Stormwater and Meltwater Management and Mitigation

A Handbook for Homer, Alaska

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A Handbook for Homer, Alaska

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Disclaimer

This document is meant as a guide for concept design and for general information only. Anyone using this guide assumes all liability arising from its use. Any references to brand names or manufacturers are for reference only and are not an endorsement by the City of Homer or the authors.

Introduction

This document is intended as a design resource for property owners, developers and contractors. It provides a summary of stormwater concepts and considerations, and should be used to guide the design of a property to limit stormwater impacts. The information below should be applied during preliminary design to integrate proper stormwater controls as part of overall site layout, whether required or simply as good practice. If required by regulation, the final specification of the stormwater management system must be certified by an engineer, but initial sizing and proper site organization can be laid out by the site designer or owner using the information in this guide.

Permanent stormwater management covers a variety of systems from the placement, sizing and connections between site drains and local storm sewers, to passive systems that reduce or hold stormwater on-site in plantings, ponds and holding structures. This guide covers permanent ***passive systems*** that manage and mitigate stormwater onsite to limit the overall hydrologic impact of a development.

> ***Passive Stormwater System***
>
> Stormwater control structure, such as a rain garden, rock bed, swale or pond that acts to slow water flows, drop sediment, and slow release or hold water during a rainstorm event.

This guide will show you how to evaluate existing site conditions, and then size and design your site modifications with permanent on-site stormwater management in mind. Through good site design techniques, the size and expense of engineered stormwater systems can be minimized, and overall stormwater control function will be more successful. This booklet covers the following topics:

Chapter 1: Stormwater - An overview
Chapter 2: Site planning for stormwater management
Chapter 3: A review of structural stormwater controls
Chapter 4: Project site analysis and predicting hydrologic function
Chapter 5: Selected structural stormwater controls in detail

This document is about permanent on-site stormwater management, including the requirements for a City of Homer Stormwater Plan (SWP), and does not cover the topic of sediment and erosion control during construction. There are a variety of documents that cover BMPs, or Best Management Practices during construction, including:

- *Alaska Storm Water Pollution Prevention Plan Guide*. Alaska Department of Transportation and Public Facilities.
  http://www.dot.state.ak.us/stwddes/dcsenviron/assets/pdf/swppp/english/eng_guide_all.pdf or
  http://www.dot.state.ak.us/stwddes/dcsenviron/resources/stormwater.shtml#
- *Developing Pollution Prevention Plans and Best Management Practices.* United States Environmental Protection Agency.
  http://www.epa.gov/npdes/pubs/sw_swppp_guide.pdf or
  http://cfpub.epa.gov/npdes/stormwater/swppp.cfm.
- Requirements listed in the City of Homer *"Standards for a Development Activity Plan."* HCC 21.48.060(e) and 21.49.060(e).

Chapter 1 - Stormwater - An overview

Understanding stormwater principles is key to understanding stormwater management. Stormwater runoff is a natural and important process, and development has direct effects on this process. To best explain the concepts in this document we will review some basic principles and describe not only what happens on an individual property, but how local stormwater effects influence the larger system.

The primary negative impact from development is an increase in the volume of surface runoff, and mitigation of this impact is the main topic of this handbook. Runoff includes both storm generated flows and snowmelt. Though we will address the unique concerns of snow and snowmelt in some sections of the document, the term *stormwater* is primarily used, and should be understood to include runoff from both rainfall and snowmelt.

Key term definitions:

This is a list of commonly used terms in this document. Other terms and concept will be described throughout the text, and a larger glossary is included in appendix A

Hydrology n. the study of the earths waters, their distribution, and the cycle involving evaporation, precipitation, etc. (Webster)

Infiltrate v. to filter or pass gradually through, to penetrate **- Infiltration** n. (Webster) As in, water penetrating and passing into/through the soil.

Impervious adj. Incapable of being penetrated, as by moisture (Webster)

Intercept v. to seize or stop in its course **– interception** n. (Webster) As in, a plant seizes or stops the movement of water/rain.

Mitigate v. to make or become less severe, **-mitigation** n. (Webster) such as making runoff less severe by implementing a stormwater management system.

Attenuate v. to lessen or weaken - **attenuation** n**.** (Webster). As in, lessening the rate and/or volume of stormwater runoff or peak flows.

Runoff n**.** Water that flows on the surface of the ground or other terrestrial surfaces.

Hydrologic Cycle

Hydrology is the study of water movement. The hydrologic cycle is the endless circulation of water within the environment (see Figure 1) from water bodies to atmosphere and back again. Water takes various forms during this cycle, such as clouds, rain, snow, subsurface flows, creeks, lakes, oceans and water vapor.

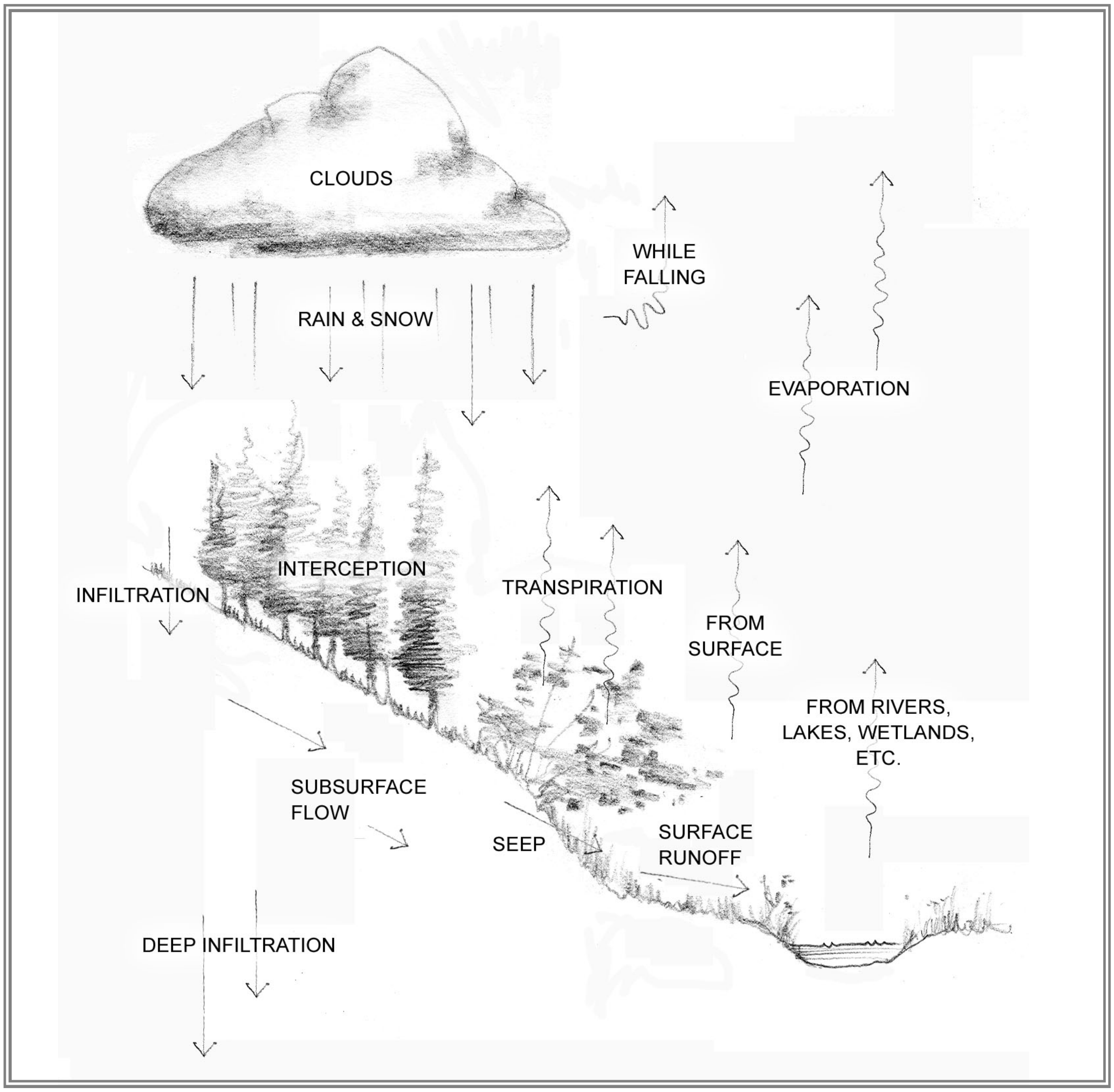


Figure 1 – Hydrologic Cycle

This document is concerned mainly with the dynamic flows of rain- and surface-water. Rain water flow is generally described by three paths: *absorption* by soil, which infiltrates into the water table, evaporates or flows in subsurface water; *interception* by plants and other surfaces, never reaching the ground, but instead directly evaporating from the wetted surface; and *overland flow*, or runoff.

In a natural vegetated condition, a high percentage of rain is absorbed or intercepted, and overland flow is slowed and held by plants, soil and surface roughness, then either evaporates or slowly flows into local wetlands, creeks, water tables and aquifers through surface and subsurface flows.

Watershed

When discussing runoff and where it goes it is important to understand the concept of a *watershed*. Watersheds are areas of drainage bounded by ridges. A watershed can be described as the land area that drains into a local water body such as a creek, lake, river, or ocean.

Larger watersheds are defined by rivers or lakes and have many sub-watersheds, or smaller drainage areas that can be defined for any point for a more detailed analysis. For an individual property this might include the local area draining into a culvert. For municipal stormwater management this might include the entire area that drains into a local creek, ditch or storm sewer. Sub-watersheds eventually connect downstream with other drainages from other sub-watersheds to a larger drainage channel, river or water body. At the largest scale, North America is divided into two watersheds that drain into either the Pacific or the Atlantic Oceans, separated by the Continental Divide.

A clearly defined and important watershed in Homer is the Bridge Creek Watershed, where all the water that falls within the surrounding ridges flows into and is held in the reservoir as Homer's municipal water source.

Because local drainages have formed, or are constructed in relation to the size of their watershed, it is important to understand that all effects within a watershed are cumulative in their impact on that drainage. A change at any point upstream is felt at every point downstream. Because of these connections within a watershed, everyone upstream has a responsibility to those downstream.

