 1989. Design of Rip Rap Revetment. U.S. Department of Transportation, Federal Highway Administration. Hydraulic Engineering Circular No. 15. 1989.

FHWA (Federal Highway Administration). 1995. Culvert Repair Practices Manual. U.S. Department of Transportation, Federal Highway Administration. Publication No. FHWA-RD-94-096.

FHWA (Federal Highway Administration). 2005. Design of Roadside Channels with Flexible Linings. U.S. Department of Transportation, Federal Highway Administration. Hydraulic Engineering Circular No. 15. 2005.

APPENDIX F. STORMWATER QUALITY BEST MANAGEMENT PRACTICES

APPENDIX F
STORMWATER QUALITY BEST MANAGEMENT PRACTICES

Biofiltration Swale

Description

Biofiltration swales are open, gently sloped vegetated channels that convey water and also provide treatment. They function by slowing water velocity, allowing sediment to deposit and by filtering water through vegetation and swale substrate material. Swales that dry out between rain events are "basic swales" and should be planted with mixed grasses or other species; swales that remain wet most of the time are "wet swales" and should be planted with wetland vegetation. Wetland vegetation of wet swales must be protected from high flow; therefore wet swales must be designed as an off-line facility.

Application

Biofiltration swales are good to use in combination with end-of-pipe treatment like constructed wetlands or sediment basins and are appropriate along streets, parking lots and perimeters of building sites.

Design

Design Criteria

Design criteria for biofiltration swales are as follows:

- Water quality flow rate (swales are typically designed as on-line): See Appendix D
- Flow depth: 1 to 4 inches
- Flow velocity: 1 ft/s maximum for treatment, 3 ft/s maximum for 100-year event
- Hydraulic residence time for water: 9 minutes minimum
- Freeboard height: 6" minimum
- Longitudinal slope:
  - Basic swales: 1% to 3% or up to 6% with check dams
  - Wet swales: 2% maximum. Use steps, gabion walls, or check dams to reduce slope
- Water inlets (from most preferred to acceptable):
  - Sheet flow from street
  - Multiple dispersed inlets (curb cuts)
  - Single inlet (armored)

- Water table level:
  - Basic swales: water table must be minimum 2 feet below bottom of swale; site can be over-excavated in areas with impermeable or clay soils
  - Wet swales: no restrictions or need for underdrain; not appropriate for areas of highly infiltrative (gravelly, cobbly) soils
- Topsoil:
  - Permit infiltration but not be highly erosive: preferred sandy loam, loamy sand, loam soils
  - Composition: sand 35-60%, clay 10-25%, silt 30-55%, organics 20% (no animal waste)
  - Do not apply fertilizers, pesticides, or insecticides
- Vegetation:
  - Vegetation must be selected to accommodate expected high flow velocities
  - Vegetation must be established before introducing high flows (approximately 6 months)
  - Basic swales:
    - Vegetation and Seed mix: See vegetation recommendations below and Appendix E
    - Seed rate: 200 lbs per acre
  - Wet swales:
    - Vegetation: See vegetation recommendations below and Appendix E
    - Cover: use a combination of plugs, perennial seed, and annual seed to establish 100% cover in first year.
- The required setback is 2 feet from property lines, 10 feet from building foundations, and 50 feet from wetlands, rivers, streams and creeks, unless approved by the CBS.

Design Procedure

The following is the procedure to be followed to design biofiltration swales:

1. Identify swale type (basic or wetland)
2. Determine water quality design flow rate. Basic swales can be designed as either on-line or off-line facilities. Wet swales may be more appropriate as off-line facilities (see Appendix D).
3. Establish longitudinal slope of swale and swale bottom width. Swales with longitudinal slopes less than 1% must be designed as wet swales.
4. Use Manning's equation to calculate flow depth and find flow cross sectional area. Assume a Manning's coefficient of 0.2 – 0.35 (approx. 0.24 if mowed infrequently)
5. Compute flow velocity at design flow rate ($V = Q/A$, Q=design flow rate, A=cross sectional area of flow in swale)
6. Iteratively calculate channel length necessary to achieve hydraulic residence time of 9 minutes maximum ($L = 60Vt$, V = flow velocity, t = residence time of 9 minutes, 60 for conversion of seconds to minutes). If the stormwater does not enter at a single location, hydraulic residence time is calculated as the flow-weighted average.
7. If required length is not available on site, adjust slope and width of swale design.

8. Select vegetation appropriate to swale type.
   - Check dams 12-15 inches tall constructed of riprap for longitudinal swale slopes greater than 3%.
   - Underdrains of Schedule 40 PVC perforated pipe, 6-inch diameter. Underdrains are required for basic swales with longitudinal slopes less than 1.5% or where poorly infiltrating soils will result in saturated soil conditions. Note: underdrain must infiltrate or drain freely to an acceptable discharge point.

Figure F-1 shows typical cross-sections for a biofiltration swale.

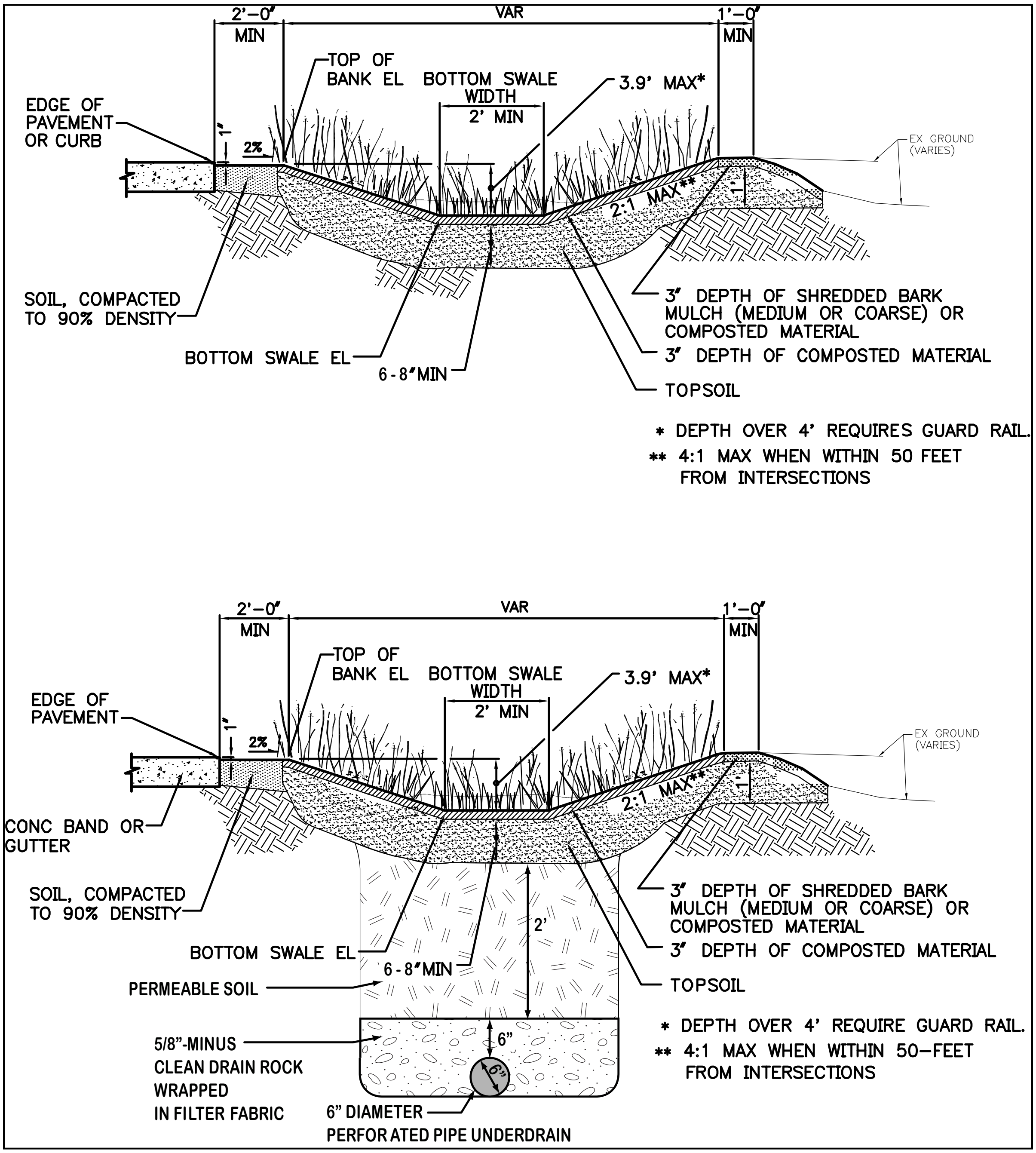

Figure F-1. Biofiltration Swale Sections

Vegetation Recommendations

The following recommendations for vegetation should be followed in design of biofiltration swales (see Appendix E for recommended plant list:

- Consider sun/shade conditions for adequate growth
- Grass swale seed mix:
  - Red or tall fescue – 60 to 70%
  - Annual rye grass – 15 to 20%
  - Bering Hairgrass – 15 to 20%
- Wetland plants:
  - Rush – 4" spacing on center
  - Bulrush – 6" to 12" spacing on center
  - Sedge – 6" spacing on center

Maintenance

Maintenance requirements for biofiltration swales are as follows:

- Inspect twice per year for debris and sediment that prevents flow or restricts plant growth
- Grass swale:
  - Mow grass twice per year and remove grass clippings.
  - Perform inspections and maintenance as outlined in Table F-2.
- Wet swale:
  - Do not mow.
  - Perform inspections and maintenance outlined in Table F-2.

TABLE F-2. MAINTENANCE CHECKLIST FOR BIOFILTRATION SWALE		
Problem	Conditions to Check For	Recommended Maintenance
***Structural Components,** including inlets and outlets, check dams, and flow spreader, shall slowly and evenly treat and infiltrate stormwater.*		
Sediment Accumulation on Grass	Sediment depth exceeds 2 inches or inhibits vegetation growth in 10 percent or more of swale.	Remove sediment deposits on grass treatment area of the biofiltration swale. When finished, swale should be level from side to side and drain freely toward outlet. There should be no areas of standing water once inflow has ceased.
Standing Water	When water stands in a dry swale between storms and does not drain freely.	Any of the following may apply: remove sediment or trash blockages, improve grade from head to foot of swale, remove clogged check dams, add underdrains or convert to a wet biofiltration swale.
Water Depth	In a wet swale when water not retained to a depth of about 4 inches during the wet season.	Build up or repair outlet berm so that water is retained in the wet swale.
Flow Spreader	Flow spreader uneven or clogged so that flows are not uniformly distributed through entire swale width.	Level the spreader and clean so that flows are spread evenly over entire swale width.
Constant Base Flow	When small quantities of water continually flow through the swale, even during dry periods, and an eroded, muddy channel has formed in the swale bottom.	Add a low-flow pea-gravel drain the length of the swale or by-pass the base flow around the swale.
Inlet/Outlet	Inlet/outlet areas clogged with sediment and/or debris.	Remove material so that there is no clogging or blockage in the inlet and outlet area.
Trash and Debris	Trash and debris accumulated in the biofiltration swale.	Remove leaves, litter, and oily material. Clean curb cuts and level spreaders as needed.
***Vegetation** shall be maintained to cover a minimum of 90 percent of the facility.*		
Poor Vegetation Coverage	When grass is sparse or bare or eroded patches occur in more than 10 percent of the swale bottom.	Determine why growth is poor and correct that condition. Re-plant with plugs of grass from the upper slope: plant in the swale bottom at 8-inch intervals. Or reseed into loosened, fertile soil.
Vegetation	When the grass becomes excessively tall (greater than 10 inches); when nuisance weeds and other vegetation starts to take over.	Mow dry swale vegetation to a height of 3 to 4 inches or remove nuisance vegetation so that flow is not impeded. Remove grass clippings. Note: normally wetland vegetation does not need to be harvested unless die-back is causing oxygen depletion in downstream waters.
Excessive Shading	Growth is poor because sunlight does not reach swale.	If possible, trim back over-hanging limbs and remove brushy vegetation on adjacent slopes.
***Growing/Filter Medium,** including soil and gravels, shall sustain healthy plant cover.*		
Erosion/ Scouring	Eroded or scoured swale bottom due to flow channelization, or higher flows.	Check design flows to ensure that swale is large enough to handle flows. Bypass excess flows or enlarge swale. Repair the damaged area by filling with crushed gravel, regrade and reseed, overseed, or take plugs of grass from the upper slope and plant in the swale bottom at 8-inch intervals.

Filter Strip

Description

Filter strips are vegetated sections of land designed to accept runoff as overland sheet flow from upstream development (see Figure F-2). They may adopt any naturally vegetated form, from turf grass to emergent wetland to small forest. The dense vegetative cover facilitates pollutant removal.

Filter strips differ from swales in that swales are concave conveyance systems, while filter strips are located parallel to the contributing area, have fairly level surfaces, and provide treatment of sheet flow. Vegetated filter strips function by slowing runoff velocities, trapping sediment and other pollutants, and providing some infiltration and biologic uptake. Because they do not pond water on the surface for long periods, vegetated filter strips help maintain the temperature of the water and deter the creation of habitat for disease vectors such as mosquitoes.

Application

Filter strips can be used to treat runoff from parking lots and low volume residential to high volume streets and highways. Vegetated filter strips are generally not suitable for steep slopes or large impervious areas that can generate high-velocity runoff.

Design

Design Criteria

Design criteria for vegetated filter strips are as follows:

- The maximum allowable vegetated filter slope is 15 percent. Terraces may be used to decrease ground slopes. The minimum allowable slope is 0.5 percent.
- The minimum allowable length of filter strips is 10 feet, measured in the direction of the flow.
- The maximum allowable slope of pavement area draining to the strip is 6 percent.
- Vegetated filter areas should be clearly marked before site work begins to avoid soil disturbance during construction. No vehicular traffic, except that specifically used to construct the facility, should be allowed within 10 feet of filter areas.
- Vegetated filters are appropriate for all soil types. For grass filter strips, topsoil shall be a minimum of 3 inches thick. Filter strips with other vegetation will benefit from increased topsoil depth if infiltration capacity is sufficient.
- The required setback is 2 feet from property lines, 10 feet from building foundations, and 50 feet from wetlands, rivers, streams and creeks, unless approved by the CBS.
- The filter strip must be planted with 100-percent coverage of approved vegetation.

- The flow spreader consists of a 6-inch deep by 18-inch wide trench filled with pea gravel or crushed stone (1/8- to 3/8-inch). The surface of the gravel shall be 1 inch below the adjacent impervious surface. Flow spreaders must be constructed perfectly level to distribute flows evenly across the filter.
- Filter strip should be designed to shall drain within 48 hours.
- Washington State Department of Transportation's "ecology embankment" includes a trench at the toe of the slope backfilled with pea gravel, dolomite, gypsum and perlite. This media enhances removal of oils and metals.