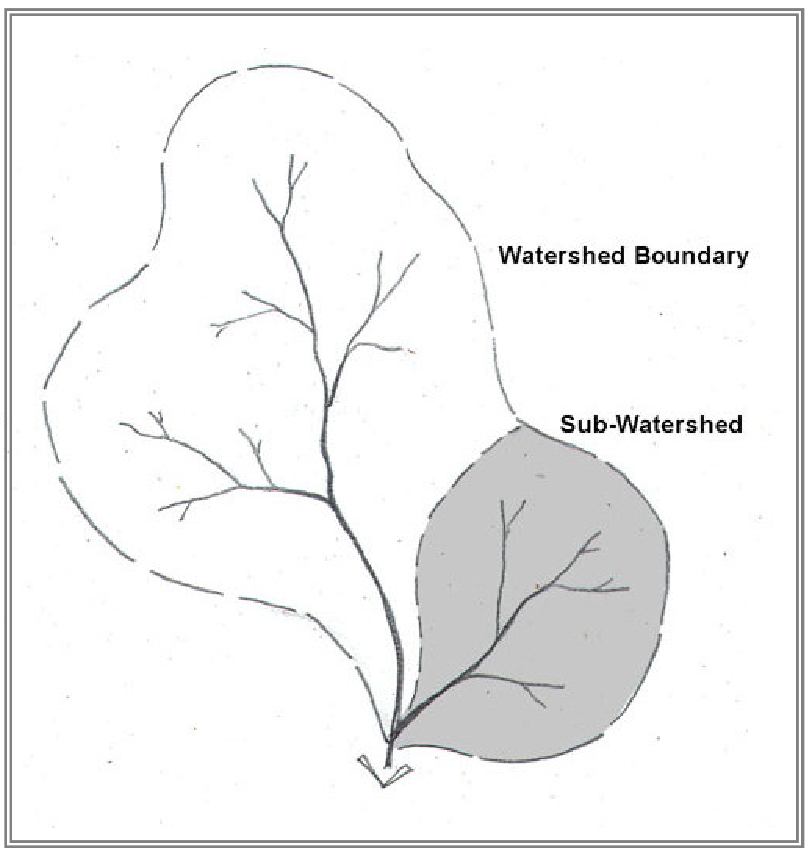


Figure 2 - Watershed

The Hydrograph

A Hydrograph is a graphic tool used to describe stormwater flows (see Figure 3). The graph plots the rate (volume per second) of surface runoff exiting a watershed for a particular intensity and duration of storm, and its shape is related to the characteristics of the watershed.

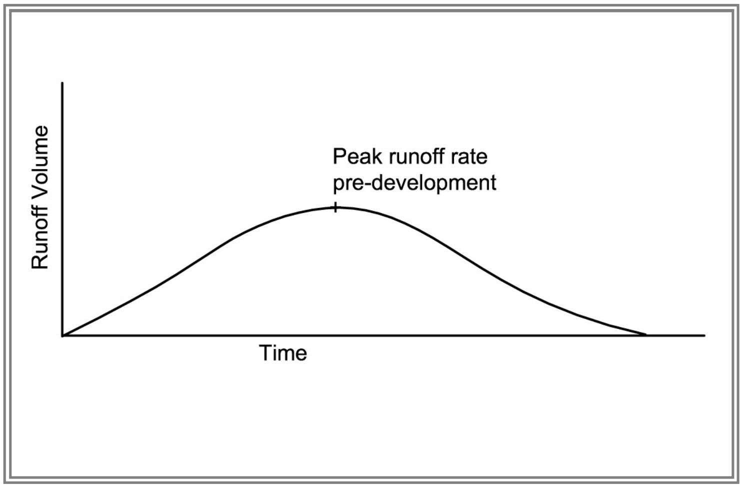


Figure 3 - Hydrograph

The bell-shape of the curve shows that initially the runoff volume is low, as much of the rainwater falling in the watershed is absorbed, detained or intercepted by the ground or vegetation. As the surfaces become saturated, more and more water becomes runoff, and the flow rate increases.

The peak of the graph, or the *peak runoff rate*, is the highest flow rate that will be reached during that particular storm event. After the storm ends, the rate of stormwater runoff will slowly decrease as the remaining water flows out of the watershed or is further absorbed.

Because the shape of the curve, whether it is flat or steep, is related to how much water is absorbed or detained after it hits the ground, any changes to these surface characteristics will affect the peak rate and how soon that peak is reached.

Development – downstream effects and upstream responsibilities

Development impacts the hydrologic cycle in a variety of ways, primarily by causing a significant increase in the amount of rainwater that becomes overland runoff, and the flow rate of that runoff. This is caused by an increase in impervious surface such as buildings, roads and driveways, and by ground compaction. When impervious coverage is increased, surface runoff volume increases and this water volume reaches local water bodies, streams and municipal management systems much faster. The removal of trees, plants and topsoil also reduces interception and absorption rates.

These increased overland flows lead to cumulative 'downstream' effects including increased flooding, erosion, sediment transport and water pollution. The larger the area of impervious surface and the more connectivity between those surfaces (roof to driveway to street, to storm-sewer pipe, etc.) the higher the volume and speed of overland flows and its cumulative effects. This increased flow rate compounds the effects of the increased volume of water by compressing the quantity of water passing a given point into a shorter period of time. By arriving at a stream or storm sewer all at once, instead of slowly over a long period, the capacity of that transport system may be overwhelmed by much smaller storm events than prior to development.

Figure 4 compares generic hydrographs for a typical pre-development and a post-development condition. In the post-development graph, a higher percentage of impervious surface area leads to an increase in the total volume of water exiting the watershed (larger area under the curve). The increased velocity of that runoff is shown by the location of the peak of the curve, it occurs earlier in the storm (time scale).

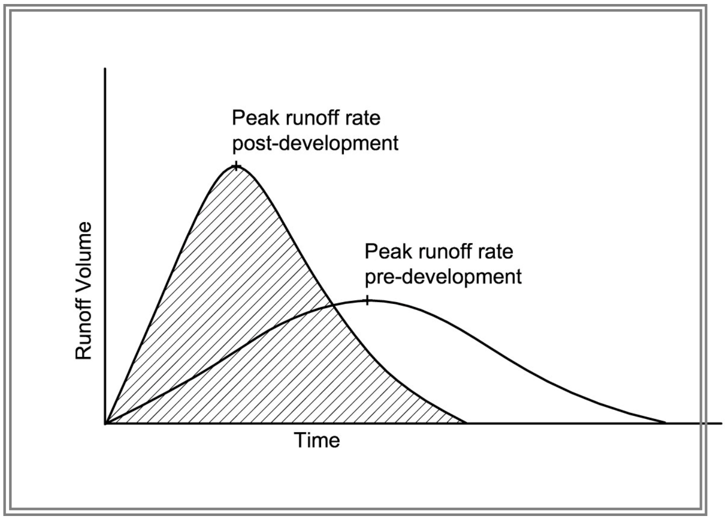


Figure 4 - Post Development Hydrograph

This steep narrow curve of high runoff rate is indicative of higher flood and erosion potential due to the higher velocity and quantity of water. Good site design strives to manage stormwater on-site to minimize these cumulative hydrologic impacts.

Ideally, the pre- and post-development hydrographs should be the same, limiting impacts on the local site, to neighbors and to the larger watershed. This is possible, even in high-density development, using the proper site design techniques described later in this handbook.

Streams and Lakes

Streams and lakes are also affected by runoff through increased erosion and the transport of suspended solids and chemical pollution. The amount of earth, sand, or other material the water can pick up and carry is directly proportional to the volume and velocity of the runoff. This means two things:

First, higher runoff volumes and rates will pick up more of the soil that makes up the structure of the drainage, which is called erosion. Increased erosion can lead to structural changes in steam channels, increasing the risks of slope failure and flooding, and damaging the functionality of stream channels and water bodies. If incised through erosion, a stream channel can become disconnected from its natural overflow area, or floodplain (see Figure 5), further accelerating flow rate and volume downstream, compounding erosion problems and downstream flood risk.

Second, eroded material from upstream must eventually be deposited somewhere downstream. This occurs where flow rates slow and allow the water to drop its sediment load, normally in pools, ponds, lakes, reservoirs and bays. Increased deposition can cause structural changes, such as reducing the holding capacity of the water body, or plugging flow ways or navigable waterways and increasing maintenance costs. Sediment and runoff from a developed environment usually carries increased levels of pollutants that can be damaging to reservoirs, spawning pools and other valuable water resources.

Water quality

Increased runoff and sediment loads can affect water quality directly and indirectly. Runoff, particularly from a developed area, carries a lot of pollutants including oil, grease, and other vehicle fluids, fertilizers, herbicides and pet waste. Pollutants and sediment can cause problems for local habitat health through direct chemical contamination, or by changing the nutrients and oxygen levels in the water.

Increased sediment and pollutant loads typically lead to high nutrient levels and decreased oxygen content, which can result in the overgrowth of aquatic plants or the inability for a lake to support fish life. While this may reduce the viability of a water body for resource production, it also often leads to increased maintenance costs.

Wetlands and Riparian Areas

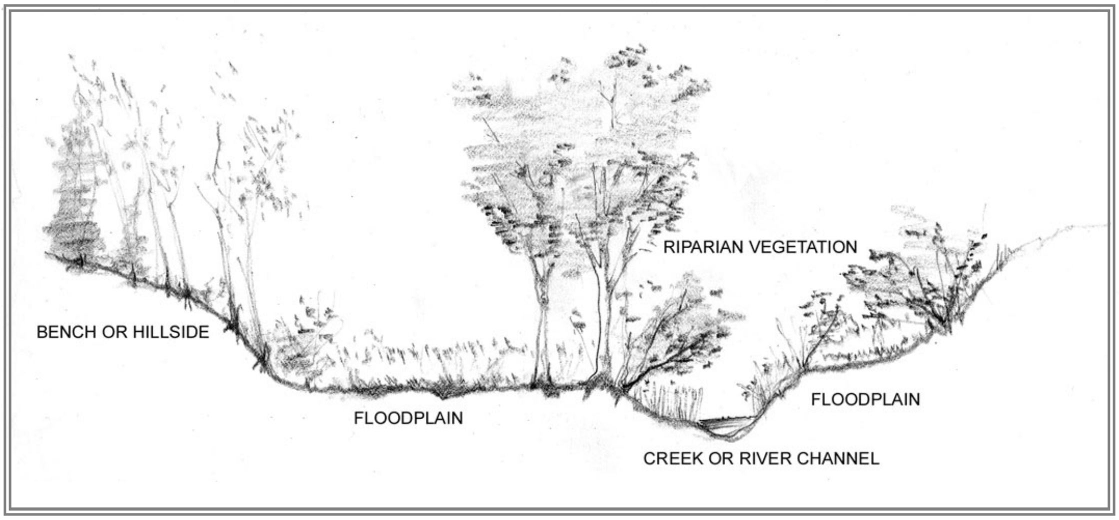


Figure 5 - Riparian section showing floodplain

Wetlands are extremely important for the control of stormwater flows. Wetlands are commonly misunderstood and thought to be a nuisance and are assumed to be areas that are always wet or have standing water. Wetlands act essentially as sponges, able to soak up large quantities of water and release it slowly over time. Most wetlands are wet most of the time, but there is often seasonal fluctuation water moving into, through and out of a wetland.

Scientific studies of how wetlands function for stormwater control have noted that wetlands reduce the magnitude of peak flows and associated flood stages, and delay the release of water during storms (Adamus, USFWS). Wetlands also buffer the effects of stormwater by filtering pollutants, allowing the release of sediment loads, and moderating the temperature of water entering riparian areas and lakes.

Groundwater discharge, a common feature of the Homer landscape, is also moderated by wetlands. Over 45% of Homer's currently mapped wetlands are discharge slope wetlands, which occur at the border of upland-wetland fringes and are important in tempering that transition.

The role these areas play in stormwater treatment and control is therefore particularly important in populated areas where development can have obvious direct impacts to these systems. Changes in hydrology such as increasing or decreasing water flowing into or through these systems can radically alter their health. Within the City of Homer over 20% of its wetlands were filled over the past decade and many of these impacts have altered the functional connections between existing wetland ecosystems. Though wetlands and riparian areas seem abundant, complex and high in biological diversity, they are very sensitive to systematic changes.

Plants & Soils

Plants are a crucial component to slowing and filtering runoff. They intercept and absorb rainwater, support the structure and chemical exchange capacity of the soil, and generally reducing the amount and slowing the velocity of runoff. Trees are especially important in limiting runoff, as their many branches and leaves will intercept rain, the roots contribute to soil structure and increase infiltration capacity, and roots themselves directly uptake water. The forest contains a huge amount of interception potential because it is organized vertically, as well as horizontally. This includes not only trees but many layers of undergrowth and a base of organic and decaying material that intercepts and slows runoff.

As a very efficient and free stormwater management structure in its own right, existing vegetation should be preserved as much as possible, either in place or transplanted or stockpiled for future use.

Plants can be especially good at reducing runoff volume and rate, as well as reducing sediment and pollution concentration. When planting new areas, native plants are often the best choices as they are already adapted to native soils, climate and hydrology. You may have to select plants carefully if you are planting next to areas that are salted in winter, such as sidewalks and parking lots. In addition the species and management of the selected plants can attract or discourage wildlife from the area. Avoid planting any known or potential invasives; water can be a vehicle for quick spread.

Shore and Bluff

Stormwater runoff also contributes significantly to bluff erosion. Surface runoff down steep bluff faces will directly cause erosion, but increased shallow subsurface water flows can also cause failure through slumping and erosion from increased soil weight. Erosion and failure can occur where shallow subsurface water seeps out of the bluff, and when subsurface water freezes and thaws in the surface of the bluff, often resulting in direct failure or undercutting along a shoreline.

Studies in Homer have suggested that groundwater content near the bluff is affected by disruption of subsurface flows or by filling of the adjacent wetlands and peatlands, and other construction that has occurred along Kachemak Drive. Along the shoreline as well as other areas of Homer, increases in overland flows due to development have led to higher rates of erosion. Any development near these sensitive areas requires careful design and management of stormwater runoff, infiltration and subsurface flows.

Infrastructure and Maintenance

As mentioned previously, an increase in surface runoff can overwhelm natural and built drainage systems. Streams, lakes, flood planes and wetlands were formed naturally, over a long period of time, in response to normal runoff patterns. If good stormwater management techniques are not employed, development can impose radical changes in these patterns in a very short period of time. While the development of one lot may initially seem insignificant in its impacts, many small changes by many people can quickly result in large effects.

Standard practice for new development has been, more often than not, to get any water off the site as quickly as possible. While this moves stormwater off of the immediate site, it means that existing drainage channels must carry much more water in a shorter period of time. As more and more properties are developed in an area, the increased runoff rate and volume become more than existing systems can handle, overwhelming both natural and built infrastructure, and requiring additional public expenditures. By not taking responsibility for stormwater on-site, new developers are placing the burden on existing property owners and the general taxpayer for new infrastructure.

All of this should be considered in a fast-growing city like Homer that depends on natural drainages and smaller engineered systems. In Homer, increased impervious surface, reduced vegetation cover, and impacts to riparian corridors, wetlands, lakes and other structures have a significant impact to the overall municipal stormwater control infrastructure. The compounding costs and taxpayer expense in municipal stormwater infrastructure demonstrates the responsibilities shared by all inhabitants in a watershed. Proper stormwater management during new construction can avoid public cost at little or no expense to the developer.

Communities all over the country are realizing that their exclusive reliance on engineered municipal stormwater systems is financially unsustainable, and they have begun instituting requirements for on-site stormwater management. For these communities it is often too late to preserve natural control infrastructure, but Homer can still avoid that long-term expense.

Regulations – public influence over public effects

Because the effects of development become evident only when compounded to effect public services costs, centralized regulations are usually the only way to institute a comprehensive stormwater management plan. In most cases these costs are local and influence the creation of local regulations on development that minimize public costs. Federal regulations, derived from the Clean Water Act also exist to protect navigable waterways and the nation's water resources, and apply to projects over an acre in size. Federal and local regulations are summarized in Appendix C.

A number of ordinances in Homer City Code address stormwater management for properties of all sizes. The most stringent local regulations are in place to protect the community water supply. These codes are in place for any property development within the Bridge Creek Watershed, and are a good example of watershed-based planning.

Proper site design for stormwater can usually be integrated into other desirable landscaping. Most cities, Homer included, also have landscaping requirements in their codes. As you will see in Chapter 2, on-site stormwater management can usually be incorporated into these other site-planning requirements to minimize additional demands on building area. When preparing a site plan, always take a comprehensive approach to minimize costs and maximize long-term private and public value.

Stormwater Specifics in Homer

Homer has particular characteristics that should be considered when formulating a strategy to manage stormwater. Due to the limited growing season and pH of soils, decomposition is slow in many of the vegetated areas of Homer. This results in a deep/dense layer of dead material on the surface of local soils. While much of Homer has underlying soil with a limited infiltration capacity, this layer of organic material is effective in absorbing and slowing large volumes of runoff.

While some water does infiltrate in areas of sandy or gravelly glacial deposits or through pervious subsurface layers, most stormwater continues slowly downhill in shallow subsurface flow. Wetlands are formed where there is a change in topography that slows or holds this shallow water flow long enough to create certain conditions of vegetation, hydrology and soil development. In other areas, surface and subsurface flows form a complex of minor drainages that divide the energy of stormwater into many small flows, rather than a few larger flows.

Because stormwater attenuation is distributed over a large area in Homer, it is particularly important to manage stormwater on each individual site, to minimize disturbance of vegetation, and to preserve wetlands and riparian areas. The many steep slopes in and around Homer are also very sensitive to small changes in hydrologic flows. In Homer, individual impacts will appear to be very small, but their cumulative effect is much greater than in areas with more defined drainage systems.

<u>Chapter 2</u> - Site planning for stormwater management

Figure 6 – Preserved and enhances wetland at entry to Islands & Ocean Visitor Center

You are probably reading this handbook because you are planning to develop your property. This chapter is an overview of design and development strategies to help guide site planning and construction, and provides a checklist of what to consider (and why) to limit the impact of your construction on local hydrology and your pocketbook. By minimizing the impact of new construction on existing site hydrology, you will also reduce the size and expense of any needed structural control measures, as discussed in chapter 3.

Since it is not possible to control the rainfall rate, and the size of your property will not change, your site will have to manage the same quantity of water after development as it did before. The goal of a good stormwater plan is therefore to retain or replace the moderating characteristics of the site prior to development.

To accomplish this, it is first important to plan the site to minimize impacts to existing surfaces with *low runoff rates* and beneficial functions as much as feasible, such as permeable soils, peat lands, and vegetated areas. Beyond that there are some basic design and construction techniques to limit possible impacts and minimize the requirements of a constructed stormwater management system. Finally, structural stormwater control elements can be sized and located to manage any remaining needs.

Site Design – retain important site function

☐ Preserve wetlands and riparian areas

Design around existing drainages and wetlands, and preserve and protect these areas through careful construction practices.

These natural features are very efficient at performing their hydrologic function, and it is difficult and expensive to replace the true function of these areas. The effectiveness of these areas is further enhanced by their connectivity within a larger-scale wetland or riparian complex, extending beyond the immediate property boundaries. This connectivity is very difficult or impossible to reproduce in a constructed stormwater management system.

Though development in wetlands is regulated by the Army Corps of Engineers under Federal law, it is best to avoid construction in wetlands for other reasons as well. Wetlands are important in the overall hydrology of a region and often an important habitat for many wildlife. Wetlands are also difficult and expensive to build on, the short- and long-term costs of developing on wetlands and reconstructing drainages can be very high. Wetland can serve an important economic function to the project by minimizing drainage infrastructure and development costs.

Instead of clearing these features to simplify construction, the site should be designed to utilize the areas to benefit the project. If it is necessary to develop on or near one of these areas, design to protect and enhance the remaining capacity of the wetland by filtering and buffering runoff before it reaches this area. Avoid designing site drainage that connects directly into an existing wetland or creek without first passing runoff through a buffer, swale, rock bed or other slowing and filtering structure. Locate buildings and driveways so the natural areas become a site amenity that is visually and functionally beneficial to the project as a whole. The construction cost savings and increase in property value can usually offset any losses in developable square-footage.

☐ Use established vegetation & soils

Plants are a crucial component in slowing and filtering runoff. Because of their importance in intercepting and absorbing rainwater, supporting the health and structure of the soil and vegetation should be a consideration. The site should be carefully laid out to avoid disturbing established vegetation and soil structure where it is most important.

Trees are especially important in limiting runoff and stabilizing sediments. With a complex structure of roots, branches and leaves they are verry efficient at mitigating stormwater runoff. Trees are very efficient and complex structures that take decades to establish. Trees that are preserved in their native context are much more effective than newly planted trees that lack size and complementary undergrowth and organic mat. Existing vegetation is also free.

When vegetation must be cleared, smaller plants and trees should be set aside for replanting, and all topsoil should be preserved or stockpiles as well. When replanting new areas, native plants are usually the best choices as they are already adapted to native soils, climate and hydrology. Avoid planting any known or potential invasives; water can be a vehicle for quick spread of these plants.

Protection of existing soils and vegetation during construction is an important consideration for the success of future landscaping and stormwater mitigation. Storage of construction equipment and construction materials on areas to be preserved (except in frozen winter conditions) will damage, compact or otherwise limit the water storage capacity of the soil, reducing soil permeability and its ability to support vegetation. Prepare a detailed site plan for staging and equipment access, stake and fence areas to be protected and provide this plan to the contractor.