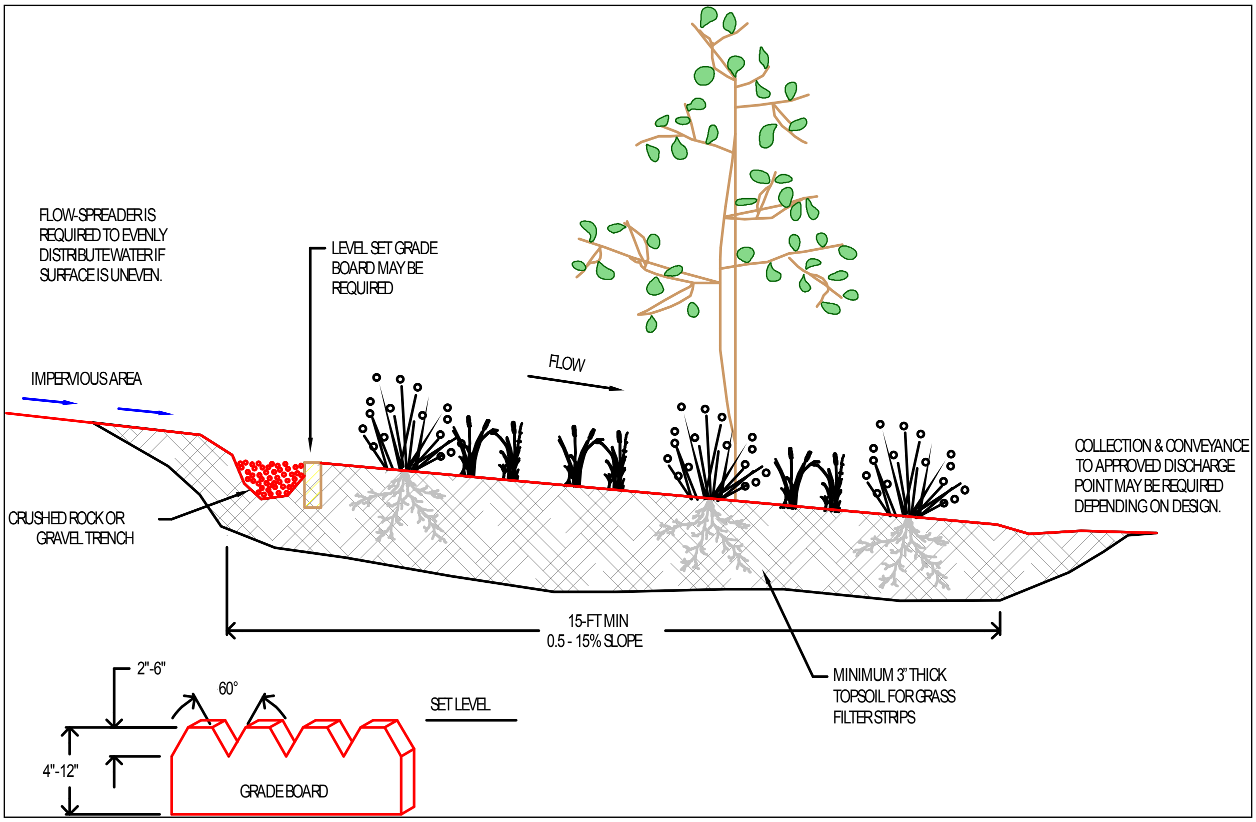

Figure F-2. Typical Vegetated Filter Strip (Adapted from City of Portland's Stormwater Management Manual, Revision 4, 2008)

Design Procedure

The following is the procedure to be followed to design vegetated filter strips (see Washington State Department of Transportation's (WSDOT) *Highway Runoff Manual* for more detailed calculation information):

1. Determine the water quality design flow rate (Q). Filter strips are typically designed as on-line facilities (see Appendix D).
2. Using Manning's equation, calculate the flow depth (y) at the design flow rate. Use Manning's n of 0.35 for grass. If calculated depth exceeds 1 inch, widen filter strip or reduce flow rate directed to filter strip.

3. Calculate design flow velocity: V = Q/Wy (W = filter width). Velocity must not exceed 0.5 ft/s
4. Using a 9-minute (minimum) residence time, calculate the length of the filter strip.

Vegetation Recommendations

The following recommendations for vegetation should be followed in design of vegetated filter strips:

- Grasses such as red fescue, annual rye grass, Bering hairgrass, and bluejoint reedgrass work well; see Appendix E for recommended species
- Seed rate: 200 pounds per acre
- A combination of shrubs, groundcovers, and trees can also be used (see Appendix F for recommended species). When planting shrubs, trees or groundcovers, use annual and perennial seed to achieve 100-percent cover in the first year. Snow plowing may damage woody species along roads and parking lots. Maintain adequate distance between paved surface and trees and shrubs.
- In areas where deicing salts may be used, salt tolerant species should be planted.

Maintenance

All facility components and vegetation shall be inspected for proper operation and structural stability. These inspections shall occur, at a minimum, quarterly for the first two years from the date of installation, two times per year thereafter, and within 48 hours after each major storm event. The facility owner must keep a log, recording all inspection dates, observations and maintenance activities. Components listed in Table F-3 shall be inspected and maintained as stated.

A maintenance schedule shall be implemented as follows:

- Dry Season (May to June) —Make any structural repairs. Improve filter medium as needed. Clear drain. Mow. Replant exposed soil and replace dead plants. Remove sediment and plant debris.
- Wet Season (July to April) —Monitor infiltration/flow-through rates. Clear inlets and outlets/overflows to maintain conveyance.
- All seasons—Remove trash and debris and weed as necessary.

TABLE F-3.
MAINTENANCE CHECKLIST FOR VEGETATED FILTER STRIP

Conditions to Check For	Recommended Maintenance
Structural Components, *including inlets and outlets, check dams, and flow spreader, shall slowly and evenly treat and infiltrate stormwater.*	
Clogged inlets or outlets	Remove sediment, debris, and vegetation blockage from catch basins, trench drains, curb inlets, and pipes to maintain at least 50-percent conveyance capacity at all times.
Ineffective flow spreaders	Clear accumulated silt and vegetation.
Sediment accumulation	Sediment depth exceeds 2 inches in 10 percent of the treatment area. Remove sediment deposits in treatment area.
Vegetation *shall be maintained to cover a minimum of 90 percent of the facility.*	
Dead or strained vegetation	Manually remove sediment accumulation. Replant per planting plan. Mulch annually. DO NOT apply fertilizers, herbicides, or pesticides.
Tall grass	Cut back to 4 to 6 inches one or two times each year.
Weeds	Manually remove weeds. Remove plant debris.
Growing/Filter Medium, *including soil and gravels, shall sustain healthy plant cover and infiltrate within 48 hours.*	
Erosion and gullies	Fill, lightly compact, and install flow spreader/plant vegetation to disperse flow. Restore or create outfalls, check dams, or splash blocks where necessary.
Slope slippage	Stabilize slopes.
Ponding	Rake, till, or amend to restore infiltration rate.

Adapted from City of Portland *Stormwater Management Manual, Revision 4* (2008)

Infiltration Basin

Description

Infiltration basins are trenches, depressions or planters that are used to temporarily store stormwater runoff, allowing pollutants to filter out as the water infiltrates through a vegetation and soil medium or rock and sand. Infiltration basins are usually flat-bottomed or shallow landscaped depressions. The basin can be designed as a concrete planter a shallow earthen rain-garden or a swale-shaped depression to infiltrate runoff.

(Abby Hall, EPA)

Because of poor soil infiltration capacity in native Sitka soils, the soil or infiltrative media shall be imported to allow for proper drainage. If native soils are used, soil infiltration tests shall be performed.

Infiltration basins function by receiving stormwater runoff from the impervious and pervious surfaces in a drainage area. An inlet pipe or sheet flow conveys the stormwater into the basin, where it is temporarily stored until it infiltrates into the ground or is collected subsurface by a perforated pipe in a washed rock bed. Infiltration basins can provide complete on-site infiltration of small storm events.

Application

Infiltration structures are ideal for infiltrating runoff from small drainage areas (<5 acres), but they need to be applied carefully. Basins should be installed where soils are permeable enough to provide adequate infiltration. However, excessively rapid infiltration indicated a lack of treatment (i.e. filtering) by the infiltration basin. Therefore infiltration basins are also not appropriate to sites with extremely high infiltration rates (i.e. sand or gravel).

Infiltration basins should not be placed where runoff with a high sediment load is anticipated. Sediment will clog the filtration bed and lead to failure of the structure. Consider using infiltration basins for secondary treatment after a filter strip, sediment forebay or swale. Because infiltration basins convey stormwater to groundwater, they are not suitable for primary treatment of runoff from sites with a high pollutant load such as fueling stations. All infiltration facilities should be protected from sediment during construction to preserve their infiltration capacity.

Design

Assessing the design infiltration rate for a site is critical in constructing a successful infiltration basin. Measured infiltrations rates typically overestimate the large-scale infiltration rate of an operating basin. In addition infiltration rates will decrease over time due to plugging with fine sediment. Therefore a safety factor must be applied to the measured existing infiltration rate to determine the design infiltration rate.

The design shall carefully consider and prevent flooding on the site. Infiltration basins are designed with an overflow pipe, weir or other conveyance that allows flows to bypass the facility. The outflow can be a pipe or a grate elevated to allow 12 inches of water storage. Depending on soil and infiltration conditions, the basin may need a perforated drain pipe in a gravel filter bed. For better infiltration, extend the gravel filter bed at least 12 inches below the frost line where possible.

Design Requirements

- Infiltration Basins are designed to treat the water quality design volume (see Appendix D).
- A conservative safety factor of 0.1 shall be applied to the measured infiltration rate for a basin. A less conservative safety factor can be determined from site variables using the methodology from the King County Surface Water Design Manual.
- The required setback is 5 feet from property lines and 10 feet from building foundations. Infiltration basins shall meet the following setback requirements from downstream slopes: minimum of 100 feet from slopes of 10 percent; add 5 feet of setback for each additional percent of slope up to 30 percent; infiltration basins shall not be used where slopes exceed 30 percent. Infiltration basins shall not be constructed within 50 feet of salmon bearing streams without CBS approval.
- The maximum designed ponding time shall be a function of the facility storage depth. Basins should be designed to store the design volume and infiltrate it into the ground within 72 hours. Overflow from the basin should be directed to a swale or other conveyance, sized to prevent erosion.
- Maximum facility storage depth is 12 inches from the top of the growing medium to the overflow inlet elevation.
- A minimum of 2 inches of freeboard shall be provided. Maximum side slopes are 3 to 1. Minimum bottom width is 2 feet. Maximum slope of bottom of infiltration basin is 6%.
- Drain rock may be required below the growing medium of a basin. For infiltration facilities where drain rock is specified to retain stormwater prior to infiltration, the specification is 1½-inch – ¾-inch washed drain rock. Where drain rock is specified primarily for detention and conveyance, the specification is ¾-inch washed drain rock. For all flow-through facilities, ¾-inch wash drain rock shall be used.
- Drain rock and growing medium must be separated by filter fabric or use a 2- to 3-inch layer of ¾ - ¼-inch washed, crushed rock.
- Surface flow is preferable to piping to avoid blockage particularly in winter. Piping shall be cast iron, ABS Schedule 40, or PVC Schedule 40. A 3-inch pipe minimum is required. Piping installation must follow the current Uniform Plumbing Code. For streets, 6-inch or 8-inch ASTM 3034 SDR 35 PVC pipe and perforated pipe are required.

Facility Design

- Basin soil shall be a sandy loam mixed with compost or a sand/soil/compost blend. It shall be roughly one-third compost by volume, free-draining, and support plant growth. Growing medium shall be a minimum 6-8 inches deep.

- Infiltration basins need not be vegetated, however plants will provide additional biological treatment and will help dispose of water through evapotranspiration. Plantings may include grasses, some wetland plants, shrubs and trees. See Appendix E for recommended species.
- Wildflowers, native grasses, and ground covers can be selected and designed to eliminate the need for mowing. Fine to medium hemlock bark or well-aged organic yard debris compost is recommended for basins. It should be placed in the facility only in areas above the high-water line. It must be weed free and applied 2 to 3 inches thick to cover all soil between plants.

Maintenance

Maintenance shall be performed as outlined in Table F-4. A maintenance schedule shall be implemented as follows:

- Dry Season (May to June) —Make any structural repairs. Improve filter medium as needed. Clear drain. Mow. Replant exposed soil and replace dead plants. Remove sediment and plant debris.
- Wet Season (July to April) —Monitor infiltration/flow-through rates. Clear inlets and outlets/overflows to maintain conveyance.
- All seasons—Remove trash and debris and weed as necessary.

TABLE F-4.
CHECKLIST FOR INFILTRATION BASIN MAINTENANCE

Problem	Conditions to Check For	Recommended Maintenance
Structural Components, *including inlets and outlets, check dams, and flow spreader, shall slowly and evenly treat and infiltrate stormwater.*		
Sediment Accumulation in the Infiltration Basin	Sediment depth exceeds 1 inch or inhibits vegetation growth.	Remove sediment buildup when 1 inch collects on soil surface to allow for infiltration, this may require the removal and replacement of the top surface of the topsoil. Water drained or pumped and sediments removed from the infiltration basin.
Inlet/Outlet	Inlet/outlet areas clogged with sediment and/or debris.	Remove material so that there is no clogging or blockage in the inlet and outlet area.
Vegetation, *coverage is not necessary for operation but provides some biological treatment to stormwater and provides habitat.*		
Poor Vegetation Coverage	Vegetation in the infiltration basin is sparse or bare.	Determine why vegetation growth is poor and correct that condition. Replant or reseed the basin.
Vegetation	Weeds and other vegetation are taking over.	Remove nuisance vegetation so that flow is not impeded.
Growing/Filter Medium, *including soil and gravels, shall sustain healthy plant cover and infiltrate within 48 hours.*		
Standing Water in Basin	Accumulation of sediment and poor growth of plants due to saturated soil	Excavate and replace filter fabric or rock and soil subgrade.

Wet Pond

Description

A wet pond is a constructed stormwater pond that retains a permanent pool of water. Wet ponds function to settle and remove sediment, provide infiltration and enable some uptake of pollutants by vegetation. Wet ponds can be designed as basic wet ponds or large wet ponds; with large wet ponds being designed for a higher level of pollutant removal.


(Abby Hall, EPA)

Application

Wet ponds treat water both by gravity settling and by biological uptake of algae and microorganisms and can remove some dissolved pollutants such as phosphorus.

Wet ponds are appropriate for subdivision developments, commercial/industrial developments and drainage from large areas. Before final planting, wet ponds can be used as a temporary sediment control facility during construction.

Design

The wet pond volume is the primary design factor in determining the treatment effectiveness of the facility. The wet pond volume shall be equal to or greater than the total volume of the water quality design storm volume (see Appendix D).

Wet ponds are most effective when designed to promote plug flow by avoiding short circuiting. Plug flow describes the condition of stormwater moving through the pond as a unit, displacing the "old" water in the permanent pool with incoming flows. As such wet ponds pool volume may be below the ground water level.

Wet pond performance varies based on design features, maintenance frequency, storm characteristics, and pond algae dynamics. Provide erosion control around all inlets and outlets, including rock, plants or vegetative mats. Figure F-3 shows a typical wet pond plan.

When the pond surface or the entire pond volume is frozen, runoff residence time in the pond and physical treatment will be significantly reduced. Freezing water in the pond inlet and outlet piping may result in conveyance by overland flow paths.

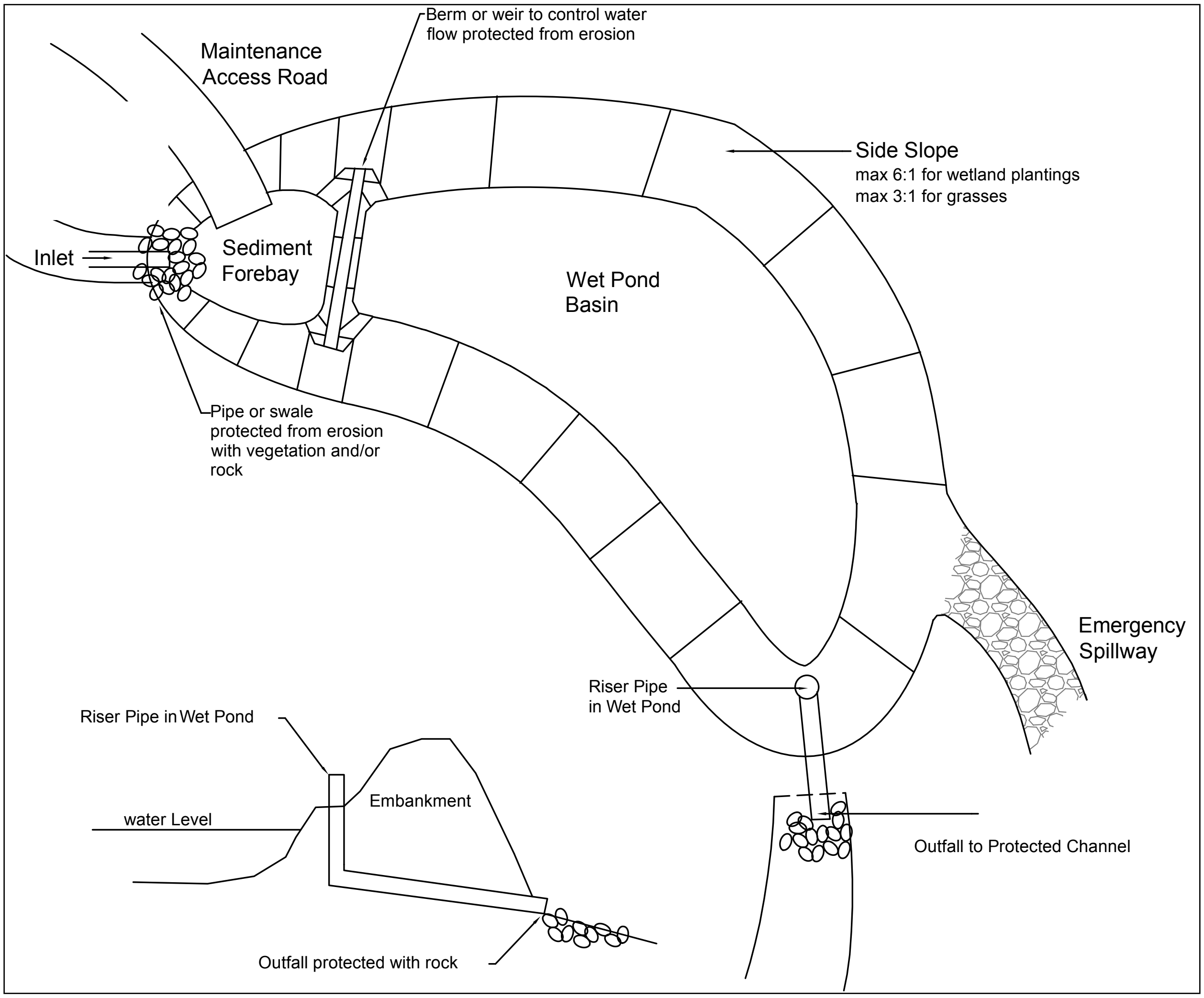

Figure F-3. Wet Pond Plan

Design Procedure

Procedures for determining wet pond dimensions:

1. Identify the water quality design storm volume for the contributing catchment area.
2. Determine wet pond dimensions following the design criteria outlined. A simple way to check the volume of each wet pond cell is to use the following equation: $V = h(A_1 + A_2)/2$ Where h is wet pond average depth, A_1 is surface area of wet pond and A_2 is the bottom area of wet pond.
3. Determine water quality design flow rate (see Appendix D) through the proposed outlet and determine primary overflow water surface.
4. Design pond outlet pipe for the proposed water quality flow. Outlet pipe must be sufficient to convey the proposed flow through the pipe in full pond conditions. Account for the critical depth and velocity head in the pipe.