Key places to retain native vegetation are around drainages, on slopes, between developed areas and wetlands, and downstream from large impervious surfaces such as parking areas. These areas usually also provide a desirable aesthetic amenity which complements the stormwater function and integrates the project into the native site.

Site Design – strategies for an effective site plan

☐ Limit fill, ditching, and site de-watering

Water control near a structure or driveway is an important consideration in any building project. Ditching and dewatering should be limited to only those areas of the site that need it. Ditching at the edge of a property takes the entire property out of the hydrologic system and will impose additional stormwater control requirements both onsite and somewhere downstream.

When ditching is necessary, consider construction the ditch like a stream with meanders as well as wide and narrow areas that will reduce flow velocities. This can be an attractive feature integrated into the site landscaping. Slow the water prior to it exiting your site or entering a main drainage channel by reintegrating the water into a natural or constructed on-site retention area. Natural areas would include existing wetlands, swales, ponds or heavily vegetated areas. Constructed systems are discussed in chapter 3, and may include ponds or basins to incorporated into your ditch layout.

☐ Limit impervious surface area

Carefully design your site and site elements for efficient function that minimizes the amount and size of impervious surfaces such as roofs, driveways, etc. Impervious surfaces are of very little or no benefit in the control of stormwater, and will put an additional runoff management burden on other areas of the site. Limiting the area in impervious surfaces will limit your impact to existing natural function, and reduce the need for additional structural stormwater controls.

☐ Limit connections between impervious surfaces

Try to limit direct connections between impervious surfaces, such as roof-to-parking or parking-to-street. As much as possible, impervious areas should be drained independently into buffer or management areas.

This can be done by placing buffers and management structures between or along the impervious surfaces to capture, slow and filter runoff. Vegetated areas between or alongside impervious surfaces can collect and limit the volume and velocity of runoff. Other areas of runoff concentration such as roof downspouts and parking areas can be directed into landscaping and or other vegetated stormwater features.

Again, the smaller the impervious area to be managed, the smaller the smaller the impact, and the management strategy needed.

☐ Slow runoff and dissipate energy

Natural landscapes are complex, both is physical nature and in scale. This complexity in the form of wetlands, creek and stream meanders, pools and riffles, distributes the energy and sediment concentration of stormwater over a large system, preventing the system form being overwhelmed if any single structure is overwhelmed. This concept can be used in general site design and when designing specific stormwater controls.

In constructed systems, a series of smaller elements is often more effective than one large structure. In a system, each element will increase the effectiveness of the next. Each slowing area will increase sediment and pollution drop-out and have a shared impact on water volume and rate of the water exiting the system. This can also help reduce maintenance needs, often limiting maintenance to only the upstream catchment basin. Multiple elements will also increase cold season function by trapping runoff or meltwater in the secondary basins when the first basin freezes, and allowing for snow storage without impacting the entire stormwater system. Multiple smaller basins or treatment systems will be less impactful visually, more closely resemble the natural look and function of the site.

☐ Design a sensitive grading plan

Homer code requires that new development have no negative impact on neighboring properties. Impacts such as runoff and erosion, as well as impacts to existing trees are often concerns that need to be considered. Long-term damage can also occur due to saturating or dewatering neighboring soils through changes in surface and subsurface water flows. A sensitive grading plan will preserve existing hydrologic flows (drainage paths), blend new topography with neighboring contours, and retain subsurface conditions with protected construction buffers.

Slope grading has a significant impact on runoff and infiltration. Reducing steep slopes (especially on impervious surfaces) and creating breaks or vegetated buffers on steep slopes will reduce the rate and concentration of surface runoff. If the property is on a medium to steep slope (10% to 20%) try to incorporate multiple stormwater management systems. In general, limit the amount of area re-graded unless the grading is beneficial to stormwater management.

During finish grading the top surface of soils should be scarified or tilled to help vegetation establish more easily. A thick layer of mulch added to graded areas will help reduce runoff, erosion and improve soil building. Avoid compacting areas that do not require compaction for structural reasons. Most importantly, when initial grading is performed, the organic and topsoil layer should be scraped and stockpiled for use in landscaped areas. This layer is extremely valuable for future soil and plant heath as well as reducing runoff, and can be expensive to artificially construct or purchase from off-site.

Soil compaction by vehicles and construction equipment can also reduce the permeability of the soil and its ability to transport water and support plants. Designers should specify protective fencing, designated staging and stocking areas and other protection and remediation measures in the construction plans and specifications. Protective fencing should be installed around areas to be protected prior to the beginning of construction, and/or specifications for soil remediation after construction should be implemented.

☐ Maintain connections beyond your property

In planning site hydrology you should understand the site in the context of the greater watershed. Whether it is planned or not, there is a hydrologic connection between the site and its watershed beyond the property lines, and you should consider exactly what these connections are.

Factors to consider include plant systems, topsoil and subsoil continuity, habitat, greenway, and trail connectivity, wetlands, and of course any defined waterways or drainages. Specific plant communities and wetland or riparian areas are also important for wildlife as food, water, shelter, and travel corridors, and often do not function if disconnected from the larger network.

Think of how the development of your property will impact or improve connectivity across and between yours and your neighbors' properties. Try to maintain a viable connection across the site to points and systems that were connected prior to development.

Site Design – cold climate considerations

☐ Freezing – winter conditions

It is important to remember that 40% or more of the precipitation in Homer occurs during the winter when the ground is frozen and functionally impervious. Special considerations must therefore be made for snow storage, winter rain, and spring melt management.

Multiple structural stormwater elements placed in succession is a good way to increase winter effectiveness. Multiple treatment areas will allow runoff to be slowed and allow water to bypass frozen and/or full areas without bypassing the entire system. Frost heave concerns may require ponds, basins, and swales to have buffers between pavement and the water holding or conveyance area. Any system designed to hold or convey water should be designed to move water in freeze thaw conditions.

Surface treatment systems, such as swales and stormwater basins usually continue to function at a limited capacity in freezing conditions. Frozen ground will essentially create an impervious surface condition. Surface roughness and dead or dormant plant material can still have a positive impact on slowing runoff and limiting sediment loads, but will have limited filtering capacity in the winter.

Around buildings, make sure the design does not encourage ice dams and glaciation, and safe bypass or overflow routes are considered. Any drain inlets or pipes need to be appropriately sized and placed to reduce the risks of freezing.

Since the frozen ground is impervious in spring melt conditions, this can cause some of the largest runoff events, and presents the highest risk of floods and infrastructure damage. A general recommendation is to oversize stormwater holding areas such as ponds and basins by 10% to 20% to accommodate ice and the higher runoff associated with spring melts. More precise sizing calculations are possible, as referenced in the bibliography.

☐ Snow storage and spring melt considerations

Figure 7 - SBS snow storage

Snow melt in urban environments can be highly polluted because it is mixed with road sand and exposed to air pollution, automobile exhaust and de-icing salts for a long period of time. Drainage and detention systems adjacent to parking lots, streets and snow storage areas should be carefully located and designed to slow and filter runoff, reducing flow velocities to encourage sand to drop out.

A detention basin or pond located below snow storage is recommended. Snow storage should not be located so that meltwater discharges directly into wetlands, creeks, streams, or surface waters. Snow should not be stored in/on/around trees and wooded areas as the sediment and salt pollution can damage vegetation.

Some landscape and stormwater structures can serve as snow storage areas in winter. However, it is recommended that drainages and ponds not be used for snow storage so that they can mitigate snowmelt and runoff during winter thaws and spring melt. Snow stored in drainage systems can cause ice-dams during melting and re-freezing, obstructing stormwater systems and primary drainages and creating flood hazards. A vegetated buffer area adjacent to a drainage swale or pond can serve as a snow storage area, allowing snowmelt to be channeled into the management system.

Site Design – other considerations

☐ Sighting of constructed stormwater management systems

Chapter 3 discusses constructed systems in more detail, but there are some general rules of thumb that should be discussed here for locating these features on a site plan. Any required stormwater plan must be approved by an engineer, but these guidelines will help you initially plan your site to avoid surprises and minimize additional engineering costs.

Constructed systems, including stormwater ponds, constructed wetlands, swales, vaults and filter strips, are usually the last line of stormwater control before runoff is allowed to exit the site. With this in mind, these structures will normally be placed at the lowest point of the lot or below the area of the lot developed.

You should never design any feature that will pool or hold any water -for any amount of time - over or immediately adjacent to a septic system. All systems designed to pool or hold water should have a well-defined path of flow and be sized adequately. Large holding ponds should not be designed immediately uphill of any habitable structure.

Do not remove large trees for the creation of a stormwater pond. Trees are very good at intercepting, absorbing and evaporating stormwater, and are probably better at managing stormwater that what you might build. Avoid damaging tree roots and soil within the drip line.

When constructing and grading a formal stormwater control structure, irregular edges and gentle slopes will have a more natural look. A careful balance between function and aesthetics should be considered so that the stormwater element becomes an integrated landscape element.

☐ Maintenance considerations

Maintenance requirements should be considered when designing your stormwater system. Plant choice and arrangement can reduce required maintenance. Maintenance may include dredging or removing sediment build up in basin areas, or the occasional removal of plant material and accumulated sediment with subsequent replanting. The frequency of sediment removal depends greatly on the amount of sediment carried into and settled out of the runoff, as well as the use of forebays or one large basin. If the basin is well-vegetated the sediment accumulation may not be obvious and removal will require mowing and or control of vegetation. Sometimes it is useful to install a depth gage, or a layer of pea gravel to help keep track of the original designed bottom of the basin.

The use of filter strips, forebays, multiple chambers or sub-chambers will often limit regular maintenance to the initial sedimentation area. Systems should be inspected in late spring or early summer, and should be maintained and repaired as necessary to be ready for late summer rains. Polluted sediment and sand from snowmelt should be collected from melt areas every spring/summer. If your site is a large commercial property you may want to consider preparing a maintenance manual for the lessee or maintenance crew.

Other maintenance will include occasional mowing or thinning of plant material. Plant material usually increases the function of a basin or swale, but very thick growth, and or a large amount of accumulated plant debris will reduce the holding capacity.

☐ Parking lot design

Pavement is one of the major contributors to high rates of stormwater runoff, but gravel parking lots are often similarly impervious and responsible for much of the mud, dust and silt contained in urban runoff. While it is preferable to minimize the area of paving by using pervious gravel surfaces or pavers, it is very important to design these parking areas well to avoid contaminating runoff.