Wet Pond Geometry

- Single cell wet ponds may be used if the wet pond volume is less than 4,000 cubic feet.
  - minimum flow path ratio is 4:1
  - provide a minimum sediment depth of 6 inches
- Two cell wet ponds should be used if the wet pond volumes greater than 4,000 cubic feet or where large sediment loads are expected.
  - minimum flow path ratio is 3:1
  - provide a minimum sediment depth of 12 inches in the first cell (sediment forebay)
  - forebay must be between 4-8 feet (excluding sediment storage one foot)
  - forebay must contain 25 to 35 percent of the total pond volume
  - Second cell depth must be less than first cell depth
  - Pool depth less than 3 feet (second cell) shall be planted with emergent wetland vegetation (see Appendix E for plant list).
- The flow path length is defined as the distance from the inlet to the outlet, as measured at mid-depth. The width at mid-depth can be found as follows: width = (average top width + average bottom width)/2.
- All inlets shall enter the first cell. If there are multiple inlets, the length-to-width ratio shall be based on the average flow path length for all inlets.

Berms, Baffles, and Slopes

- A berm or baffle shall extend across the full width of the wet pond, and tie into the wet pond side slopes.
- If the berm embankments are greater than 4 feet in height, the berm must be constructed by excavating a key equal to 50 percent of the embankment cross-sectional height and width. This requirement may be waived if recommended by a geotechnical engineer for specific site conditions. The geotechnical analysis shall address situations in which one of the two cells is empty while the other remains full of water.
- The top of the berm may extend to the water quality design water surface or be 1 foot below the water quality design water surface. A submerged berm will discourage pedestrian access.
- Side slopes shall be to 2(H):1(V) maximum.
- Erosion control measures shall be implemented as necessary
- The Alaska Department of Natural Resources requires safety design and review for all structures with storage capacity above natural ground level greater than 50 acre-feet (see Department of Natural Resources Dam Safety and Construction Unit requirements).

Inlet and Outlet

- A submerged inlet is preferred for energy dissipation however this may not be feasible in situations where high sediment loads are anticipated. The inlet to the wet pond shall be submerged with the inlet pipe invert a minimum of 2 feet from the pond bottom (not including sediment storage). The top of the inlet pipe should be submerged at least 1 foot, if possible. The distance from the bottom is set to minimize resuspension of settled sediments. Alternative inlet designs that accomplish these objectives may be acceptable.

- An outlet structure shall be protected by a trash rack. Trash rack must be hinged or easily removed for maintenance. Rack shall be adequately secured during normal pond operation.
- The pond outlet pipe shall be back-sloped or have a turn-down elbow, and extend 1 foot below the water quality design water surface to provide for trapping of oils and floatables in the wet pond. The outlet pipe shall be sized, at a minimum, to pass the water quality design flow rate.
- The overflow criteria for wet ponds are:
  - The requirement for primary overflow is satisfied by a grated inlet or cone grate to the outlet structure.
  - The bottom of the grate opening in the outlet structure shall be set at or above the height needed to pass the water quality design flow through the pond outlet pipe. The grate invert elevation sets the overflow water surface elevation.
  - The grated opening should be sized to pass the 100-year design flow. The capacity of the outlet system should be sized to pass the peak flow for the conveyance requirements.
- An emergency spillway shall be provided and designed to handle the 100-year event peak flow rate. The spillway shall maintain at least 6 inches of freeboard between the 100-year water surface elevation and the top of the embankment. Spillway shall be placed with consideration of downstream facilities.
- CBS may require a bypass/ shutoff valve to enable the pond to be taken offline for maintenance purposes.
- A gravity drain from the first cell into the second cell is recommended for maintenance if grade allows.

Access and Setbacks

- Ponds shall be constructed to maintain the following minimum setback distances:
  - 20 feet from the edge of the pond water surface to property lines and structures; unless an easement with the adjacent property owner is provided.
  - One-half of the berm height (5 feet min) from the toe of the pond berm to the nearest property line
  - 100 feet from the edge of the pond water surface to any septic tank, distribution box, or drainfield.
  - 100 feet from the edge of the pond water surface to a well
  - 50 feet from the edge of the pond water surface to salmon bearing streams
  - 50 feet from the edge of the pond water surface to any steep slope (greater than 15 percent). A geotechnical report must address the potential impact of a wet pond on a steep slope.
- Access and maintenance roads shall extend to both the wet pond inlet and outlet structures. An access ramp (7H minimum: 1V) shall be provided to the bottom of the first cell unless all portions of the cell can be reached and sediment loaded from the top of the pond. If the dividing berm is also used for access, it should be built to sustain loads of up to 80,000 pounds.

Vegetation Planting Requirements

- If the second cell of a basic wet pond is 3 feet or shallower, the pond must be vegetated with emergent wetland species in 6 inches of topsoil. Planting of shallow pond areas helps to stabilize settled sediment and prevent resuspension. See Appendix E for recommended species.
- Do not plant shrubs or trees within 10 feet of the inlet or outlet pipes.
- Planting on the berm may be regulated by dam safety requirements.
- Bank planting can discourage waterfowl use of the pond and provide shading.
- Large wet ponds intended for phosphorus control should not be planted within the cells, as the plants will release phosphorus in the winter when they die off.

Recommended Design Features

The following design features should be incorporated into the wet pond design where site conditions allow:

- For wet pond depths in excess of 6 feet, it is recommended that some form of recirculation be provided in the summer, such as a fountain or aerator, to prevent stagnation and low dissolved oxygen conditions.
- A tear-drop shape, with the inlet at the narrow end, rather than a rectangular pond is preferred since it minimizes dead zones caused by corners.
- The number of inlets to the facility should be limited; ideally there should be only one inlet. The flow path length should be maximized from inlet to outlet for all inlets to the facility.
- The following design features should be incorporated to enhance aesthetics and safety where possible:
  - Provide pedestrian access to shallow pool areas enhanced with emergent wetland vegetation. This allows the pond to be more accessible without incurring safety risks.
  - Provide sufficiently gentle side slopes to avoid the need for fencing (3:1 or flatter).
  - Provide visual enhancement with clusters of trees and shrubs. On most pond sites, it is important to amend the soil before planting since ponds are typically placed well below the native soil horizon in very poor soils. Make sure dam safety restrictions against planting do not apply.
  - Orient the pond length along the direction of prevailing summer winds (typically west or southwest) to enhance wind mixing.

Maintenance

Maintenance shall be performed as outlined in Table F-5.

TABLE F-5.
CHECKLIST FOR WET POND MAINTENANCE

Problem	Conditions to Check For	Recommended Maintenance
Structural Components, *including inlets and outlets/overflows shall freely convey stormwater.*		
Sediment Accumulation in pond or forebay	Sediment depth exceeds 18 inches in the wet pond or inhibits vegetation growth.	Excavate and remove sediment. Sediments should be tested for pollutants and disposed of in accordance with local health department requirements.
Eroded Banks	Bank sloughing or significant erosion of banks or berms.	Regrade and compact to match original design geometry.
Trash and Debris Accumulation	Debris accumulated in the pond after a large storm.	All debris and accumulated petroleum products should be removed from the wet pond.
Inlet/Outlet	Inlet/outlet areas clogged with sediment and/or debris.	Remove material so that there is no clogging or blockage in the inlet and outlet area.
Riprap Scatter/ Loss	Bank stabilization/ energy dissipation features are displaced.	Replace all missing and displaced riprap with the same size material. Depth and width of the riprap shall remain as designed.
Vegetation		
Dead or strained vegetation	When vegetation is sparse or bare or eroded patches occur in the wet pond bottom.	Determine why vegetation growth is poor and correct that condition. Replant as necessary. DO NOT apply fertilizers, herbicides or pesticides.
Vegetation	When the grass becomes excessively tall (greater than 10 inches); when nuisance weeds and other vegetation starts to take over.	Mow vegetation or remove nuisance vegetation so that flow is not impeded. Grass should be mowed to a height of 3 to 4 inches. Remove grass clippings.

Hydrodynamic Separator

Description

Hydrodynamic separators are water quality treatment devices designed to clean stormwater by settling and trapping sediment. In addition, hydrodynamic separators may be designed to trap and retain oils and floatables. Hydrodynamic separators are typically installed on-line and may be cost-effective because no separate flow control is necessary. Hydrodynamic separators are typically proprietary devices marketed under names such as Stormceptor (see Figure F-5), Vortechs or Downstream Defender.

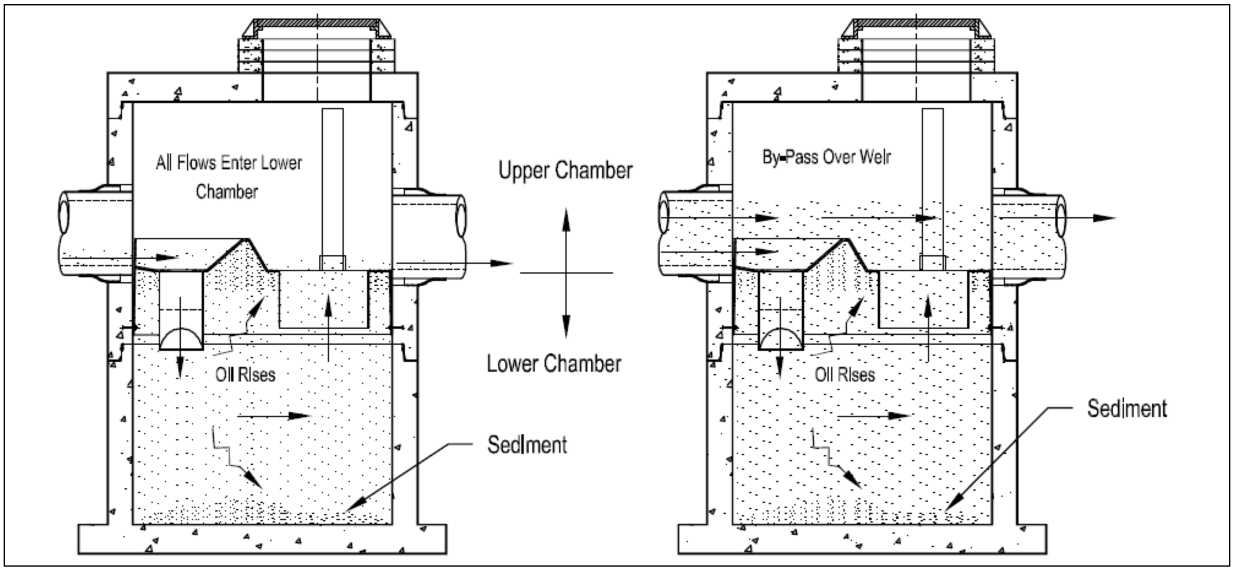

Figure F-5. Stormceptor Hydrodynamic Separator Sections

Application

Hydrodynamic separators are most effective where the materials to be removed from runoff are heavy particulates—which can be settled—or floatables which can be captured, rather than solids with poor settleability or dissolved pollutants.

Design

Hydrodynamic separators shall be sized to remove 80% of TSS annual load assuming an influent sediment concentration of 100 mg/L with a mean sediment size of 80 microns.

Hydrodynamic separators are typically designed as a proprietary plastic or metal insert into a standard concrete 48-inch-diameter or larger catch basin. Flow paths through hydrodynamic separators vary according to the device design. Typically stormwater tangentially enters the basin below the effluent line, imparting a circular flow motion. Due to centrifugal force, suspended particles move to the center of the device and settle to the bottom. The insert is designed to trap oils and other floatables and can include a screen. Flows higher than the treatment flow rate can pass around or over the insert and are less likely to entrain previously separated sediment, oil and floatables. Head loss through the separator will depend on system design and the model but is generally on the order of 1 foot or less.

Hydrodynamic separators are available in a range of sizes. Separators may be sized to the water quality storm peak flow rate or be sized using a proprietary model. The Stormceptor manufacturer uses a proprietary continuous model to size a separator to site conditions to meet a sediment removal performance based on the device's treatment efficiency and assumed influent sediment characteristics.

The Stormceptor model uses precipitation data from the airport gage; sizing the structure using this data will not be appropriate in the downtown hydrologic area where precipitation is higher.

Separators should operate effectively throughout the year if they are installed below the frost line. Entrance velocities to the structure must be checked to avoid premature high flow bypassing of the treatment system. Application of separators may be limited by the required head loss through the structure. Hydrodynamic separators do not remove dissolved pollutants and are not approved for use as an oil-control device.

Maintenance

Hydrodynamic separators shall be inspected for proper operation and structural stability. These inspections shall occur, at a minimum, quarterly for the first two years from the date of installation, two times per year thereafter, and within 48 hours after each major storm event. The facility owner must keep a log, recording all inspection dates, observations and maintenance activities. Components listed in Table F-7 shall be inspected and maintained as stated.

TABLE F-7.
MAINTENANCE CHECKLIST FOR HYDRODYNAMIC SEPARATORS

Conditions to Check For	Recommended Maintenance
Structural Components, *including inlets and outlets, inserts, weirs and screens*	
Clogged inlets or outlets	Remove sediment or debris blockage.
Pollutant accumulation	Clean separators regularly to keep accumulated oil from escaping during storms. They must be cleaned before the end of June to remove material that has accumulated during the dry season, after all spills, and after a significant storm. Remove accumulated oil when the thickness reaches 1 inch. A vacuum truck may be used for oil, sediment, sludge and wastewater removal. Dispose of removed solids and liquids appropriately.
Sediment accumulation	Remove sediment at a minimum when the amount of sediment is greater than 6 inches. Dispose of removed solids and liquids appropriately.
Structural integrity, loose fittings, broken or missing components	Immediately repair or replace any major damage to prevent catastrophic failure. Minor damage, such as dents or rust spots, may not need immediate replacement, but should be monitored.

A maintenance schedule shall be implemented as follows:

- Dry Season (May to June): Clean separator as necessary and make any structural repairs.
- Wet Season (July to April): Monthly inspection to ensure proper operation, and during and immediately after a large storm event of ≥2 inches per 24 hours.

APPENDIX G. WATER QUALITY SOURCE CONTROL BEST MANAGEMENT PRACTICES

APPENDIX G.
WATER QUALITY SOURCE CONTROL BEST MANAGEMENT PRACTICES

Water Quality Source Control
General BMPs

The following operational source control BMPs should be implemented at applicable commercial and industrial establishments.