For low-density residential areas, gravel surfaces are an economical option for parking areas. On these properties there is usually enough space to plan for a swale or vegetated border around the parking area to filter runoff before it enters a ditch or drainage. Preferably, the paved area is small enough that runoff can simply be directed into vegetation, and not sent to a ditch. If low-fines gravel is used, the gravel surface will be more pervious, and will contain less silt and sand to contaminate runoff. A well-graded mix (both small and larger aggregates) will create a dense, asphalt-like surface, but fines can wash out, and puddles can become mud wallows if not well-maintained.

Disconnecting impervious surfaces is always recommended. Grading and layout should include runoff catchments and filtering prior to releasing water into storm drains, ditches, creeks or wetlands.

In commercial areas parking tends to be paved with asphalt or gravel. Careful planning and layout of driveways and parking layout will maximize function while allowing a minimum amount of paving. In larger parking lots (over 24 spaces), Homer code requires landscaped islands among the parking spaces. These islands can be designed to catch and filter runoff as well as provide the intended aesthetic benefits. Shared parking between neighboring properties is a good way to create efficient parking areas, and can also allow sharing of stormwater management strategies. It is sometimes possible to design a limited number of paved parking spaces, and to consider pervious surfaces such as coarse gravel or geocell-reinforced soil on the spaces that are infrequently used.

☐ Streets and arterials

There are a great variety of examples of passive stormwater systems that can be incorporated into city streets, often also enhancing safety and being a visual amenity. Portland Metro is a good initial source of information. Main considerations include limiting paved width where possible, thereby limiting impervious area. In addition many cities are beginning to limit direct connection of curb and gutters to storm drains. A curb Gutter drain can be directed under the sidewalk to a rain garden or detention area. Or, Bulb outs, often used for traffic calming, can be planted and used to slow and filter stormwater from a curb and gutter system. In both these cases there should be an overflow drain either to a storm sewer, or other conveyance structure to prevent any flooding or similar hazards.

Figure 8 - Curb and gutter directing runoff to a rain garden in Portland, OR

Site Design - Examples

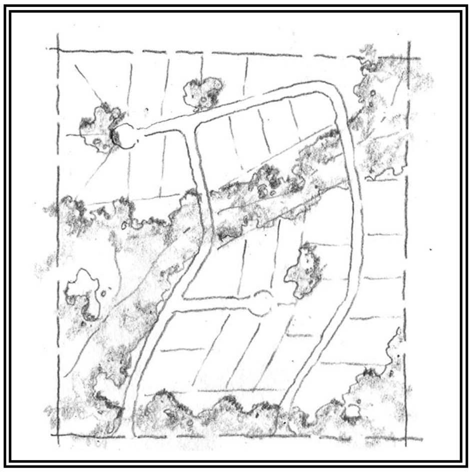
Here are a few examples of low impact development plans that show post development layouts that consider the techniques discussed above. Examples are included for a subdivision and a commercial lot. The sample layout procedures apply equally well to lower-density residential properties. Your property will probably include techniques from one or more of these property types, depending on development density and land character.

Example One - Subdivision:

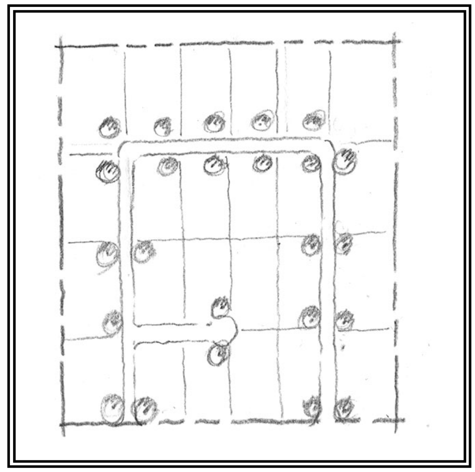
When subdividing a parcel, it is worth laying out new lot lines with some sensitivity to the larger landscape systems on the property. Designing around significant vegetation, drainages and topography will not only limit the development impacts of the individual lots, but also result in all the lots being equally developable. Development costs will also likely be lower if natural drainages are utilized, and lots are usually more valuable when integrated with natural features.

In the example below the site has an existing drainage corridor and wetland area. While these are only seasonally wet, they have associated forest cover and riparian vegetation, and are very valuable for stormwater management, habitat, and aesthetic value. Both layouts below contain the same number of lots and the same length of road.

In example 1a, the riparian areas, drainages, and wetland areas are preserved and in turn the lots made smaller by about 10 percent. This technique is often called cluster development or a conservation subdivision. Preserving these areas will be very valuable to manage the increased runoff from development of the streets and individual lots. They can also function as public greenways and parks with the potential for trail development becoming a neighborhood amenity. They also create visual and physical separation between some of the properties, allowing a greater sense of privacy. Other considerations include keeping street width to a minimum, thereby limiting the impervious coverage.



Example 1a – Stormwater design



Example 1b – Standard design

Example 1b shows a standard grid development, where the entire area is cleared and graded with wide streets and limited landscape planting. Not only does this greatly increase runoff, but drainage infrastructure will have to be extensive to manage runoff when the roads are built and as the area is further developed. In addition there is no sense of individuality or privacy from one lot to the next.

Example Two - Commercial:

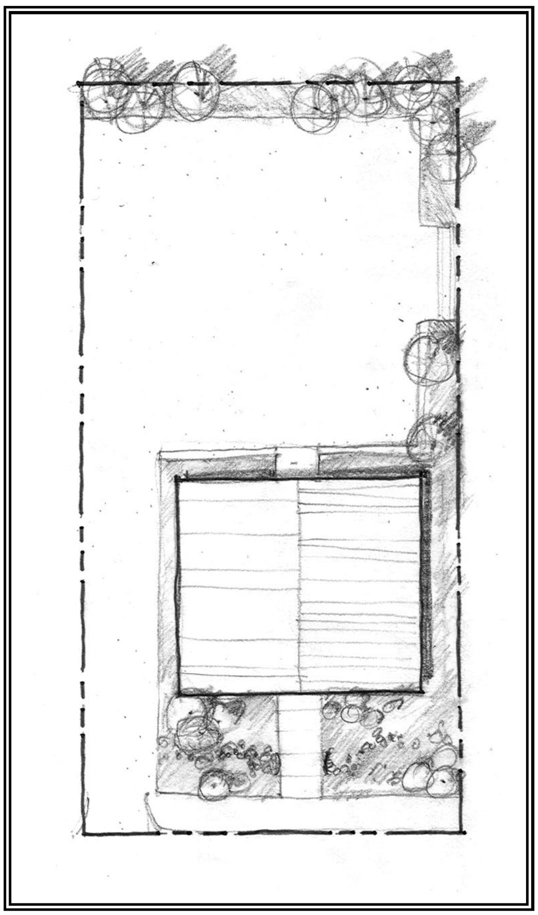
In this example we will look at a standard commercial lot, 75'x150' sloping from the rear to street-front (top to bottom of picture).

Standard development (example 2b) often places the parking in front of the building for reasons including setback restrictions and parking ratios. However, this results in a large paved area, contiguous impervious surfaces, and no landscaping breaks before runoff exits the lot. Roof runoff flows directly onto the parking area then directly across the sidewalk and onto the street. This generates a large amount of runoff that exits the site very quickly, also resulting in high suspended solid and pollutant loads in the runoff. Contiguous paving right up to the sidewalk also makes for a very exposed and somewhat unsafe environment for pedestrians. This is a fairly typical development plan for many existing Homer lots, but does not meet current code requirements.

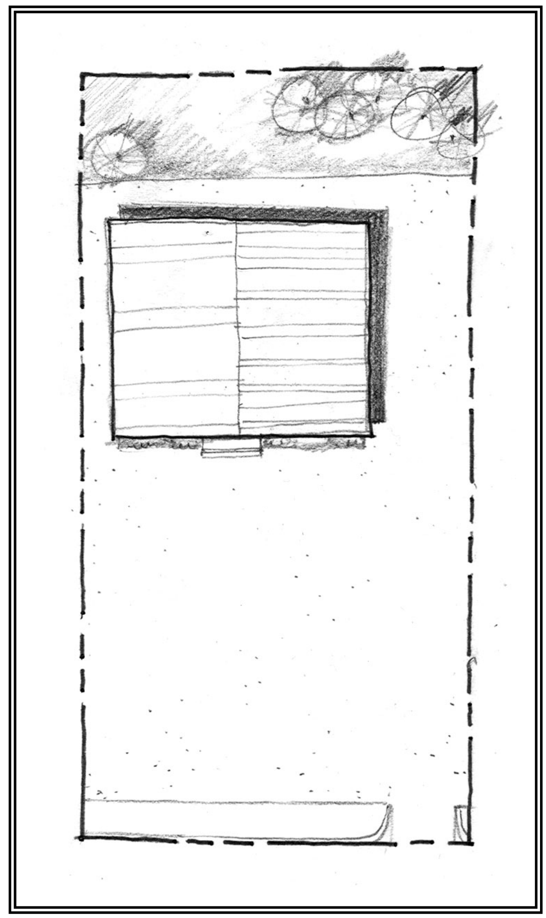
Developing the site in a manner that follows the recommendations described earlier in the chapter might result in something similar to that in example 2a. In this example the building is placed toward the front of the lot for visibility, with parking behind. The setback area, usually used for parking, is here used for a stormwater basin and required (and desirable) landscaping.

While this arrangement may seem to allow for less parking, this creates a much more efficient design to meet stormwater requirements, and parking is not reduced. By coordinating with neighboring lots this could also allow for shared driveways and shared, double-loaded, pull-through parking for even more efficiency. Stormwater management can also be shared if neighboring lots are developed in a similar manner. This design has about the same amount of landscaped area, but the impervious surfaces drain *into* the landscaped area, greatly increasing the amount of time it takes for site runoff to exit the site.

Parking lot and roof drain in to landscaped swales that direct the stormwater toward the front of the property into a rain garden or detention area. The collection of the roof and parking runoff in the landscaped areas slows (by 20 minutes or more) and filters the runoff before it reaches the city infrastructure. In large parking lots, landscaped parking islands with curb breaks can also be used as filter strips and swales to collect, channel, delay and filter runoff. This layout meets code, and stormwater requirements are met by multi-purpose landscape, stormwater and setback compliance. This layout also creates a safe and aesthetic environment for pedestrians.



Example 2a - Stormwater design



Example 2b – Standard design

Chapter 3: *A review of structural stormwater controls*

Structural stormwater controls are intentional modifications of landforms to retain, slow and direct runoff to minimize flow volumes and velocities. The term also refers to large, artificial structures like underground storage cells, and smaller elements like rain gardens or filter strips. These intentional control structures are designed to mitigate stormwater flows efficiently, and to accomplish specific functions of slowing, retaining, detaining or infiltrating water, and/or dealing with sediment loads and contamination. Using the appropriate combination of site layout and stormwater management structures, it is possible to mitigate lost natural stormwater function on a developed site.