Formation of a Pollution Prevention Team

- Assign one or more individuals to be responsible for stormwater pollution control.
- Train all team members in the operation, maintenance and inspections of BMPs, acceptable material handling practices, and spill response and reporting procedures.
- Establish responsibilities for inspections, operation and maintenance, and availability for emergency situations.

Good Housekeeping

- Promptly contain and clean up solid and liquid pollutant leaks and spills. Use solid absorbents (e.g., clay and peat absorbents and rags) for cleanup of liquid spills and leaks where practicable.
- Sweep paved material-handling and storage areas regularly as needed. Do not hose down pollutants from any area to the ground, storm drain, conveyance ditch, unless the pollutants are conveyed to an approved treatment system.
- Clean oil, debris, sludge, etc. from all BMP systems regularly,
- Promptly repair or replace all substantially cracked or otherwise damaged paved secondary containment, high-intensity parking and any other drainage areas that are subject to pollutant material leaks or spills.
- Promptly repair or replace all leaking connections, pipes, hoses, valves, etc. that can contaminate stormwater.
- Dispose of hazardous wastes appropriately i.e. CBJ hazardous wastes clean up days. Recycle materials, such as oils, solvents and wood waste, to the maximum extent practicable.

Preventive Maintenance

- Prevent the discharge of unpermitted liquid or solid wastes, process wastewater and sewage to ground or surface water, or to storm drains that discharge to surface water or to the ground.
- Conduct all cleaning, steam cleaning or pressure washing of oily equipment or containers inside a building or on an impervious contained area, such as a concrete pad. Direct contaminated stormwater from such areas to a sanitary sewer where allowed by the CBJ sewer department or to other approved treatment.
- Do not pave over contaminated soil unless it has been determined that groundwater has not been and will not be contaminated by the soil.

- At industrial and commercial facilities, drain oil and fuel filters before disposal. Discard empty oil and fuel filters, oily rags and other oily solid waste into appropriately closed and properly labeled containers, and in compliance with the Uniform Fire Code.
- For the storage of liquids, use containers, such as steel and plastic drums, that are rigid and durable, resistant to corrosion due to weather and fluid content, non-absorbent, water tight, rodent-proof, and equipped with a close-fitting cover.
- For the temporary storage of solid wastes contaminated with liquids or other potential pollutant materials, use dumpsters, garbage cans, drums and comparable containers that are durable, corrosion-resistant, non-absorbent, non-leaking and equipped with either a solid cover or screen cover to prevent littering. If covered with a screen, the container must be stored under a lean-to or equivalent structure.
- Minimize use of toxic cleaning solvents, such as chlorinated solvents, and other toxic chemicals.
- Stencil warning signs at stormwater catch basins and drains, e.g., "Dump no waste."

Spill Prevention and Cleanup

- If pollutant materials are stored on-site, have spill containment and cleanup kits readily accessible. Place and maintain spill kits at outside areas where there is a potential for fluid spills. These kits should be stocked as appropriate for the materials being handled and the size of the potential spill.
- If a spill has reached or may reach a sanitary or a storm sewer, groundwater or surface water, notify CBJ sewer department immediately. Notification must comply with and federal spill reporting requirements.
- Do not flush absorbent materials or other spill cleanup materials to a storm drain. Collect the contaminated absorbent material as a solid and place in appropriate disposal containers.

Inspections

Conduct one visual inspection annually during a storm event to achieve the following:

- Verify that the descriptions of the pollutant sources identified by the pollution prevention team are accurate.
- Verify that the stormwater pollutant controls (BMPs) being implemented are adequate.
- Update the site map to reflect current conditions.
- Include observations of the presence of floating materials, suspended solids, oil and grease, discoloration, turbidity and odor in stormwater discharges, in outside vehicle maintenance/repair, and in liquid handling and storage areas.
- Determine whether there are unpermitted non-stormwater discharges to storm drains or receiving waters, such as process wastewater and vehicle/equipment washwater, and either eliminate or obtain a permit for such a discharge.

Conduct one dry season inspection each year in May or June.

Record Keeping

- Retain visual inspection reports and reports of spills or hazardous substances for three years

Fueling at Dedicated Stations

Description of Pollutant Sources

A fueling station is a facility dedicated to the transfer of fuels from a stationary pumping station to mobile vehicles or equipment. It includes above- or under-ground fuel storage facilities. In addition to general service gas stations, fueling may occur at 24-hour convenience stores, construction sites, warehouses, car washes, manufacturing establishments, port facilities, and businesses with fleet vehicles. Typically, stormwater contamination at fueling stations is caused by leaks or spills of fuels, lube oils, radiator coolants and vehicle wash water.

Pollutant Control Approach

New or substantially remodeled* fueling stations must be constructed on an impervious concrete pad under a roof to keep out rainfall and stormwater run-on. A treatment BMP must be used for contaminated stormwater and wastewaters in the fueling containment area.

> * Substantial remodeling includes replacing the canopy or relocating or adding one or more fuel dispensers in a way that modifies the paving in the fueling area.

Operational BMPs for New or Substantially Remodeled Fueling Stations

- Prepare an emergency spill response and cleanup plan and have designated trained staff available on site or on call at all times to promptly and properly implement that plan and immediately cleanup all spills. Keep suitable cleanup materials, such as dry adsorbent materials, on site to allow prompt cleanup of a spill.
- Train employees in the proper use of fuel dispensers. Post signs in accordance with the Uniform Fire Code (UFC). Post "No Topping Off" signs (topping off gas tanks causes spillage and vents gas fumes to the air). Make sure that the automatic shutoff on the fuel nozzle is functioning properly.
- The person conducting the fuel transfer must be present at the fueling pump during fuel transfer, particularly at unattended or self-serve stations.
- Keep drained oil filters in a suitable container or drum.

Structural Source Control BMPs for New or Substantially Remodeled Fueling Stations

- Design the fueling island to control spills (dead-end sump or spill control separator in compliance with the UFC), and to treat collected stormwater and/or wastewater to required State water quality levels. Slope the concrete containment pad around the fueling island toward trench drains, catch basins or a dead-end sump. The slope of the drains shall not be less than 1 percent (UFC Section 7901.8). Drains to treatment shall have a shutoff valve, which must be closed in the event of a spill. The spill control sump must be sized in compliance with UFC Section 7901.8; or
- Design the fueling island as a spill containment pad with a sill or berm raised to a minimum of 4 inches (UFC Section 7901.8) to prevent the runoff of spilled liquids and to prevent run-on of stormwater from the surrounding area. Raised sills are not required at the open-grate trenches that connect to an approved drainage-control system.
- The fueling pad must be paved with Portland cement concrete or equivalent. Asphalt is not considered an equivalent material.

- The fueling island must have a roof or canopy to prevent the direct entry of precipitation onto the spill containment pad. The roof or canopy should, at a minimum, cover the spill containment pad (within the grade break or fuel dispensing area) and preferably extend several additional feet to reduce the introduction of windblown rain. Connect all roof drains to storm drains outside the fueling containment area.
- Stormwater collected on the fuel island containment pad must be conveyed to a sanitary sewer system, if approved by the sanitary authority; or to an approved treatment system such as an oil-water separator and a basic treatment BMP. Discharges from treatment systems to storm drains or surface water or to the ground must not display ongoing or recurring visible sheen and must not contain a significant amount of oil and grease.
- Alternatively, stormwater collected on the fuel island containment pad may be collected and held for proper offsite disposal.
- Conveyance of any fuel-contaminated stormwater to a sanitary sewer must be approved by CBJ and must comply with pretreatment regulations. These regulations prohibit discharges that could cause fire or explosion. An explosive or flammable mixture is defined under state and federal pretreatment regulations, based on a flash point determination of the mixture. If contaminated stormwater is determined not to be explosive, then it could be conveyed to a sanitary sewer system.
- Transfer the fuel from delivery tank trucks to the fuel storage tank in impervious contained areas and ensure that appropriate overflow protection is used. Alternatively, cover nearby storm drains during the filling process and use drip pans under all hose connections.

Building, Repair, and Maintenance of Boats and Ships

Description of Pollutant Sources

Most marinas and boatyards are located on or adjacent to coastal waters, lakes and rivers, and their activities can contribute significant pollution directly to these water bodies. The following BMPs apply to onshore repair activities, mobile operations, and on-water fueling and repair operations. These can pollute stormwater and surface water with toxic organic compounds and oils/greases, heavy metals, suspended solids, and abnormal pH.

Soil may enter a water body during construction and by stormwater runoff. Operating boats in shallow waters can scour the bottom and re-suspend bottom sediment, as well as cut off or uproot plants. Sediments are also stirred up during dredging operations.

Pollutant Control Approach

Apply good housekeeping and preventive maintenance and contain pollutants in and around work areas.

Operational BMPs

The following BMPs apply to operations engaged in boat building, mooring, maintenance and repair:

- Move maintenance and repair activities to covered areas onshore if possible. This action reduces some of the potential for direct pollution of water bodies.
- Shelter any blasting and spray painting activities by hanging wind blocking tarps to prevent dust and overspray.
- Use ground cloths, drip pans pads or other approved methods for collection of spills in painting, maintenance, repair and finishing activities. Use sanders that have dust containment.
- Collect bilge and ballast water that has an oily sheen on the surface. Properly dispose of it rather than dumping it in surface waters or on land.
- Employ a bilge pump-out service or use oil absorbent pads to capture the oil in bilge water before pumping. If pads are used, they must be recycled or properly disposed of.
- To avoid spilling directly in surface water bodies, perform paint and solvent mixing, fuel mixing and similar handling of liquids on-shore. Clean up spills immediately. Do not wash spills to a storm drain or surface water.
- Collect and properly dispose of wash water from washing painted boat hulls. Consider taking the boat to a local boat yard that is equipped to collect and treat the wash water.
- Dispose of hazardous wastes appropriately i.e. CBJ hazardous wastes clean up days.

Required Routine Maintenance

- Store and maintain appropriate spill cleanup materials in a clearly marked location. Ensure that employees are familiar with the site’s spill control plan spill cleanup procedures.
- Sweep maintenance yard areas, docks, and boat ramps as needed to collect sandblasting material, paint chips, oils and other loose debris. These collected materials are to be properly disposed of. Do not hose down the area to a storm drain or to the water.

Deicing and Anti-Icing Operations; Airports and Streets

Description of Pollutant Sources

This section applies to deicing and anti-icing operations to control ice and snow on streets, highways, airport runways and aircraft. Deicers commonly used on highways and streets include sand, gravel, sodium chloride (rock salt) and magnesium chloride. Deicers used on aircraft are typically ethylene glycol and propylene glycol. These deicing and anti-icing compounds become pollutants when they enter storm drains or surface water after application. Leaks and spills of these chemicals can also occur during handling and storage. BMPs for aircraft deicers and anti-icers must be consistent with aviation safety and the operational needs of the aircraft operator.

BMPs for Aircraft

The following BMPs are required for operations that perform deicing and/or anti-icing operations on aircraft:

- Conduct aircraft deicing or anti-icing applications in impervious containment areas. Collect aircraft deicer or anti-icer spent chemicals, such as glycol, draining from the aircraft in deicing or anti-icing application areas and convey to a sanitary sewer, treatment or other approved disposal or recovery method. Divert deicing runoff from paved gate areas to appropriate collection areas or conveyances for proper treatment or disposal.
- Do not allow spent deicer or anti-icer chemicals, or stormwater contaminated with aircraft deicer or anti-icer, to be discharged from application areas, including gate areas, to surface water or ground water, directly or indirectly.
- Transfer deicing and anti-icing chemicals on an impervious containment pad, or equivalent spill/leak containment area, and store in secondary containment areas.

The following BMPs are optional unless the above minimum BMPs fail to provide adequate source control:

- Establish a centralized aircraft de/anti-icing facility or, centralize activities in designated areas of the tarmac equipped with separate collection drains for the spent deicer liquids.
- Consider installing an aircraft de/anti-icing chemical recovery system, or contract with a chemical recycler.

BMPs for Airport Runways/Taxiways

The following BMPs are required for operations that are engaged in airport runway/taxiway deicing and anti-icing:

- Avoid excessive application of all de/anti-icing chemicals.
- Store and transfer de/anti-icing materials on an impervious containment pad or an equivalent containment area and/or under cover.
- Do not hose down the area to a storm drain, a conveyance to a storm drain, or a receiving water.

Choose one or more of the following options for stockpiles greater than 5 cubic yards of erodible or water soluble materials:

- Store in a building or a paved and bermed covered area.

- Place temporary plastic sheeting over the material.
- Pave the area and install a stormwater drainage system. Place curbs or berms along the perimeter of the area to prevent the run-off of uncontaminated stormwater and to collect and convey drainage to treatment. Slope the paved area in a manner that minimizes the contact between stormwater (e.g., pooling) and leachable materials in compost, logs, bark, wood chips, etc.
- For large stockpiles that cannot be covered, implement containment practices at the perimeter of the site and at any catch basins as needed to prevent erosion and discharge of the stockpiled material offsite or to a storm drain. Ensure that contaminated stormwater is not discharged directly to catch basins without being conveyed through a treatment BMP.

The following BMPs are optional unless the above minimum BMPs fail to provide adequate source control:

- Include limits on toxic materials and phosphorous in the specifications for de/anti-icers, where applicable.
- Consider using anti-icing materials rather than deicers if it will result in less adverse environmental impact.
- Select cost-effective de/anti-icers that cause the least adverse environmental impact.

BMPs for Streets/Highways

The following BMPs apply to operations that are engaged in street/highway deicing and anti-icing:

- Select de/anti-icers that cause the least adverse environmental impact. Apply only as needed using minimum effective quantities.
- Intensify roadway cleaning in early spring to help remove particulates from road surfaces.
- Where feasible and practical, use roadway deicers, such as calcium magnesium acetate, potassium acetate, or similar materials, as they cause less adverse environmental impact than urea and sodium chloride.
- Store and transfer de/anti-icing materials in an area with an impervious surface.
- Sweep/clean up accumulated de/anti-icing materials and grit from roads as soon as possible after the road surface clears.
- Include limits on toxic metals in the specifications for de/anti-icers.

Maintenance of Roadside Ditches

Description of Pollutant Sources

Common road debris including eroded soil, oils, vegetative particles and heavy metals can be a source of stormwater pollutants.

Pollutant Control Approach

Roadside ditches should be maintained to preserve the condition and capacity for which they were originally constructed, and to minimize bare or thinly vegetated ground surfaces. Maintenance practices should provide for erosion and sediment control.

Operational BMPs for Maintenance of Roadside Ditches

The following BMPs apply to all activities pertaining to roadside ditches:

- Inspect roadside ditches regularly to identify sediment accumulations and localized erosion.
- Ditches should be kept free of trash and debris. Maintain on a regular basis.
- Do not plow snow or ice into ditches.
- Vegetation in ditches prevents erosion and cleanses runoff waters. Remove vegetation only when flow is blocked or excess sediments have accumulated. Conduct ditch maintenance (seeding, fertilizer application, harvesting) in May or June, where possible. This allows vegetative cover to be re-established by the next wet season, thereby minimizing erosion of the ditch as well as making the ditch effective as a biofilter. See Appendix E "Grasses" for appropriate grass species.
- In the area between the edge of the pavement and the bottom of the ditch, commonly known as the "bare earth zone," use grass wherever possible. Vegetation should be established from the edge of the pavement if possible, or at least from the top of the slope of the ditch.
- Reseed with the following seed mix:
  - Red or tall fescue – 60 to 70%
  - Annual rye grass – 15 to 20%
  - Bering Hairgrass – 15 to 20%
- Ditch cleanings are not to be left on roadway surfaces. Sweep dirt and debris remaining on the pavement at the completion of ditch cleaning operations.
- Roadside ditch cleanings not contaminated by spills or other releases may be screened to remove litter and separated into soil and vegetative matter (leaves, grass, branches, needles, etc.). The soil fraction may be handled as "clean soils" and the vegetative matter can be composted or disposed of in a municipal waste landfill.
- Roadside ditch cleanings contaminated by spills or other releases known or suspected to contain dangerous waste must be handled following state and federal regulations unless testing determines it is not dangerous waste. See Street Sweeping and Disposal of Street Wastes BMP.
- Examine culverts on a regular basis for scour or sedimentation at the inlet and outlet, and repair as necessary. Give priority to culverts conveying perennial or salmon-bearing streams

and culverts near streams in areas of high sediment load, such as those near subdivisions during construction.

- Install biofiltration swales and filter strips to treat roadside runoff wherever practical and use engineered topsoils wherever necessary to maintain adequate vegetation. These systems can improve stormwater pollutant control upstream of roadside ditches.

Maintenance and Repair of Vehicles and Equipment

Description of Pollutant Sources

Pollutant sources include parts/vehicle cleaning, spills/leaks of fuel and other liquids, replacement of liquids, outdoor storage of batteries/liquids/parts, and vehicle parking.

Pollutant Control Approach

Good control of leaks and spills of fluids using good housekeeping, and cover and containment BMPs.

Operational BMPs for Maintenance and Repair of Vehicles and Equipment

The following BMPs apply to all activities pertaining to maintenance and repair of vehicles and equipment:

- Inspect for leaks all incoming vehicles, parts and equipment stored temporarily outside.
- Use drip pans or containers under parts or vehicles that drip or that are likely to drip liquids, such as during dismantling of liquid-containing parts of removal or transfer of liquids.
- Remove batteries and liquids from vehicles and equipment in designated areas designed to prevent stormwater contamination. Store cracked batteries in a covered non-leaking secondary equipment system.
- Empty oil and fuel filters before disposal of waste oil and fuel.
- Do not pour/convey washwater, liquid waste, or other pollutants into storm drains or to surface water. Check with the local sanitary sewer authority for approval to convey to a sanitary sewer.
- Do not connect maintenance and repair shop floor drains to storm drains or to surface water. To allow for snowmelt during the winter, a drainage trench with a sump for particulate collection can be installed and used only for draining the snowmelt and not for discharging any vehicular or shop pollutants.
- Dispose of hazardous wastes appropriately i.e. CBJ hazardous wastes clean up days.

The following BMPs are optional unless the above minimum BMPs fail to provide adequate source control:

- Consider storing damaged vehicles inside a building or other covered containment until all liquids are removed. Remove liquids from vehicles retired for scrap.
- Clean parts with aqueous detergent based solutions or non-chlorinated solvents such as kerosene or high flash mineral spirits, and/or use wire brushing or sand blasting whenever practicable. Avoid using toxic liquid cleaners such as methylene chloride, 1,1,1-trichloroethane, trichloroethylene or similar chlorinated solvents. Choose cleaning agents that can be recycled.
- Inspect all BMPs regularly, particularly after a significant storm. Identify and correct deficiencies to ensure that the BMPs are functioning as intended.
- Avoid hosing down work areas. Use dry methods for cleaning leaked fluids.
- Recycle greases, used oil, oil filters, antifreeze, cleaning solutions, automotive batteries, hydraulic fluids, transmission fluids, and engine oils.

- Do not mix dissimilar or incompatible waste liquids stored for recycling.

Structural Source Control BMPs

- Conduct all maintenance and repair of vehicles and equipment in a building or other covered impervious containment area that is sloped to prevent run-on of uncontaminated stormwater and runoff of contaminated stormwater.
- The maintenance of refrigeration engines in refrigerated trailers may be conducted in a parking area with due caution to avoid the release of engine or refrigeration fluids to storm drains or surface waters.
- Park large mobile equipment, such as log stackers, in a designated contained area.

Treatment

Contaminated stormwater runoff from vehicle staging and maintenance areas must be conveyed to a sanitary sewer, if allowed by the local sewer authority, or to an oil-water separator, applicable filter, or other equivalent oil treatment system.

Snow Removal and Disposal

Description of Pollutant Sources

Snow and ice from streets and parking lots can be a source of vegetative debris, paper, fine dust, sand and gravel, vehicle liquids (oil, antifreeze), tire wear residues, heavy metals (lead and zinc), soil particles, ice control salts, domestic wastes, lawn chemicals, and vehicle combustion products.

Snow and ice plowed onto ditches and stream buffers and other natural areas can damage vegetation and block flow conveyance.

Snow and ice plowed into catch basins and other drainage structures can block flow conveyance and may result in flooding.

Pollutant Control Approach

Minimize pollution sources to snow and ice to same extent as other stormwater. Dispose of snow and ice only to approved areas.

Operational BMPs for Snow Removal and Disposal

The following BMPs apply to activities pertaining to Snow Removal and Disposal:

- Do not plow or store snow or ice into streams or wetlands or onto stream or wetland buffers.
- Do not plow snow and ice into ditches or other conveyance structures.
- Do not plow snow or ice to public land such as roads or sidewalks.
- Snow disposed into salt water must be done in accordance with DEC regulations.
- Maintain drainage structures such as catch basin inlets and culverts free of snow and ice.
- Dispose of snow in a snow disposal site approved by DEC.
- Select de/anti-icers that cause the least adverse environmental impact. Apply only as needed using minimum quantities.
- Place collected snow over well-drained soil to allow filtration, adsorption and microbial activity.
- If a pervious surface is not available store snow on impervious surface such as a corner of a parking lot where meltwater can be safely conveyed to the water quality treatment BMP if required or to the drainage system.
- Clean-up debris left after the snowmelt, and restore the soil if needed.

Water Quality Source Control
Site- and Activity-Specific BMPs

Street Sweeping and Disposal of Street Wastes

Description of Pollutant Sources

Streets are a source of litter, fine dust, sand and gravel, ice control salts, vehicle liquids (oil, antifreeze), tire wear residues, heavy metals (lead and zinc), vehicle combustion products, vegetative debris, soil particles and lawn chemicals.

Pollutant Control Approach

Sweeping can be an important part of street and parking lot management to reduce stormwater pollution. Sweeping can readily remove litter, sand and gravel from the surface. Depending on the type of equipment used and site conditions sweeping can also remove a significant proportion of the fine sediments and dust that contain oil, metals and other contaminants.

Street sweepings and other street wastes must be disposed of properly.

Operational BMPs for Street Sweeping and Road Waste Disposal

The following BMPs apply to activities pertaining to Street Sweeping and Street Waste Disposal:

- Liquids from oil-water separators must be disposed of to the municipal treatment system or other location as approved by CBJ.
- Solids from oil-water separators and from sand filters must be disposed of as solid waste at a state or federal permitted landfill.
- Select de/anti-icers that cause the least adverse environmental impact. Apply only as needed using minimum quantities.
- Conduct sweeping after spring snowmelt and before rainy season begins in July.
- Regularly sweep dust accumulation areas that can contaminate stormwater. Sweeping should be conducted using high efficiency vacuum filter equipment to minimize dust generation and to ensure optimal dust removal.
- Conduct sweeping when pavement is dry to improve fine sediment and dust removal.
- Coarse sand and gravel screened from street sweeping after recent road sanding, may be reused for street sanding, providing there is no obvious contamination from spills.
- Dispose of street sweeping solids as fill in commercial and industrial areas, roadway medians, and similar sites, where there is limited direct human contact with the soil, and the soils will be stabilized with vegetation or other means. Avoid use in parks, play fields, golf courses and other recreational settings where direct exposure to the public is possible.
- Street wastes with obvious contamination (unusual color, staining, corrosion, unusual odors, fumes, and oily sheen) should be segregated until tested or disposed of as solid waste.
- If disposal to the municipal sewer system is not an option street waste liquids should be disposed of to a CBJ approved water quality or oil control BMP.

Agricultural Waste Management

Description of Pollutant Sources

Agricultural waste typically associated with animals includes, but is not limited to manure, bedding and litter, wasted feed, runoff from feedlots and holding areas, and wastewater from buildings like dairy parlors.

Best management practices such as pasture rotation and renovation to maintain adequate vegetative cover, riparian buffers, and structures built to trap or retain waste should be utilized in order to prevent contamination of both surface waters and groundwater.

If not managed properly, agricultural waste from farm operations can pollute the environment resulting in impacts to water quality and a general loss of aesthetics. The degradation of water quality can impact adjacent waterways and groundwater both onsite and offsite. This degradation reduces the ability of these resources to support aquatic life and water for human and animal consumption. Nitrates, which are commonly associated with fertilizers and agricultural waste runoff, can seep into groundwater. Well water contaminated with nitrates is hazardous to humans, particularly for infants, as it results in oxygen depletion in the blood.

Where feasible, the reuse of animal waste in farming operations can reduce the quantity and hauling costs of commercial fertilizer. The contribution of animal waste increases the organic matter content of soils, which not only increases nutrient availability for crops but also improves the water holding capacity and tilth of the soil.

Pollutant Control Approach

Control animal waste storage and disposal and animal waste fertilizer application to prevent contamination of stormwater and local water bodies.

Operational BMPs for Animal Waste Management

- Store waste in an acceptable form until it is needed. Waste can be stored as a solid in building structures or covered with plastic sheeting, or as a liquid that can be stored in holding ponds or anaerobic lagoons.
- Avoid spillage or overflow of lagoons, ponds and structures used to house waste.
- When applying waste as fertilizer, apply during the dry season so valuable nutrients are not lost and environmental, human, and animal health problems are not created.
- Do not apply waste to fields when heavy rain is expected and runoff potential is high. Where possible, divert runoff from land above livestock areas.
- Do not spread waste near within a wetland or stream buffers. Do not spread waste in ditches or other conveyance structures.
- Employ other conservation practices that minimize runoff and erosion to fields where waste is applied. Maintain healthy riparian and wetland buffers to filter runoff.
- Exclude livestock from sensitive areas such as riparian buffers and wetlands. If an alternative water supply source is unavailable for livestock, create dedicated, limited access points to streams for drinking.

Landscaping and Lawn/Vegetation Management

Description of Pollutant Sources

This activity encompasses all aspects of landscaping and vegetation management, from small-scale yard maintenance to large-scale commercial landscaping businesses and vegetation management programs. It includes vegetation removal, pesticide and herbicide application, fertilizer application, watering, clearing, grading, and other practices. These may contaminate stormwater runoff with the following pollutants: pesticides and other toxic organic compounds; metals, such as arsenic, cadmium, chromium, copper, lead and zinc; oils; suspended solids; and coliform bacteria.

> **Note:** The term pesticide includes insecticides, herbicides, fungicides, etc.

Fertilizer runoff adds nutrients to water, causing excessive plant and algae growth. When too much growth occurs, the dead and/or dying plant material in the water can take the oxygen out of the water and suffocate all other life in the water.

Pollutant Control Approach

- Control fertilizer and pesticide applications, soil erosion, and site debris to prevent contamination of stormwater.
- Consider using the Integrated Pest Management (IPM) approach for pest control, and use pesticides only as a last resort. IPM is an effective pest management approach that uses an array of methods to manage pest damage with the least possible hazard to people and the environment. Using IPM practices can significantly reduce or eliminate the needs for pesticides.

Note: Integrated Pest Management (IPM) is an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices to manage pest damage by the most economical means, and with the least possible hazard to people, property, and the environment.

Operational BMPs for Landscaping

The following BMPs or equivalent measures, methods or practices apply to landscaping activities:

- Use native species when appropriate.
- Install engineered soil/landscape systems to improve infiltration and the regulation of stormwater in landscaped areas.
- Do not dispose of collected vegetation into waterways or storm drainage systems.
- Conduct mulch-mowing whenever possible or dispose of grass clippings, leaves, sticks, or other collective vegetation by composting, if feasible.
- Use mulch or other erosion control measures when soils are exposed for more than one week during the dry season or two days during the rainy season.
- If oil or other chemicals are handled, store and maintain appropriate oil and chemical spill cleanup materials in readily accessible locations. Ensure that employees are familiar with proper spill cleanup procedures.
- Till fertilizers into the soil rather than dumping or broadcasting onto the surface. Determine the proper fertilizer application for the types of soil and vegetation encountered.
- Till a topsoil mix or composted organic material into the soil to create a well-mixed transition layer that encourages plant establishment.
- Use manual and/or mechanical methods of vegetation removal rather than applying herbicides, where practical.

Note: Installing an amended soil/landscape system can preserve both the plant system and the soil system more effectively. This type of approach provides a soil/landscape system with adequate depth, permeability, and organic matter to sustain itself and continue working as an effective stormwater infiltration system and a nutrient cycle.

Operational BMPs for the Use of Pesticides

The following BMPs apply to activities involving pesticide use:

- Develop and implement an IPM and use pesticides only as a last resort.
- Implement a pesticide-use plan and include at a minimum: a list of selected pesticides and their uses; brands, formulations, application methods, and quantities to be used; equipment use and maintenance procedures; safety, storage, and disposal methods; and monitoring, record keeping, and public notice procedures.

- Choose the least toxic pesticide available that is capable of reducing the infestation to acceptable levels. The pesticide should readily degrade in the environment or have properties that strongly bind it to the soil. Any pest control used should be conducted at the life stage when the pest is most vulnerable. For example, if it is necessary to use a *Bacillus thuringiensis* application to control tent caterpillars, it must be applied before the caterpillars cocoon or it will be ineffective. Any method used should be site-specific and not used wholesale over a wide area.
- Apply the pesticide according to label directions. Under no conditions shall pesticides be applied in quantities that exceed manufacturer's instructions.
- Mix the pesticides and clean the application equipment in an area where accidental spills will not enter surface or ground waters, and will not contaminate the soil.
- Store pesticides in enclosed areas or in covered impervious containment. Ensure that pesticide contaminated stormwater or spills/leaks of pesticides are not discharged into storm drains. Do not hose down the paved areas to a storm drain or conveyance ditch. Store and maintain appropriate spill cleanup materials in a location known to all near the storage area.
- Clean up any spilled pesticides and ensure that the pesticide-contaminated waste materials are kept in designated covered and contained areas.
- The pesticide application equipment must be capable of immediate shutoff in the event of an emergency.
- Do not spray pesticides within 100 feet of open waters including wetlands, ponds, and streams, sloughs and any drainage ditch or channel that leads to open water except when approved by the local jurisdiction. All sensitive areas including wells, creeks, and wetlands must be flagged prior to spraying.
- As required by the local government, complete public posting of the area to be sprayed prior to the application.
- Spray applications should only be conducted during weather conditions as specified in the label direction and applicable local and state regulation. Do not apply during rain or immediately before expected rain.

The following BMPs are optional unless the previous BMPs fail to provide adequate source control:

- Consider alternatives to the use of pesticides such as covering or harvesting weeds, substitute vegetative growth, and manual weed control/moss removal.
- Once a pesticide is applied, its effectiveness should be evaluated for possible improvement. Records should be kept showing the applicability and inapplicability of the pesticides considered.
- An annual evaluation procedure should be developed including a review of the effectiveness of pesticide applications, impact on buffers and sensitive areas (including potable wells), public concerns, and recent toxicological information on pesticides used/proposed for use.
- Rinse liquid from equipment cleaning and/or triple-rinsing of pesticide containers should be used as products, recycled into product or disposed of properly.
- Consider the use of soil amendments, such as compost, that are known to control some common diseases in plants. The following are three possible mechanisms for disease control by compost addition (U.S. EPA Publication 530-F-9-044):
  - Successful competition for nutrients by antibiotic production;

– Successful predation against pathogens by beneficial microorganisms;

– Activation of disease-resistant genes in plants by composts.

Operational BMPs for Lawn/Vegetation Management

The following BMPs apply to all lawn/vegetation management activities:

- Use at least a 3-inch topsoil layer with at least 8 percent organic matter to provide a sufficient vegetation-growing medium. Amending existing landscapes and turf systems by increasing the percent organic matter and depth of topsoil can substantially improve the permeability of the soil and the disease-resistance of the vegetation, and reduce fertilizer, herbicide, and pesticide demand. Organic matter is the least water-soluble form of nutrient that can be added to the soil. Composted organic matter generally releases only about 2 to 10 percent of its total nitrogen annually, and this release corresponds closely to the plant growth cycle. If natural plant debris and mulch are returned to the soil, this system can continue recycling nutrients indefinitely.
- Select the appropriate turfgrass mixture for the climate and soil type.
- Selection of desired plant species can be made by adjusting the soil properties of the subject site. Consult a soil restoration specialist for site-specific conditions.
- Aerate lawns regularly in areas of heavy use where the soil tends to become compacted. Aeration should be conducted while grasses in the lawn are growing most vigorously. Remove layers of thatch greater than ¾-inch deep.
- Mowing is a stress-creating activity for turf grass. When grass is mowed too short, its productivity is decreased and there is less growth of roots and rhizomes. The turf becomes less tolerant of environmental stresses and more disease prone and reliant on outside means such as pesticides and fertilizers to remain healthy. Set the mowing height at the highest acceptable level and mow at times and intervals designed to minimize stress on the turf. Generally, mowing only 1/3 of the grass blade height will prevent stressing the turf.
- Fertilizer management:
  - Turfgrass is most responsive to nitrogen fertilization, followed by potassium and phosphorus. Fertilization needs vary by site, depending on plant, soil and climate conditions. Evaluation of soil nutrient levels through regular testing ensures the best possible efficiency and economy of fertilization.
  - Fertilizers should be applied in amounts appropriate for the target vegetation and at the time of year that minimizes losses to surface and ground waters. Do not fertilize when the soil is dry. Alternatively, do not apply fertilizers within three days prior to predicted rainfall. The longer the period between fertilizer application and rainfall, the less fertilizer runoff occurs.
  - Use slow release fertilizers such as methylene urea, IDBU, or resin-coated fertilizers when appropriate, generally in the spring. Non-synthetic fertilizers are encouraged. Use of slow release fertilizers is especially important in areas with sandy or gravelly soils.
  - Time the fertilizer application to periods of maximum uptake. Generally fall and spring applications are recommended.
  - Properly trained persons should apply all fertilizers. At commercial and industrial facilities, fertilizers should not be applied to bioswales, filter strips or buffer areas that drain to sensitive water bodies unless approved by the local jurisdiction.