Figure 9 – Stormwater pond at Homer Public Library Peter Briggs 2006

These structures can be specified for the quantifiable needs of the site, using methods introduced in chapter 4. If your site is laid out according to the best practices in chapter two, you should have minimized the need for additional stormwater control measures, and the costs associated with their construction. Most sites, if developed to their maximum potential, will require some additional stormwater controls. This chapter lists some of these structures, what they do, and how to design them.

This section is a basic introduction to types and spatial requirements of various stormwater control structures that can be used on a site. Which elements you choose will depend on the area available on site, the functional need, and aesthetic desires. Most of these elements can be integrated into the existing landscaping plan to minimize additional costs and space requirements. An engineer should be consulted when a City Storm water Plan (SWP) is required, but with the following information you can make the initial decisions on sighting, spatial organization and rough sizing that will affect critical planning decisions.

Stormwater pond or basin

Stormwater basins or ponds are designed to permanently hold (retention basin), temporarily hold (detention basin) and/or infiltrate runoff. Slowing and holding of water allows sediment and pollutants to drop out of suspension and be managed on site. Ponds and basins can be gravel or rock-lined beds, or vegetated depressions.

The plants or rocks will facilitate sediment dropout, and plants in particular will help with active filtration of pollution. If infiltration is not appropriate at the site, a clay or synthetic liner should be installed. All ponds and basins should be designed with emergency spillways and/or bypasses in case of extreme storm events. Emergency bypass and overflows should consider snow and ice dam potential. When sizing the basin you may also want to consider possible future development and increased holding requirements.

Portions of a basin can also serve as snow storage if planned for that purpose. Melt water should be directed through the basin. For larger basins, public safety should be considered to ensure the hidden pond is not a hazard.

There are four primary types of stormwater ponds or basins:

- **Detention Basin**
  A detention basin is a large bowl type area that is designed to temporarily hold water. It is therefore seasonally wet, but is primarily a dry meadow, field or gravel bed. Since it is designed to temporarily collect and hold runoff during storm events it can also be a mowed grassy area serving a dual purpose as lawn or park green. Subsurface drainage beds can also be installed to increase warm weather capacity.
- **Detention or Retention pond**
  This is a pond designed to be wet year round. A *detention* pond has water year round but will temporarily hold more water during storm events, slowing the peak runoff rate and volume. A *retention* pond is designed to hold all water indefinitely.
- **Infiltration basins**
  These are stormwater basins, or ponds, that are designed specifically for infiltration. The location and soil profile is crucial (see testing recommendations on page 26). These are often designed to recharge a local water table or wetland complex, and can also serve as a buffer or filter for runoff prior to entering a local creek, river, lake, etc. These are very effective for filtering sediment and light pollutant loads. Careful vegetation selection can greatly enhance pollutant filtering and uptake (bioremediation). These should be carefully designed to limit pollutant infiltration into key water sources such as drinking water or fish habitat.
- **Pipe and pond**
  This is planned network of area drains that direct runoff via pipes into a stormwater pond that may be located remotely, even off-site. Occasionally a site layout restricts the possibility of creating a stormwater pond immediately adjacent to runoff concentration and collection. In this case, area drains are placed where needed to collect runoff and pipe it to a surface stormwater pond. This technique can be used to centralize stormwater management in densely developed areas like a subdivision or downtown. The pond at the Portland Pollution Control Lab (Figure 10) is an example of such a system, filtering water from an entire adjacent neighborhood before it enters the Willamette River.

Figure 10 - Portland Pollution Control Lab – pipe and pond

Stormwater wetland

A stormwater wetland is an intentionally-constructed wetland containing very specific plants and soils to either re-create a natural wetland, or to fulfill a very specific wetland filtration function. This is usually highly designed to ensure the establishment and function of appropriate plants and water levels, with soil structure and profile being an important consideration. Depending on the design and function, these wetlands can eventually fall under federal or state control as a jurisdictional wetland, in which case permits may be required to perform maintenance such as dredging.

Submerged 'wetland'

If standing water is a concern, careful design and engineering can create a submerged 'wetland'. These are usually a combination of gravel, sand and earth beds that collect and filter water just below the surface, basically creating a pervious soil with frequent or constant inundation. These are designed so that water moves through the subsurface media and either infiltrates or flows out of a designated outlet. Often planted with wetland plants for added filtering they can be very effective and visually pleasing. In cold climates the surface will remain frozen limiting surface water input and function to the depth of frost line.

Bioretention area – rain garden

An area of landscaping that collects, slows and filters stormwater. This is an excavated area that is back-filled with a pervious soil and planted as a garden or landscaped area. Plants chosen will need to be able to tolerate occasional or frequent inundation. If needed, an overflow drain can be incorporated as shown in Figure 8. In cold climates the soil surface will remain frozen, limiting surface water input and function to the depth of frost line.

Figure 8 - Rain Garden

Bioswale – vegetated swale or ditch

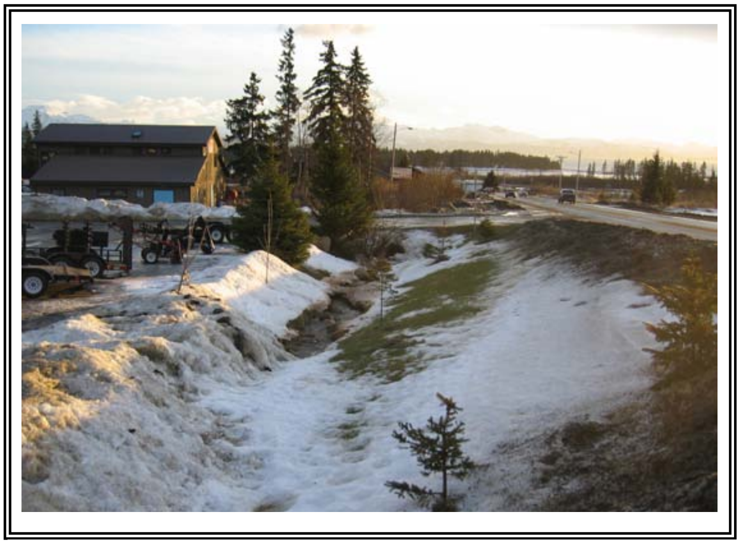


Figure 9 - Vegetated ditch at Lakeside Mall

This planted earthen conveyance ditch is usually used to convey surface runoff to a larger collection ditch or drain. Vegetation and soils, as well as shallow design grades and check dams help slow the water within the swale and increase sediment and pollutant filtration and local infiltration. This differs from a standard ditch in that it is wider than deep and fully vegetated. Steep sided ditches do not encourage slowing of filtering of sediment, and can add to sediment in the water with bare soil erosion. Depending on the soils a subsurface drainage material may be incorporated to limit surface ponding, increase long-term water storage (dry swale), and allow subsurface flows in light freeze conditions. This is a very effective method for pollution and volume control. A swale can serve as a snow storage area, but snow and ice dams may affect function. Careful consideration in the sighting and design should be made to limit frost heave in adjacent paving.

Filter strip

A filter strip is simply a planted area between an impervious surface and a ditch, pond or area drain. The rough surface slows runoff to encourage sediments and pollutants to drop out to be filtered by the plants and soils. This has limited effectiveness without careful planting and grading. However, thick planting with grasses or other ground cover makes this a very effective filter. However, a lawn that is maintained with fertilizer and herbicides is contrary to the intent of this management technique because it introduces additional contamination into the water.

A surface slope of less than 3% is desirable to properly slow runoff and encourage sediment to drop out. This area will have limited function during freezing temperatures, but becomes an excellent snow storage area. A filter strip adjacent to a pond, basin, swale, or drain is an effective management element that ensures the coldwater function of the adjacent structure.

Dry well or vault – subsurface detention & infiltration

A dry-well or vault is a formal, highly-constructed containment structures installed underground. Commercial products are available in concrete or cellular plastic that can support the normal weight of soil, pavers and walking or even driving surfaces. These can also be constructed as rock beds that are either open or covered with filter fabric and soil or gravel.

Depending on the existing soils and stormwater systems in place, these can be designed for infiltration and/or detention. These can range from small and simple buried cells that accept roof downspout drainage, to large, structurally reinforced areas below parking lots to capture runoff. Drywells and vaults must be engineered to ensure appropriate soil infiltration, soil and structural stability and design lifespan, and inlets and overflows must be properly sized to avoid early failure or structural damage.

Infiltration structures

Infiltration systems should be carefully considered in Homer. Most Homer soils have very low permeability, and soil tests are usually necessary to plan and locate infiltration that is appropriate and safe on your site and will limit impacts to adjacent sites. Ideally when infiltrating runoff most of the water will travel vertically, deep into the soil and the main aquifer. However, if not designed appropriately infiltration may end up moving horizontally, which can overcharge the subsurface flow and cause erosion and slope failures. An engineer should be consulted for this type of system.

If infiltration is being considered, or if the property is adjacent to any bluffs, slopes, or other areas of potential high erosion or soil failure, it is advisable to run a few specific tests including a falling head test and a double ring infiltrometer test. The falling head test will help determine the hydraulic conductivity and the double ring infiltrometer test will test specifically the vertical infiltration rate. In addition, tests can be run to specifically track the movement and possible reemergence of input water.

Structures specifically designed for infiltration are usually discouraged if ground water, bedrock or other impervious layers are less than 4' below the infiltration surface. NRCS Class C or D soils commonly found in Homer have low or very slow infiltration rates. In most locations in Homer infiltration should not be the *main* design intent, but simply passively encouraged as water is slowed and filtered.

Any large infiltration structures should be located at appropriate distances from structures and site amenities to protect their function and safety. Some standard recommendations are:

At least 100' from a well.
At least 25' from a building foundation.
At least 100' from surface waters (sometimes less distance from wetlands is acceptable).
At least 50' from a septic tank, leach field or pit.

Gravity separator – oil and water separator

This is a structure with multiple chambers usually divided by baffles and some filters to separate oil and trash in one basin, suspended solids in another, with a clean-water outlet. These are primarily used in large parking areas, at car washes or auto repair yards where contaminants are concentrated, or in areas where industrial or commercial activities occur. Commonly these structures are required for certain industrial projects before site runoff enters a storm drain or other drainage system.

The first chamber of the separator used for trash and/or oil separation. Since oil floats, this chamber is designed to keep the oil floating on a layer of water, while allowing most of the water to pass through a lower outlet to the next chamber. The next chamber is usually for sediment deposition and has an overflow or filter to trap sediment before the water passes on to further filtration or into local storm drains. This system requires periodic maintenance to function properly and should be specified by an engineer.

Sand filter

A sand filter is a multi-chambered structure that is filled with sand, or sometimes peat, compost, activated carbon, or some combination of these. This is primarily used in large parking areas, in areas where industrial or commercial activities occur, or prior to a storm drain that drains directly into a creek or other sensitive habitat. These are expensive, require a lot of maintenance, and have varying results and therefore require careful engineering and monitoring.

Green Roof – vegetated or Eco-roof

A green roof essentially places the ground under the structure onto the structure's roof. While this technique was used in the literal sense for many homesteader cabins in the area, current products are quite sophisticated and easy to install. As this technique has become widespread in recent years in both commercial and residential buildings, many commercial products are now available that have standardized the installation.

Installation is a multi-layered system consisting of a waterproof membrane, a root barrier, a drainage layer, and a lightweight soil layer resulting in a planted surface. Green roofs offer many of the benefits of vegetated ground including rainwater detention and reduced runoff, habitat value and no accumulation and transport of the sediments that can collect and wash off of a normal roof. There are also significant benefits to the building including high insulation value, reduced maintenance and longer roof life because the waterproof membrane is protected from UV and mechanical degradation.

In many cases it is entirely possible to avoid the need for additional structural on-site stormwater controls if a building has a green roof and the site has been designed well.

French drain or curtain drain

These are linear, subsurface water conveyance drains built out of gravel, filter fabric, drainboard, and/or other pervious material and may or may not include a perforated pipe. This structure encourages the collection of water into the drain through a surface material of gravel, sand or planted earth, and provides a path-of-least-resistance below the surface through the drain material to a specified outlet. These are commonly used along foundations and retaining walls or close to exposed bluffs to decrease the hydrostatic soil pressure on the wall or bluff face and encourage drainage.

Well-designed French drains can be very effective in reducing the surface flow volume and rate of runoff, and in limiting sediment and pollution transport in runoff. This technique can also be used to maintain the connectivity of a larger drainage system, subsurface flow or even wetland under a road, driveway or walkway.

Pervious Paving

Pervious paving includes coarse gravel over permeable geotextile, pervious pavers and paving materials, and geocell-reinforced soil or gravel. This technique primarily slows stormwater runoff and reduces sediment, but can also allow infiltration in permeable soils..

With all pervious paving systems the subsurface soil, base course application and thickness can all influence slowing and infiltration. As a general rule uncompacted pervious soils with a deep base course and/or surface course will significantly slow and infiltrate stormwater, often reducing or eliminating runoff from the paving area. On the opposite end of the spectrum an impervious compacted soil with a shallow paving grade and limited or no base course will only slow runoff and offers little filtering of sediment loads. The following are some characteristics of the various installations.

- **Gravel – no fines**
  Coarse gravel in an un-graded mix – specifically without sand or fines - can be a very pervious surface and can slow runoff and reduce sediment load and allow for infiltration. The size of the aggregate, the depth of the gravel, the nature and compaction and transition to the soil below the gravel will all contribute to the effectiveness of this as a stormwater management technique. Use of a filter fabric below the gravel will keep the gravel from sinking into the surface soils. The type of filter fabric will range in permeability; Typar has limited or no permeability while certain landscape filter fabrics and drain boards have high permeability (they can look like mesh, felt, or a scrubbing pad). With coarse gravel the need for sand or salt in winter will be less.

  Note: Homer City Code considers gravel drives and parking lots as impervious surfaces. In the Bridge Creek Watershed Protection District proven gravel mixes or certification from an engineer is required to have a gravel surface considered pervious.

- **Modular paving systems**
  Modular paving systems range from concrete blocks to plastic cellular systems (geocells). The voids can be filled with sand, gravel or with earth and planted to create stable surfaces that meet certain vehicular access needs while still allowing for less runoff than a paved surface.

  Plastic geocell systems are used frequently for trail construction in Alaska, and can work just as well for residential and limited-use commercial driveways, parking areas, and pedestrian traffic areas.

  Brick, concrete pavers, or other stone type paving, if set with sand will allow water to drain in between the paving pieces. Pavers may not be desirable for all applications in cold climates as they have edges that can catch snow ploughs and are subject to frost heave.

- **Pervious concrete and asphalt**
  This is a concrete or asphalt mix that does not contain fines. The product when cured has small voids allowing water to drain through the pavement. If not designed and installed well the pavement may break up and/or become clogged with sediment. It is therefore not recommended in areas where the pavement will be sanded in the winter.

Chapter 4: *Project site analysis and predicting hydrologic function*

This chapter will take you through the steps you will need to follow to understand and document the specific hydrology of your site. It is imperative to properly inventory your site prior to any site work to document existing drainage patterns and land cover. Through this inventory you (and your designer and engineer) will be able to understand how to manage existing drainage as the site is developed, and properly plan for new runoff created by your construction.

This chapter begins with some generalities, then moves on to more specific technical requirements and calculations. By the end of the chapter you will be able to make initial rough calculations defining hydrologic function and quantifying additional stormwater management requirements for your project. This chapter presents a simplified method for making these calculations, but it will give you a starting point for making educated site planning decisions.

The goal of this exercise is to quantify the impact of the proposed development on the site's stormwater function so you can determine the appropriate mitigation strategy and area requirements. Using these techniques, you will also be able to compare the performance of various site plan options during the design process.

This may seem excessive for a small residential construction project or an addition, but mapping these elements will help determine not only the best current strategy, but also will map appropriate patterns for future construction or expansion. On a commercial site which usually demands a higher density of development, it is particularly important to understand the impacts of development, and in most cases a stormwater plan will require this level of site analysis.

As discussed in chapter 2, clearing and starting with a blank slate may not be the cheapest or smartest way to proceed, as you will lose much of the site's efficient, natural stormwater features. Proper site analysis is an important first step that will pay off as the project moves forward.

Analyze and Map the site – water and topography

Start by creating an existing or pre-development site plan documenting site topography and hydrology. The Homer Planning and Zoning Office can provide fairly precise contours of properties within the city limits, but more detail is usually needed to identify minor drainages, top and toe of slopes, etc. Ask the following questions and document your findings when analyzing your site:

- Are there any changes in slope on your property or near your property line? Document any changes and estimate steepness (% slope) if possible.
- Does any water drain onto the site?
- Where does water come onto the site? Where does it come from?
- Is there any overland flow from or toward neighboring properties? Any slope that terminates or continues from another property onto yours that will shed surface runoff?
- Are there any creeks, drainages or ditches on or around the property?
- Where does water exit the site?
- Does the property slope towards another property? Does surface flow from your property drain as a sheet onto someone else's?
- Does water collect anywhere on site? Does water stay on the surface or does it seep in somewhere?
- Are there any possible wetlands, ponds or bogs that should be delineated by a consultant?

Analyze and Map the site – soils and vegetation

Take careful inventory of existing conditions. Soil and vegetation are crucial elements in stormwater management. Soils vary greatly in their ability to absorb water and in their susceptibility to erosion with increased runoff caused by development. Vegetation, both living plants and the often thick organic mat of decomposing vegetation, greatly increases the site's water holding capacity, and these characteristics should be noted in your analysis.

The permeability of the soils on your site will be critical to the choice and design of your stormwater management strategy. Use the NRCS soils maps from Appendix B or online to find out the soil type that is likely to be at your site. These maps are fairly accurate for Homer, and contain information on soil engineering characteristics such as permeability that will be used in initial calculations (see page 33 and chapter 5).

For larger projects, or where a stormwater system is required by ordinance or federal regulations, a civil engineer will be needed. Often a civil/soils engineer is already employed by the design team to identify soil characteristics that will influence building structural or on-site sewer design, so consider asking him to provide a site plan with existing soils and their hydrological characteristics. Note the following characteristics on your site analysis:

- What types of soil are on the site? Use NRCS maps and/or consult a soils engineer to conduct soil sampling.
- Has your site already been built on, disturbed, filled or excavated? Note the location and the type of fill material, if applicable.
- Are there trees on the site? Are there areas of distinct plant types? Map any identifiable boundaries of different plant groups. These boundaries will often be determined by other site patterns such as water, soil and topography.
- How deep is the organic layer on the site? Note, if possible, the thickness of the organic soil layer across the site. This can be done by digging a small test hole, 18"-30" deep, where appropriate. This usually varies by plant community and/or topographical position.
- Are the trees or other plant groupings on your site part of larger groupings that continue onto neighboring properties? Map main plant and tree connections and grouping beyond your property.

How should these documented features direct your design and construction?

There are a variety of ways this information can help you design and plan your construction. First, this information may help you determine if you need any wetland paperwork or permits. Second, this information can help you determine possible hazards, or areas of concern, and will also help determine your construction cost and how to minimize it, as well as how to avoid impacts to neighbors and your local watershed hydrology. In addition, this will help determine any areas worth preservation and protection, as well as the general character of your site and your neighborhood. It will also allow you to quantify the pre- and post-construction hydrology to determine stormwater management concerns and permit requirements.

Are there wetlands on your site?

Refer to the local wetlands map online or at the Planning and Zoning Office to see if anything is mapped on your property. This mapping is quite good, but the resolution is limited, so some areas are over-mapped and some areas are under-mapped. However, even if the map does not show wetlands on your property you may still have some, and you should know what to look for in your site analysis.

Wetlands are not always defined by standing surface water. If there are wetland features such as deep organic soils, peat lands, bogs, creeks, swamps or indicator plant species such as cotton grass and black spruce you should contact the Environmental Protection Agency (EPA) and/or the US Army Corps of Engineers (Corps) to determine if jurisdictional wetlands might be present. The Corps may give you an initial assessment and/or a recommendation to obtain a technical wetland delineation report from a professional delineator.

> **Jurisdictional Wetland**
>
> "*Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.*" – EPA (Federal Register 1980)
>
> Three criteria must be present to have a jurisdictional wetland:
>
> 1. Hydric soils
> 2. Wetland hydrology
> 3. Hydrophytic vegetation

A wetland delineation will need to be submitted to the Corps for their records prior to any construction, or City permits. Development, including buildings, driveways and roads, as well as movement of soil or fill in wetlands is regulated by the Corps under the Federal Clean Water Act. If your project will impact a jurisdictional wetland in any way (filling, ditching, draining), you will need to file the appropriate permit with the Corps. It is best to contact the agencies prior to any design and construction, since penalties can be expensive and/or time consuming.

How should existing water and topography affect my design and construction?

If there is water draining onto your site from an adjacent property, either in a drainage or as sheet flow you will have to manage it once it is on your site. You may need to collect and/or divert this water if you are planning any building in its path. However, you may also want to consider that slopes, bluffs, or active creeks may also erode or fail during a storm event, so plan carefully and accordingly to limit any construction or grading that may increase the erosion potential. It is often cheaper to avoid construction in these areas, if possible.