The following BMPs are optional unless previous BMPs fail to provide adequate source control:

- Integrated Pest Management is the most effective BMP measure that can be taken for herbicide, insecticide, and fungicide use. An IPM program might consist of the following steps:

  Step 1: Correctly identify pests and understand their lifecycle.

  Step 2: Establish tolerance thresholds for pests.

  Step 3: Monitor to detect and prevent pest problems.

  Step 4: Modify the maintenance program to promote healthy plants and discourage pests.

  Step 5: Use cultural, physical, mechanical or biological controls first if pests exceed the tolerance thresholds.

  Step 6: Evaluate and record the effectiveness of the control and modify maintenance practices to support lawn or landscape recovery and prevent recurrence.

- Fertilizers should be worked into the soil rather than dumped or broadcast onto the surface. Determine the proper fertilizer application for the types of soil and vegetation involved. Soil should be tested for the correct fertilizer usage.
- Use mechanical methods of vegetation removal rather than applying herbicides.
- An effective measure that can be taken to reduce pesticide use, excessive watering, and removal of dead vegetation involves careful soil mixing and layering prior to planting. A topsoil mix or composted organic material should be rototilled into the soil to create a transition layer that encourages plant establishment and water retention. This practice can improve the health of planted vegetation, resulting in better disease resistance.
- Use native plants in landscaping. Native plants do not require extensive fertilizer or pesticide applications

Automobile Washing

Description of Pollutant Sources

Most homeowners wash their cars in a driveway or in the street with wash waters typically flowing to the stormwater conveyance system, which then discharges stormwater directly into the nearest water body. Soaps and detergents, even those that are labeled biodegradable, can be poisonous to crabs, shellfish, and fish, damaging gills and depleting the water of oxygen. Soils that are washed off cars contain a variety of pollutants, including residues from exhaust fumes, brake pads, gasoline and motor oil.

Pollutant Control Approach

Contain and control all cleaning activity, making sure that wash water discharges into a sanitary sewer system with no discharge to a stormwater conveyance system or to surface water.

Operational BMPs for Automobile Washing

- Conduct vehicle washing at a commercial washing facility where the washing occurs in an enclosure and drains to a sanitary sewer. Or, wash vehicles in a building constructed specifically for washing of vehicles and equipment, which drains to a sanitary sewer.
- If washing must be done at home, wash the vehicle directly over the yard, or make sure the wash water drains into a vegetated area. This allows the water and soap to soak into the ground instead of flowing into the local water body.
- Select a soap that does not contain phosphates or wash the car without soap if possible.
- Sweep driveways and street gutters before washing vehicles to clean up dirt, leaves, trash and other materials that may flow into the storm drain along with wash water. This helps reduce storm drain maintenance costs as well as protect water quality.

Household Hazardous Material Use, Storage, and Disposal

Description of Pollutant Sources

Household hazardous materials are materials found in homes that exhibit characteristics such as corrosivity, ignitability, reactivity or toxicity. These include oil-based paints and stains, paint thinner, gasoline, charcoal starter fluid, cleaners, waxes, pesticides, fingernail polish removal and wood preservatives. When these products are emptied onto the ground through leaks, spills or improper disposal, they may enter the stormwater conveyance system and flow directly into local water bodies, harming fish and wildlife. They can also infiltrate into the ground and contaminate drinking water.

Ground water contamination occurs when these products are poured down a sink drain or a toilet and into a septic system. If these products are poured down sink drains and toilets into municipal sewers, hazardous compounds will pass through the wastewater treatment plant and contaminate receiving waters, or they can harm the biological process used at the treatment plant, reducing overall treatment efficiency.

When hazardous materials are disposed of in a household garbage can, they can leak in landfills and contaminate groundwater.

Operational BMPs for Household Hazardous Material Use, Storage, and Disposal

The following BMPs apply to household hazardous materials:

- Follow manufacturers' directions in the use of all hazardous materials.
- Place drip pans and ground cloths under any work areas outdoors and at all potential drip and spill locations during movement and use of hazardous materials.
- When hazardous materials are in use, place the container inside of a tub or bucket to minimize spills.
- Keep appropriate spill cleanup materials on hand. Cat litter is good for many oil-based spills. Dispose of this cat litter as solid waste.
- Keep tight fitting lids on all containers and inspect containers regularly for leaks.
- Store containers inside of a building unless this is not permitted due to site constraints or fire code requirements. Store containers off the ground. Keep them out of the weather to avoid rusting, freezing, cracking, labels falling off, etc.
- Dispose of hazardous materials and their containers at an approved Hazardous Material Storage and Disposal Site i.e. CBJ hazardous waste cleanup days. Never dump products labeled *poisonous, corrosive, caustic, flammable, inflammable, volatile, explosive danger, warning, caution* or *dangerous outdoors*, in a stormwater drain or into sinks, toilets or drains.
- Use less toxic products whenever possible.
- If an activity involving the use of hazardous material can be moved indoors out of the weather, then do so. Make sure that ventilation is adequate.
- Latex paints are not a hazardous waste but are not accepted in liquid form at landfills. To dispose, leave uncovered in a protected place until dry, then place in the garbage. To dry waste paint quickly, pour cat litter into the can to absorb the paint.

On-Site Sewage Maintenance and Operation

Description of Pollutant Sources

Sample tests of stormwater discharges and receiving water occasionally indicate high levels of fecal coliform bacteria. A potential source of bacteria is malfunctioning on-site sewage systems (septic systems). Septic tank failures have been documented on private property in Juneau.

Septic systems vary widely in their design and complexity. In its simplest design, a septic tank is the first stage of a private sewage disposal system. The septic tank is a water-tight tank below ground that is usually made out of concrete but may be fiberglass, plastic or steel. Septic tanks have one or two access ports for inspection and maintenance, which are usually buried a few inches below the ground. The tank receives household wastewater through an inlet pipe at one end, settles out larger material to the bottom, breaks down waste material with bacteria present in the tank, and delivers the partially treated wastewater out another pipe on the opposite end of the tank to the disposal field.

The disposal field is the second stage of the private sewage disposal system and completes the final breakdown of wastewater with organisms in the soil. The disposal field consists of narrow trenches filled with gravel and perforated pipes that distribute wastewater to the field. Disposal systems should be mounded systems because of poor infiltration in local soils. With proper maintenance, a well-designed system can last a long time; however, disposal fields will clog if forced to handle large particles that should settle out in the bottom of the septic tank.

Pollutant Control Approach

Owners of septic systems must follow all the requirements of the Alaska DEC.

Operational BMPs for On-Site Sewage Maintenance and Operation

- Have septic systems inspected and maintained on a regular basis. Inspections should be done to measure accumulated sludge every year. Pumping should be done every two years. Failure to remove sludge periodically will result in reduced settling capacity and eventual overloading of the disposal field, which can be difficult and expensive to fix. Maintenance is required on complex systems—those serving more than one single-family residence or commercial establishments.
- Eliminate or restrict garbage disposal use. This can significantly reduce the loading of solids to the septic tank, thus reducing the pumping frequency.
- Reduce and spread water use out over the day. Septic tanks are limited in their ability to handle rapid large increases in the amount of water discharged into them. Excess wastewater flow can cause turbulence in the tank, flushing accumulated solids into the disposal field. Over time this will impair the ability of the disposal field to function. Limit water-using appliances to one at a time. Do one load of clothes a day rather than several in one day. Practice water conservation at home.
- Do not dispose of chemicals in the septic system. Septic systems are designed to dispose of household wastewater only. Occasional use of household cleaners in accordance with the manufacturer's recommendations should not harm a septic system. There is little evidence that products advertised for use as septic system cleaners and substitutes for pumping actually work as advertised.

Pet Waste Management

Description of Pollutant Sources

Pet waste in a yard, on the sidewalk or in the gutter usually enters a stormwater conveyance system that flows directly into the closest water body. Animal fecal matter in the water may lead to a number of problems. Fecal matter contains nutrients, which cause weeds and algae to grow more rapidly than normal robbing the water of oxygen needed to support fish and other aquatic life. Pet waste releases ammonia into the water, which, combined with low oxygen levels and warm water, can kill fish. Pet waste can also contain pathogens such as bacteria, viruses, and parasitic worms, which can transmit disease to humans, other pets and wild animals. These include campylobacteriosis (bacterial infection), salmonellosis (bacterial infection), toxocariasis (roundworm infection), toxoplasmosis (protozoan parasite infection), giardias (protozoan parasite infection), fecal coliform (bacteria in feces), and *E. Coli* (bacteria in feces). Because of the threat these pathogens pose for humans, high levels of these contaminants in a body of water may lead to closed beaches and restricted fishing and shellfish harvesting.

Pollutant Control Approach

Apply good housekeeping and properly dispose of all pet waste.

Operational BMPs for Pet Waste Management

The following BMPs are recommended:

- To prevent plumbing problems, **DO NOT FLUSH CAT LITTER**.
- Septic systems are not designed to accommodate the high pollutant load of pet waste. To prevent premature failure or excessive maintenance costs, do not flush pet wastes to a septic system. Seal the waste in a plastic bag and throw it in the garbage.
- If the waste is mixed with grass clippings and allowed to decompose, it should be safe to use on trees, shrubs or flower gardens. There are products available through pet stores and catalogs that can be added to the waste to help it decompose more quickly and without odor. Always check the labels carefully with these products to be sure they are environmentally friendly. Keep composting sites away from areas where children play and vegetable gardens.

The following BMPs are optional unless the minimum required BMPs fail to provide adequate source control:

- Double-bag animal excrement and tie securely before throwing away. Or, seal it in a leak-proof container before throwing away.
- Pay attention to the pet food selected. The type of pet food affects the quality and quantity of pet waste. The easier food is to digest, the more completely it will be digested, resulting in smaller stools that will decompose more quickly. Consult a veterinarian with questions about the nutritional value of a particular brand of pet food.
- Control where pets relieve themselves. Make the yard more appealing to the pet by tilling a small section of the ground, thus reserving that spot solely for the pet’s needs. On walks, carry a scoop and a plastic bag, or a bucket with a lid and handle.

Landscaping and Lawn/Vegetation Management

Description of Pollutant Sources

> **Note:** The term pesticide includes insecticides, herbicides, fungicides, etc.

This activity encompasses residential small-scale yard maintenance landscaping and vegetation management. It includes vegetation removal, pesticide and herbicide application, fertilizer application, watering, clearing, grading, and other practices. These may contaminate stormwater runoff with the following pollutants: pesticides and other toxic organic compounds; metals, such as arsenic, cadmium, chromium, copper, lead and zinc; oils; suspended solids; and coliform bacteria.

Fertilizer runoff adds nutrients to water, causing excessive plant and algae growth. When too much growth occurs, the dead and/or dying plant material in the water can take the oxygen out of the water and suffocate all other life in the water.

Pollutant Control Approach

Control fertilizer and pesticide applications, soil erosion, and site debris to prevent contamination of stormwater.

Operational BMPs for Landscaping

The following BMPs or equivalent measures, methods or practices are recommended in landscaping activities:

- Use native plant species appropriate to site conditions.
- Install engineered soil/landscape systems to improve infiltration and the regulation of stormwater in landscaped areas.
- Do not dispose of collected vegetation into waterways or storm drainage systems.
- Dispose of grass clippings, leaves, sticks or other vegetation by composting if feasible.

Operational BMPs for the Use of Pesticides

The following BMPs are recommended in activities involving pesticide use:

- Choose the least toxic pesticide available that is capable of reducing the infestation to acceptable levels. Consider alternative to pesticides such as manual control and mulching. The pesticide should readily degrade in the environment or have properties that strongly bind it to the soil. Any pest control used should be conducted at the life stage when the pest is most vulnerable.
- Apply, store and dispose of the pesticide according to label directions. Under no conditions shall pesticides be applied in quantities that exceed manufacturer's instructions.
- Clean up any spilled pesticides and ensure that the pesticide-contaminated waste materials are kept in designated covered and contained areas.
- Do not spray pesticides within 100 feet of open waters including wetlands, ponds, and streams, sloughs and any drainage ditch or channel that leads to open water except when approved by the local jurisdiction. All sensitive areas including wells, creeks, and wetlands must be flagged prior to spraying.

- Spray applications should only be conducted during weather conditions as specified in the label direction and applicable local and state regulation. Do not apply during rain or immediately before expected rain.

Operational BMPs for Lawn/Vegetation Management

The following BMPs are recommended in all lawn/vegetation management activities:

- Use at least an 3-inch topsoil layer with at least 8 percent organic matter to provide a sufficient vegetation-growing medium. Amending existing landscapes and turf systems by increasing the percent organic matter and depth of topsoil can substantially improve the permeability of the soil and the disease-resistance of the vegetation, and reduce fertilizer, herbicide, and pesticide demand. Organic matter is the least water-soluble form of nutrient that can be added to the soil. Conduct mulch mowing to return natural plant debris and mulch to the soil.
- Select a turfgrass mixture appropriate for the specific microclimate and soil type of the site. Selection of desired plant species can be made by adjusting the soil properties of the subject site.
- Aerate lawns regularly in areas of heavy use where the soil tends to become compacted. Aeration should be conducted while grasses in the lawn are growing most vigorously. Remove layers of thatch greater than ¾-inch deep.
- Mowing is a stress-creating activity for turf grass. When grass is mowed too short, its productivity is decreased and there is less growth of roots and rhizomes. The turf becomes less tolerant of environmental stresses and more disease prone and reliant on outside means such as pesticides and fertilizers to remain healthy. Set the mowing height at the highest acceptable level and mow at times and intervals designed to minimize stress on the turf. Generally, mowing only 1/3 of the grass blade height will prevent stressing the turf.
- Fertilizer management:
  - Turfgrass is most responsive to nitrogen fertilization, followed by potassium and phosphorus. Fertilization needs vary by site, depending on plant, soil and climate conditions. Evaluation of soil nutrient levels through regular testing ensures the best possible efficiency and economy of fertilization.
  - Fertilizers should be applied in amounts appropriate for the target vegetation and at the time of year that minimizes losses to surface and ground waters. Do not fertilize when the soil is dry. Alternatively, do not apply fertilizers within three days prior to predicted rainfall. The longer the period between fertilizer application and rainfall, the less fertilizer runoff occurs.
  - Use compost or other slow release fertilizers such as methylene urea or resin-coated fertilizers when appropriate, generally in the fall or spring. Non-synthetic fertilizers are encouraged. Use of slow release fertilizers is especially important in areas with sandy or gravelly soils.

APPENDIX H.
STORMWATER DESIGN STANDARDS

APPENDIX H
STORMWATER DESIGN STANDARDS

BACKGROUND

This appendix presents acceptable methods for the analysis and design of conveyance systems and hydraulic structures. This chapter presents the following:

- Design and analysis methods
- Pipe systems
- Outfalls
- Culverts
- Open conveyances
- Private drainage systems.

Where space and topography permit, open conveyances are preferred for stormwater conveyance.

DESIGN EVENT STORM FREQUENCY

Hydraulic structures are analyzed and sized for a specific storm frequency to provide an acceptable level of service at an acceptable cost. When selecting a storm frequency for design, consideration is given to the potential degree of damage to adjacent properties, potential hazard and inconvenience to the public, the number of users, and the initial construction cost of the conveyance system or hydraulic structure. According to CBJ code Chapter 49.35 “development shall accommodate the post-development 25-year storm event.”

The design event recurrence interval indicates the probability that such an event will occur in any one year. The greater the recurrence interval, the lower the probability that the event will occur in any given year. For example, a peak flow having a 25-year recurrence interval has a 4 percent probability of being equaled or exceeded in any future year. A peak flow having a 2-year recurrence interval has a 50 percent probability of being equaled or exceeded in any future year. Table H-1 shows the design event for each conveyance system category.

TABLE H-1.
DESIGN EVENT FREQUENCIES

Type of Structure	Design Return Period (Exceedance Probability)
Roadway Culverts	100 years (1%)
Driveway Culverts	25 years (4%)
Trunk Storm Sewer System and Storm Sewer Feeder Lines	25 years (4%)
Outfall Energy Dissipation	100 years (1%)
Side Ditches, Storm Water Inlets and Gutter Flow	25 years (4%)
Bridges in Designated Flood Hazard Areas	100 years (1%)

DETERMINATION OF DESIGN FLOWS

All existing and proposed conveyance systems shall be analyzed and designed using the peak flows from the hydrographs developed according to Appendix D or other approved methodology. In general, either event-based or continuous runoff hydrologic modeling may be used for conveyance sizing. See Appendix D for full details.

Exception: For drainage sub-basins of 10 acres or less with a time of concentration of less than 100 minutes, the capacity of conveyance elements may be determined using the rational method.

OFF-SITE ANALYSIS

Off-site analysis shall initially consist of a qualitative assessment of existing and potential flooding and erosion problems upstream and downstream of the site and of the conveyance capacity of the primary and overflow stormwater runoff flow paths. If conditions warrant, a more detailed quantitative analysis shall be required. Areas with steep slopes or erosive soils warrant increased review of runoff conveyance.

Conveyance analysis shall be conducted for at least a quarter-mile downstream from the site to evaluate potential impacts as well as the adequacy of the downstream conveyance facilities to accommodate flow from the site and all other upstream sources. Conveyance analysis shall extend upstream of the site past any backwater conditions caused by the proposed development.

For the 25-year event, there shall be a minimum of one-half foot of freeboard between the water surface and the top of any manhole or catch basin.

BACKWATER ANALYSIS

A computer program capable of backwater profile analysis, such as Hydrologic Engineering Center-River Analysis System (HEC-RAS) for surface water conveyance or Storm Water Management Model (SWMM) for pipe conveyance, is recommended over hand calculations.

CONVEYANCE SYSTEM ROUTE DESIGN

Where feasible, all pipes shall be located outside the travel lane, unless otherwise specified below. New conveyance system alignments that are not in dedicated tracts or rights-of-way shall be located in drainage easements that are adjacent and parallel to property lines. The width of the permanent easement must be completely within a single parcel or tract and not split between adjacent properties. Topography and existing conditions are the only conditions under which a drainage easement may be placed not adjacent and parallel to a property line. Requirements for conveyance system tracts and easements are discussed below.

Exceptions:

- This routing requirement shall not apply in cases where it would require relocation of streams or natural drainage channels.
- Perpendicular crossings and cul-de-sacs are exempted from this requirement.
- For curved sections only of local minor roads and local road cul-de-sacs, pipe placement may be located underneath pavement areas, but no closer than 6 feet from the roadway centerline.

EASEMENTS, ACCESS, AND DEDICATED TRACTS

Natural Channels and Stormwater Facilities

All man-made drainage facilities and conveyances and all natural channels (on the project site) used for conveyance of altered flows due to development (including swales, ditches, stream channels, lake shores, wetlands, potholes, estuaries, gullies, ravines, etc.) shall be located within easements or dedicated tracts as required by CBJ. Easements shall contain the natural features and facilities and shall allow CBJ access for purposes of inspection, maintenance, repair or replacement, flood control, water quality monitoring, and other activities permitted by law.

All drainage facilities such as wet ponds or infiltration systems to be maintained by the CBJ shall be located in tracts dedicated to CBJ. Conveyance systems can be in easements.

Maintenance Access

A minimum 20-foot wide access easement shall be provided to drainage facilities from a public street or right-of-way. Access easements shall be surfaced with a minimum 12-foot width of crushed rock, or other approved surface to allow year-round equipment access to the facility.

Maintenance access must be provided for all manholes, catch basins, vaults, or other underground drainage facilities to be maintained by CBJ. Maintenance shall be through an access easement or dedicated tract. Drainage structures for conveyance without vehicular access must be channeled.

Access to Conveyance Systems

All publicly and privately maintained conveyance systems shall be located in dedicated tracts, drainage easements, or public rights-of-way in accordance with this manual. **Exception**: roof downspout, minor yard, and footing drains unless they serve other adjacent properties.

Table H-2 lists minimum easements for drainage facilities.

TABLE H-2.
MINIMUM EASEMENT WIDTHS FOR CONVEYANCE SYSTEM ACCESS, INSPECTION AND MAINTENANCE

Conveyance Width	Easement Width
Channels	15 feet from top of slope on one side for access, 5 feet from top of slope for other side
Pipes/Outfalls ≤ 60”	20 feet centered on pipe[a]
Pipes/Outfalls > 60”	30 feet centered on pipe[a]

a. May be greater, depending on depth and number of pipes in easement.

Conveyance systems to be maintained and operated by CBJ must be located in a dedicated tract or drainage easement granted to CBJ. Any new conveyance system located on private property designed to convey drainage from other private properties must be located in a private drainage easement granted to the contributors of stormwater to the systems to convey surface and stormwater and to permit access for maintenance or replacement in the case of failure.

All drainage tracts and easements, public and private, must have a minimum width of 20 feet. In addition, all pipes and channels must be located within the easement so that each pipe face or top edge of channel is no closer than 5 feet from its adjacent easement boundary. Pipes greater than 5 feet in diameter and channels with top widths greater than 5 feet shall be placed in easements adjusted accordingly, so as to meet the required dimensions from the easement boundaries.

PIPE SYSTEM DESIGN CRITERIA

Pipe systems are networks of storm drain pipes, catch basins, manholes, and inlets designed and constructed to convey storm and surface water. The hydraulic analysis of flow in storm drain pipes typically is limited to "gravity flow"; however, in analyzing existing systems it may be necessary to address pressurized conditions.

Analysis Methods

Two methods of hydraulic analysis using Manning's equation are used for the analysis of pipe systems. The first method is the Uniform Flow Analysis Method, commonly referred to as the Manning's Equation, and is used for the design of new pipe systems and analysis of existing pipe systems. The second method is the Backwater Analysis Method described in Appendix D and is used to analyze the capacity of both proposed, and existing, pipe systems. If off site analysis determines that, as a result of the project, runoff would cause damage or interrupt vital services, a backwater (pressure sewer) analysis shall be required. Results shall be submitted in tabular and graphic format showing hydraulic and energy gradient.

When using the Manning's equation for design, each pipe in the system shall be sized and sloped such that its barrel capacity at normal full flow is equal or greater than the required conveyance capacity. Table H-3 provides the recommended Manning's "n" values for preliminary design for pipe systems. (Note: The "n" values for this method are 15 percent higher in order to account for entrance, exit, junction, and bend head losses.) Manning's "n" values used for final pipe design must be documented in the Stormwater Site Plan.

Nomographs may also be used for sizing the pipes. For pipes flowing partially full, the actual velocity may be estimated from engineering nomographs by calculating Q_{full} and V_{full} and using the ratio of Q_{design}/Q_{full} to find V and d (depth of flow).

Acceptable Pipe Sizes

All storm drainage pipe shall have a minimum 18-inch diameter unless approved by CBJ. Cross-street connections from a concrete inlet to a Type III or IV catch basin or manhole (CB leads) may use corrugated polyethylene pipe 12-inch diameter if approved. Storm sewer pipe used for private roof/footing/yard drain systems can be less than 12-inch diameter if sized according to the application and approved by CBJ.

Pipe Materials

Pipe materials shall meet the requirements of CBJ standard specifications. All storm drainage pipe, except as otherwise provided for in these standards, shall be double-walled, corrugated, polyethylene pipe, minimum 18-inch diameter unless approved by CBJ, with a smooth internal diameter (AASHTO M-294 Type S) or approved equal, with a joint meeting CBJ standards, except for perforated pipe and major underground detention facilities. Drainage pipe shall have a minimum cover of 12 inches as measured from the top of pipe to the top of paved surface.

TABLE H-3. RECOMMENDED MANNING'S "N" VALUES FOR PRELIMINARY PIPE DESIGN		
	Analysis Method	
Type of Pipe Material	Backwater Flow	Manning's Equation Flow
A. Concrete pipe and CPP-smooth interior pipe	0.012	0.014
B. Annular Corrugated Metal Pipe or Pipe Arch:		
1. 2⅔ x ½ inch corrugation (riveted)		
a. plain or fully coated	0.024	0.028
b. paved invert (40% of circumference paved):		
(1) flow full depth	0.018	0.021
(2) flow 0.8 depth	0.016	0.018
(3) flow 0.6 depth	0.013	0.015
c. treatment 5	0.013	0.015
2. 2.3 x 1-inch corrugation	0.027	0.031
3. 3.6 x 2-inch corrugation (field bolted)	0.030	0.035
C. Helical 2⅔ x ½-inch corrugation and CPEP-single wall	0.024	0.028
D. Spiral rib metal pipe and PVC pipe	0.011	0.013
E. Ductile iron pipe cement lined	0.012	0.014
F. High density polyethylene pipe (butt fused only)	0.009	0.009

When extreme slope conditions or other unusual topographic conditions exist, other pipe materials and methods may be used with prior approval by CBJ, such as, but not limited to, polyvinyl chloride (PVC) or high density polyethylene (HDPE).

All metal parts must be corrosion resistant. Examples of preferred materials include aluminum, stainless steel, and plastic. Zinc and galvanized materials are discouraged because of aquatic toxicity. Painted metal parts shall not be used because of poor longevity.

Pipe material, joints, and protective treatment shall be in accordance with CBJ Standard Specifications and AASHTO and ASTM treatment standards as amended by the CBJ. The applicant is responsible for contacting CBJ to determine the allowable pipe materials which can be used.

Pipe Slope and Velocity

Minimum velocity is 2 feet per second at design flow. CBJ may waive these minimums in cases where topography and existing drainage systems make it impractical to meet the standard.

Maximum slopes, velocities, and anchor spacings are shown in Table H-4. If velocities exceed 15 feet per second for the conveyance system design event, provide anchors at bends and junctions.

Pipe direction changes or size increases or decreases are allowed only at manholes and catch basins. This does not apply to detention tanks or vaults.

Downsizing of pipes is only allowed under special conditions as allowed by CBJ (i.e., no hydraulic jump can occur; downstream pipe slope is significantly greater than the upstream slope; velocities remain in the 3 to 8 fps range, no debris blockage potential etc.).

TABLE H-4. MAXIMUM PIPE SLOPES AND VELOCITIES			
Pipe Material	Pipe Slope Above Which Pipe Anchors Required and Minimum Anchor Spacing[a]	Max. Slope Allowed	Max. Velocity at Full Flow
Spiral Rib[b], PVC[b], CPEP-single wall	20% (minimum 1 anchor per 100 feet of pipe)	20%[d]	30 fps
Concrete[b] or CPP-smooth interior[b]	20% (minimum 1 anchor per 50 feet of pipe)	20%[d]	30 fps
HDPE[c]	50% (minimum 1 anchor per 100 feet of pipe; cross slope installations only)	None	None

a. As supported by engineering calculations.

b. Not allowed in landslide hazard areas.

c. Butt-fused pipe joints required. Above-ground installation is required on slopes greater than 40% to minimize disturbance to steep slopes.

d. Maximum slope of 200% allowed for these pipe materials with no joints (one section) with structures at each end and properly grouted.

Key: PVC = polyvinyl chloride pipe; CPP = corrugated high density polyethylene pipe; HDPE = high density polyethylene

Downsizing of downstream culverts within a closed system with culverts 18-inches in diameter or smaller will not be permitted.

Normally pipes connecting into a structure shall match crown elevations (see exceptions in the layout criteria below).

Pipes on Steep Slopes

Steep slopes (greater than 20 percent) shall require all drainage to be piped from the top to the bottom in HDPE pipe (butt fused). Additional anchoring design is required for these pipes.

Pipe System Layout Criteria

Pipes must be laid true to line and grade with no curves, bends, or deflections in any direction. Exceptions may include HDPE on steep slopes per engineer.

A break in grade or alignment or changes in pipe material shall occur only at catch basins or manholes.

Connections to a pipe system shall be made only at catch basins or manholes. No wyes or tees are allowed except on private roof/footing/yard drain systems on pipes 8-inches in diameter, or less, with clean-outs upstream of each wye or tee.

Provide 6 inches minimum vertical and 3 feet minimum horizontal clearance (outside surfaces) between storm drain pipes and other utility pipes and conduits.

Suitable pipe cover over storm pipes in road rights-of-way shall be calculated for HS-20 loading by the Engineer of Record. Pipe cover is measured from the finished grade elevation down to the top of the outside surface of the pipe. Pipe manufacturers' recommendations are acceptable if verified by the Project Engineer.

Pipe cover in areas not subject to vehicular loads, such as landscape planters and yards, may be reduced to an 18-inch minimum.

Access barriers are required on all pipes 18 inches and larger exiting a closed pipe system. Debris barriers (trash racks) are required on inlets to closed concrete structures (see CBJ Engineering Standard Details).

Where a minimal fall is necessary between inlet and outlet pipes in a structure, pipes must be aligned vertically by one of the following in order of preference:

- Match pipe crowns
- Match 80 percent diameters of pipes
- Match pipe inverts.

Where inlet pipes are higher than outlet pipes, drop manhole connections may be required or increased durability in the structure floor may be required.

HDPE pipe systems longer than 100 feet must be anchored at the upstream end if the slope exceeds 25 percent and the downstream end placed in a minimum 4 foot long section of the next larger pipe size. This sliding sleeve connection allows for the high thermal expansion/contraction coefficient of the pipe material.

Pipe Structure Criteria

Catch Basins and Manholes

For the purposes of this manual, all catch basins and manholes shall meet the requirements outlined in CBJ Engineering Standard Details and standard specifications.

Catch basin (or manhole) diameter shall be determined by pipe diameter and orientation at the junction structure. A plan view of the junction structure, drawn to scale, will be required when more than four pipes enter the structure on the same plane, or if angles of approach and clearance between pipes is of concern. The plan view (and sections if necessary) must ensure a minimum distance (of solid concrete wall) between pipe openings of 8 inches for 48 inch and 54 inch diameter catch basins and 12 inches for 72 inch and 96 inch diameter catch basins.

Catch basin evaluation of structural integrity for H-20 loading will be required for multiple junction catch basins and other structures which exceed the recommendations of the manufacturers.

Catch basins shall be provided within 50 feet of the entrance to a pipe system silt and debris removal.

Maximum surface runs between inlet structures on paved roadway surface shall be as listed in Table H-5.

Minimum longitudinal roadway slope shall be 0.5 percent.

The Washington State Department of Transportation Hydraulics Manual can be used in determining the capacity of inlet grates when capacity is of concern. When verifying capacity, assume grate areas on slopes are 80 percent free of debris, and “vaned” grates are 95 percent free. In sags or low spots, assume grates are 50 percent free of debris, and “vaned” grates, 75 percent free.

A metal frame and grate for catch basin and inlet, that is deemed bicycle safe, shall be used for all structures collecting drainage from the paved roadway surface (see CBJ Engineering Standard Details).

TABLE H-5. MAXIMUM SURFACE RUNS BETWEEN INLET STRUCTURES	
Roadway Slope (%)	Maximum Spacing (feet)
0.5 to 1	200
1 to 6	350
6 to 8	350
8 to 12	150

OUTFALLS

All piped discharges to streams, rivers, ponds, lakes, or other open bodies of water are designated outfalls and shall provide for energy dissipation to prevent erosion at or near the point of discharge. Properly designed outfalls are critical to reducing the chance of adverse impacts as the result of concentrated discharges from pipe systems and culverts, both onsite and downstream. Outfall energy dissipation systems include rock splash pads, flow dispersal trenches, gabion or other energy dissipaters, and tightline systems. A tightline system is typically a continuous length of pipe used to convey flows down a steep or sensitive slope with appropriate energy dissipation at the discharge end.

General Design Criteria for Outfall Features

All energy dissipation at outfalls shall be designed for peak flows from a 100-year, 24-hour storm event. For outfalls with a maximum flow velocity of less than 10 feet per second, a rock splash pad is acceptable. For velocities equal to or greater than 10 feet per second, an engineered energy dissipater must be provided. See Table H-6 for a summary of the rock protection requirements at outfalls. The following sections provide general design criteria for various types of outfall features.

**TABLE H-6.
ROCK PROTECTION AT OUTFALLS**

Discharge Velocity at Design Flow (fps)	Minimum Dimensions for Required Protection				
	Type	Thickness	Width	Length	Height
0 to 5	Class I Riprap	1 foot	Diameter + 6 feet	8 feet or 4 x diameter, whichever is greater	Crown + 1 foot
>5 to 10	Class II Riprap	2 feet	Diameter + 6 feet or 3 x diameter, whichever is greater	12 feet or 4 x diameter, whichever is greater	Crown + 1 foot
>10 to 20	Class III Riprap or Gabion outfall	As required	As required	As required	Crown + 1 foot
>20	Engineered energy dissipater required				

Note: Riprap sizing governed by side slopes on outlet channel is assumed to be approximately 3:1.

General Design Criteria to Protect Aquatic Species and Habitat

Outfall structures should be located where they minimize impacts to fish, shellfish, and their habitats. However, new pipe outfalls can also provide an opportunity for low-cost fish habitat improvements. For example, an alcove of low-velocity water can be created by constructing the pipe outfall and associated energy dissipater back from the stream edge and digging a channel, over widened to the upstream side, from the outfall to the stream. Overwintering juvenile and migrating adult salmonids may use the alcove as shelter during high flows. Potential habitat improvements should be discussed with the Alaska Department of Fish and Game (ADF&G) biologist prior to inclusion in design.

Bank stabilization, bioengineering, and habitat features may be required for disturbed areas. Outfalls that discharge to the ocean or a major water body may require tide gates. Contact the CBJ for specific requirements.

Rock Splash Pad

At a minimum, all outfalls as defined above must be provided with a rock splash pad except as specified in Table H-6.

Flow Dispersal Trench

The flow dispersal trenches should only be used when both criteria below are met:

- An outfall is necessary to disperse concentrated flows across uplands where no conveyance system exists and the natural (existing) discharge is unconcentrated.
- The 100-year peak discharge rate is less than or equal to one-half of a cubic foot per second.

Tightline Systems

Tightline systems may be needed to prevent aggravation or creation of a downstream erosion problem. The following general design criteria apply to tightline systems:

- Outfall tightlines may be installed in trenches with standard bedding on slopes up to 20 percent. In order to minimize disturbance to slopes greater than 20 percent, it is recommended that tightlines be placed at grade with proper pipe anchorage and support.
- Except as indicated above, tightlines or conveyances that traverse the marine intertidal zone and connect to outfalls should be buried to a depth sufficient to avoid exposure of the line during storm events or future changes in beach elevation. If non-native material is used to bed the tightline, such material should be covered with at least 3 feet of native bed material or equivalent.
- HDPE tightlines must be designed to address the material limitations, particularly thermal expansion and contraction and pressure design, as specified by the manufacturer. The coefficient of thermal expansion and contraction for solid wall polyethylene (SWPE) pipe is on the order of 0.001 inch per foot per Fahrenheit degree. Sliding sleeve connections should be used to address this thermal expansion and contraction. These sleeve connections consist of a section of the appropriate length of the next larger size diameter of pipe into which the outfall pipe is fitted. These sleeve connections should be located as close to the discharge end of the outfall system as is practical.
- Due to the ability of HDPE tightlines to transmit flows of very high energy, special consideration for energy dissipation must be made. Flows of very high energy will require a specifically engineered energy dissipater structure.

CULVERT CRITERIA

For the purpose of this manual, culverts are single runs of pipe that are open at each end and have no structures such as manholes or catch basins.

Approved pipe materials are detailed in the pipe system design criteria earlier in this chapter. Galvanized or aluminized pipe are not permitted in marine environments or where contact with salt water may occur, even infrequently through backwater events.

Culvert Design Criteria

Flow capacity shall be determined by analyzing inlet and outlet control for headwater depth. Nomographs used for culvert design shall be included in the submitted stormwater plan.

All culverts shall be designed to convey the flows for the design storm event. The maximum design headwater depth shall be 1.5 times the diameter of the culvert with no saturation of roadbeds. Culverts shall be a minimum 18 inches diameter unless approved by CBJ.

Inlets and outlets shall be protected from erosion by a CBJ Culvert Headwall (see CBJ Standard Details) and rock lining, riprap, or biostabilization as detailed in Table H-6 and approved by CBJ.

Debris and access barriers are required on inlet and outlet ends of all culverts greater than 18 inches in diameter. Culverts greater than 36 inches in diameter within stream corridors are exempt.

Minimum culvert velocity shall be 2 feet per second and maximum culvert velocity shall be 15 feet per second. A maximum velocity of 30 feet per second may be used with an engineered outlet protection designed. No maximum velocity for HDPE pipe shall be established but outlet protection shall be provided.

All CPP and PVC culverts and pipe systems shall have concrete headwalls at exposed pipe ends.

Bends are not permitted in culvert pipes.

If the minimum cover cannot be provided on a flat site, pipe shall be designed for loadings by a licensed engineer.

- Maximum culvert length: 150 feet
- Minimum separation from other pipes:
  - 6 inches vertical (with bedding) and in accord with the CBJ design criteria.
  - 3 feet horizontal.

Trench backfill shall be per CBJ Standard Specifications.

All driveway culverts shall be of sufficient length to provide a minimum 3:1 slope from the edge of the driveway to the bottom of the ditch. Culverts shall have beveled end sections to match the side slope.

Fish Passage

Fish passage shall be accommodated as required by ADF&G and/or the U.S. Army Corps of Engineers.

OPEN CONVEYANCES

Open conveyances can be either roadside ditches, grass lined swales, or a combination thereof. Consideration must be given to public safety when designing open conveyances adjacent to traveled ways and when accessible to the public. Where space and topography permit, open conveyances are the preferred means of collecting and conveying stormwater.

Open conveyances shall be designed by one of the following methods:

- Manning's Equation (for uniform flow depth, flow velocity, and constant channel cross-section)
- Direct Step Backwater Method (utilizing the energy equation)
- Standard Step Backwater Method (utilizing a computer program).

Velocities must be low enough to prevent channel erosion based on the native soil characteristics or the compacted fill material. For velocities above 5 feet per second, channels shall have either rock-lined bottoms and side slopes to the roadway shoulder top with a minimum thickness of 8 inches, or shall be stabilized in a fashion acceptable to the CBJ. Water quality shall not be degraded due to passage through an open conveyance. See Table H-7.

TABLE H-7.
OPEN CONVEYANCE PROTECTION

Velocity at Design Flow (fps)				Minimum Height Required Above Design
Greater Than	Less Than or Equal To	Protection	Thickness	Water Surface (feet)
0	5	Grass Lining	N/A	0.5
5	8	Class I Riprap	1 feet	2
8	12	Class II Riprap	2 feet	2
12	20	Slope mattress, gabion, etc.	Varies	1

Note: Riprap sizing governed by side slopes on channel, assumed ~3.1. Bioengineered lining allowed for design flow up to 8 fps.

Channels having a slope less than 6 percent and having peak velocities less than 5 feet per second shall be lined with vegetation.

Channel side slopes shall not exceed 2:1 for undisturbed ground (cuts) as well as for disturbed ground (embankments). All constructed channels shall be compacted per CBJ standard specifications and standard details. Channel side slopes adjacent to roads shall not exceed 2:1 and will meet all other AASHTO and CBJ road standards.

Channels shall be designed with a minimum freeboard of one-half-foot when the design flow is 10 cubic feet per second or less and 1 foot when the design discharge is greater than 10 cubic feet per second.

Check dams for erosion and sedimentation control may be used for stepping down channels and swales being used for biofiltration.

PRIVATE DRAINAGE SYSTEMS

The engineering analysis for a private drainage system is the same as for a public system.

Discharge Locations

Stormwater will not be permitted to discharge directly onto CBJ roads or system without the prior approval of the CBJ. Discharges to a CBJ system shall be into a structure such as an inlet, catch basin, manhole, through an approved sidewalk underdrain or curb drain, or into an existing or created CBJ ditch. Concentrated drainage will not be allowed to discharge across sidewalks, curbs, or driveways.

Roof downspouts and subsurface drains are required to be directed to a dispersion system or to the stormwater drainage system.

Drainage Stub-Outs

If drainage outlets (stub-outs) are to be provided for each individual lot, the stub-outs shall conform to the following:

- Each outlet shall be suitably located at the lowest elevation on the lot, so as to service all future roof downspouts and footing drains, driveways, yard drains, and any other surface or subsurface drains necessary to render the lots suitable for their intended use. Each outlet shall have free-flowing, positive drainage to an approved stormwater conveyance system or to an approved outfall location.
- Outlets on each lot shall be located per CBJ standard details.
- The developer and/or contractor is responsible for coordinating the locations of all stub-out conveyance lines with respect to the utilities (e.g., power, gas, telephone, television).
- All individual stub-outs shall be owned and maintained by the property owner to the storm drain main line.

APPENDIX I.
STORMWATER SITE PLAN

APPENDIX I
STORMWATER SITE PLAN

BACKGROUND

The stormwater site plan shall document how development of a site will satisfy the Excavation and Grading Code 19.12.120.1. The stormwater site plan requirements are intended to complement existing requirements for grading and land use permits. The stormwater site plan shall satisfy the requirements for the drainage plan as described in CBJ Code 49.35.510.

THRESHOLDS AND EXEMPTIONS

A stormwater site plan shall be prepared for development establishing more than 5,000 square feet of new or replaced impervious surface.

Maintenance activities and utility projects that replace trench surface in kind shall be exempt from the requirement to complete a Stormwater Site Plan.

PLAN ELEMENTS

A Stormwater Site Plan shall include each of the following sections (if sections do not apply, list and mark NA).

Project Engineer's Certification

The project engineer responsible for completion of the Stormwater Site Plan as described herein shall be a professional engineer with a current State of Alaska license. All plans and specifications, calculations, certifications, as-built drawings, and all other submittals which will become part of the permanent record of the Project must be dated and bear the project engineer's official seal and signature.

Phased Project Submittals

A phased project means a project where multiple separate and distinct construction activities may take place at different times but all under a single plan. The stormwater plan shall show the overall project, clearly delineating phase boundaries, and estimating dates of construction (if known). Phased projects shall be completed in accordance with approved plans and in accordance with phased development requirements placed upon the development by CBJ. Phasing of projects shall not result in a reduction of drainage control requirements.

Proposed Project Description

Include the project name, applicant's name, address, and telephone number, project engineer's name, address and phone number, date of submittal, contact's name, address, and telephone number, and the name, address and phone number of the contractor, if known.

Briefly describe project and type of permit for which the applicant is applying, address and legal description of property, parcel number, property zoning, etc. Describe other permits required (e.g., hydraulic permits, U.S. Army Corps of Engineers Section 404 Permit, wetlands, etc.) and present status.

Site Map

Use a scale of 1 inch = 100 feet. On a topographic map, show existing conditions and the proposed project including (as applicable) but not limited to:

- Project boundaries, subbasin boundaries, and offsite area tributary to the project
- Major drainage features (such as channels and detention facilities and floodways), and flow path to receiving waters
- Existing topography for the site
- Finished grades
- Existing structures within 100 feet of project boundaries
- Utilities
- Existing paved surfaces, including roads
- Easements, both existing and proposed
- Areas of possible significant environmental concern (e.g., gullies, ravines, swales, wetlands, steep slopes, estuaries, springs, creeks, lakes, etc.). For natural drainage features show direction of flow
- 100-year flood plain boundary (if applicable)
- Existing and proposed wells onsite and on adjacent properties (both of record and not of record) within specified setbacks
- Proposed structures including roads and parking surfaces
- Lot dimensions and areas
- Proposed drainage facilities
- Limits of clearing and grading
- Required natural buffer areas

Contour intervals on the site plan shall be at a minimum as follows:

- 2-foot intervals for slopes of 0 to 15 percent
- 5-foot intervals for slopes of 16 to 40 percent
- 10-foot intervals for slopes greater than 40 percent

Topography must be field verified for drainage easements and conveyance systems. Contours shall extend a minimum of 25 feet beyond property lines and shall extend sufficiently to depict existing conditions. If survey is restricted to the project site due to lack of legal access, contours shall be provided by other means; i.e., comprehensive drainage maps, etc.

Identify unit areas greater than 1 acre contributing to a conveyance or water quality treatment structure including offsite area. Show the following on the site map (or on a schedule) for unit areas: total project area; total impervious (new and replaced), pollution generating impervious, and total disturbed area; average slope.

- Conveyance data, identifier (for reference to model output), length, slope, inverts up and down
- Overland flow paths and distances

- Soil types as required
- Locations of soil pits and infiltration tests as required
- Spot water surface elevations, discharges and velocities for the design event

Schedule of Structures

Show the following information**:**

- Catch basin/manhole
- Street name
- Cross-street (nearest)
- Stationing
- Coordinate System (i.e., Northings and Eastings), if used
- Street side
- Catch basin/manhole diameter or size
- Invert in/out
- Pipe diameter in/out
- Type of each structure and pipe, i.e., Type II, concrete.

Plan and Profile Sheet

Show the following:

- Original ground line at 100-foot stations and at significant ground breaks and topographic features, with accuracy to within 0.1 feet on unpaved surface and 0.01 feet on paved surfaces.
- Typical roadway/storm drainage cross-sections when applicable.
- Existing and proposed drainage features, indicating direction of flow, size, and kind of each drainage channel, pipe and structure. The status of existing drainage structures must be clarified as either, “existing-abandon” or “existing-remove.”
- Final surface and storm drain profile with stationing the same as the site/grading plan sheets. Preferably reading from left to right, to show stationing of points of curve, tangent, and intersection of vertical curves, with elevations to 0.01 feet.
- Surface grade and vertical curve data; roads to be measured at centerline.
- Datum and all bench mark information shall use established U.S.C. and G.S. control or CBJ bench marks when there is an existing bench mark within one-half mile of the project.
- Vertical scale 1 inch = 5 feet. Clarifying details may be drawn to a convenient scale. Use 1 inch = 10 feet for vertical scale when horizontal scale is at 1 inch = 100 feet.
- When roads end at a property line, the existing ground profile shall be continued a minimum of 200 feet to show the proposed vertical alignment is reasonable.
- When intersecting road profile grades have a difference of 1 percent or less, a vertical curve is not required. All other vertical grade intersections will require a minimum 50-foot vertical curve.

Pollution Source Control

Pollution source control is the application of pollution prevention practices on a developed site to reduce contamination of stormwater runoff at its source. BMPs and resource management systems are designed to reduce the amount of contaminants used and potentially discharged to the environment. The pollution source control section of the plan shall incorporate the relevant information found in Chapter 3 of this manual.

BMP Design

Identify pollutants of concern anticipated in runoff from the site. Provide discussion of BMP selection including rationale for why a particular BMP was selected. Provide calculations demonstrating that water quality BMPs are sized to the water quality design event.

Maintenance Plan

The importance of maintenance for the proper functioning of stormwater control facilities cannot be over-emphasized. A substantial portion of failures (clogging of filters, resuspension of sediments, loss of storage capacity, etc.) of such facilities is due to inadequate maintenance. At private facilities, a copy of the maintenance plan shall be retained onsite or within reasonable access to the site, and shall be transferred with the property to the new owner. For public facilities, a copy of the plan shall be retained in the appropriate department.

Should proposed maintenance differ from that shown in the BMP descriptions the project engineer will prepare a maintenance plan. The maintenance plan shall describe required type and frequency of long-term maintenance of drainage facilities and identification of the party (or parties) responsible for maintenance and operation.

Off Site Analysis

Provide calculations of peak runoff rates from the proposed project drainage basin for the 25-year event. Provide analysis demonstrating that the upstream and downstream conveyance systems and the proposed drainage structures can accommodate runoff from the 25-year event.

Other Permit Approvals

Any other permits obtained for the project relating to site development shall be submitted