Also consider where water drains from your site. Your construction will probably increase the amount of runoff leaving your site, so make sure the rate and or volume that you produce or concentrate can be handled appropriately. The Homer code states "development activities shall not adversely impact other properties by causing damaging alteration of surface water drainage, surface water ponding, slope failure, erosion, situation, or root damage to neighboring trees, or other impacts." *(HCC Performance Standards for each district)*

If there are any creeks, drainages, wetlands or other natural water features on your site, try to preserve them. It is often cheaper to avoid construction in these areas. But any impact you have on them will have a much larger effect on the local watershed and general hydrology of the area. These systems have been designed over many years by nature and are usually well sized and placed for existing conditions. Consider them an amenity. They can be beautiful and attract wildlife, but they can also help manage your stormwater. Avoid channeling all runoff directly into an existing feature. Draining directly into a feature can cause pollution, erosion, and flooding. As much as possible slow and filter the water with elements such as filter strips, swales, ponds and basins. This will keep the natural water features functioning and healthy.

How should existing plants and soil affect my design and construction?

An important consideration for passive stormwater management and the success of future landscaping is the protection of existing soils and vegetation during construction. Trees and vegetation are the main players in slowing, filtering, and using potential runoff. The organic or topsoil layer, the product of decades of plant growth, death and decomposition, is extremely valuable, particularly in Homer where decomposition is relatively slow and soils are fairly impervious. In addition the existing soils and short growing season limit growth of trees and many plants, so maximize the use of existing trees and plants rather than incurring expense and waiting years for replacement trees and plants to grow in.

While excessive runoff and erosion is often what is considered when defining no negative impact on neighboring properties, drying, limiting or damming surface water can also have negative impacts. Soil compaction by vehicles and construction equipment either on-purpose or inadvertently can greatly reduce the permeability of the soil, its ability to support plants, and therefore lead to an increase in erosion and runoff. Also changing the hydrology on your property may have negative effects on trees and vegetation on your neighbor's property. Note conditions on neighboring properties that may affect the viability of plant or soil structure on your site.

How to calculate existing hydrology

You should now have most of the information needed to calculate the peak runoff rate of your site. Be sure you have mapped the approximate areas of discreet vegetation, slope and soil characteristics on your site. Use the categories from Table 1 to determine what characteristics you will need to delineate.

With this information we will use the ***rational method*** to determine the ***peak runoff rate*** of your property. While this formula may look cumbersome initially it is quite easy to use. We will review the formula, and then give an example to help explain the different variables.

The Rational Formula

$$q = CiA$$

q = the peak runoff rate in cubic feet per second (ft^3/s)

C = unitless Runoff Coefficient (see Table 1)

i = rainfall intensity in inches per hour (see Table 2)

A = area of drainage in acres

The Runoff Coefficient (**C**) is a pre-determined runoff rate derived by surface and subsurface conditions and can be found in Table 1 below. A value of 0 represents a completely pervious surface that will generate no runoff, while a value of 1 represents a completely impervious or saturated surface.

Each storm has a different duration and rainfall intensity (**i**). Because we are concerned with avoiding damage from large events, peak runoff rate is normally calculated using a *design storm* value. This is a value for which the management system will be designed. Data for Homer is listed in Table 2 below and includes 2-year, 10-year, and 100-year design storm intensities. These numbers are based on historical data and are assumed to statistically occur once in the given time period.[1] Which of these numbers you use depends on how well you want your site to perform, and/or the regulatory standards.

Normally the Rational Method is used to calculate the maximum rate of runoff for a short duration design storm and may consider a number of other surface and site layout qualities. For a Homer Stormwater Plan (SWP), the applicant is required to base discharge rates on the 10-year design storm, and channel flow protection on a 2-year, 3-hour design storm.[2] For the examples here we will use the 10-year, 24-hour storm, and simplify the analysis by assuming that all surfaces are mixed throughout the site.

Surface area (**A**) for each type of surface is measured in acres. If you have measured areas in square feet you can simply convert the area to acres by dividing by 43,560.

1 acre = 43, 560 sq. ft. ***so*** **acres = Square Feet / 43,560**

Table 1 - Runoff Coefficient – C *(unitless)*

	NRCS Soil Type [3]			
Land Use Description	**A**	**B**	**C**	**D**
Wooded/forest land				
flat 0-2% slope	0.08	0.10	0.12	0.15
2-6% slope	0.11	0.14	0.16	0.20
steep 6%+ slope	0.14	0.18	0.20	0.25
Meadow, Pasture or Lawn				
flat 0-2% slope	0.14	0.2	0.26	0.30
2-6% slope	0.22	0.28	0.35	0.40
steep 6%+ slope	0.30	0.37	0.44	0.50
Dirt road/driveway	0.70	0.70	0.70	0.70
Gravel Road/driveway	0.70	0.70	0.70	0.70
Asphalt or Concrete Paving	0.90	0.90	0.90	0.90
Roof (non vegetated)	0.90	0.90	0.90	0.90

after McCuen 2004

[1] The 2002 floods were caused by a 100-year storm event, its effects exacerbated by already saturated or frozen soils with a higher **C** than normal.
[2] HCC 21.48.060(g)(10) and 21.49.060(g)(10)
[3] NRCS Soil Type can be found in Appendix B or at http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx

Table 2 – Design Storm Intensity – i *(in/hr)*

	2-year	**10-year**	100-year
1 hour	0.50	0.70	1.00
3 hour	0.35	0.50	0.83
6 hour	0.33	0.47	0.75
24 hour	0.13	***0.19***	0.30

Estimated from Miller 1963 for Homer, AK

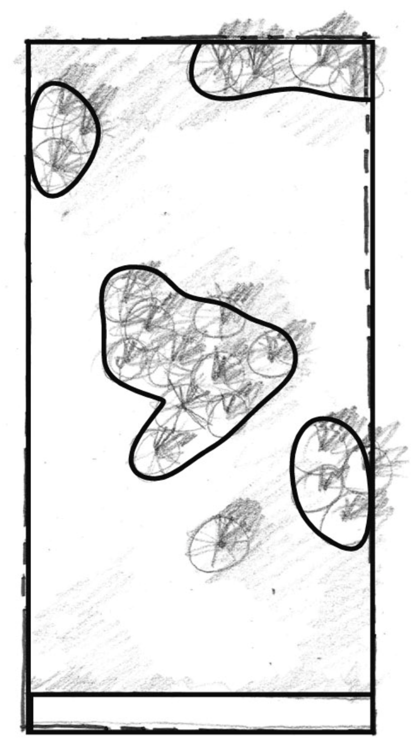
After preparing a proposed development plan, you will be able to approximate the peak runoff rate for the proposed post-development condition and understand the changes you may be making to the site hydrology. This will be a basis of determining the need for, and sizing of, stormwater management elements on your site. These numbers should also be used to quantify your drainage or stormwater management plan that will be prepared by your engineer and submitted to the City.

If you have used good stormwater design techniques, as discussed in chapter 2, your post-development peak runoff rate will be much closer to pre-development conditions than standard development practices. If you would like to, or are required to build an artificial stormwater control structure to further control stormwater flows, good site layout will mean that this structure will be much smaller and much cheaper.

Example

In this example we will estimate the pre- and post-development hydrology of a generic property, using the example of the 1/4-acre commercial lot from chapter 2, page 20 (example 2). This will give you a better understanding of this formula and will demonstrate the potential change in hydrology between the undeveloped condition and a well-designed site as well as a poorly-designed site.

The undeveloped lot has a varied topography averaging 3% and areas of woodland, open meadow and existing sidewalk. For this example we will use the 10-year 24-hour design storm specified in Homer City Code.



Pre-development

Using the rational formula **q=CiA**

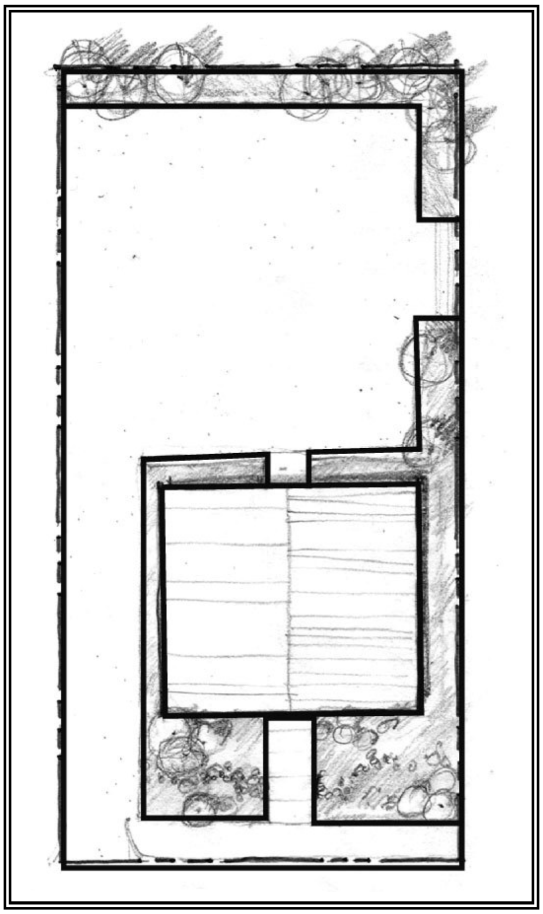
Design storm intensity (**i**) = 0.19

For NRCS Soil type **Group C** value from Appendix B for downtown location

Runoff coefficient **C** values from Table 1 above

Area (**A**) = 0.5 acres = 21,780 sq.ft./43,560

Note we have calculated the acreage of each area by dividing the square footage by 43,560.



Undeveloped **q**

	C	**A**	**q**
		ac	*cfs*
Forest 3%	0.16	0.05	0.001
Meadow 3%	0.35	0.20	0.013
Paved	0.9	0.01	0.002
Total Property q			**0.017**

Proposed Development **q**.

	C	**A**	**q**
Forest 3%	0.16	0.02	0.001
Meadow 3%	0.35	0.06	0.004
roof	0.9	0.05	0.008
Paved	0.9	0.15	0.025
Total Property q			**0.038**

While these numbers may seem small at first glance, remember that **q** is calculated in cubic feet per second or cfs, a standard engineering unit for hydrology. If we look carefully we can see that the rate of water exiting the developed property as runoff is 2.2 times higher than the runoff in the pre development state.

Remember that these are simple **q** calculations that we can use to estimate the size of mitigation measures like swale depth and width and rain garden/basin size. This simple calculation uses the 10-year 24-hour storm, and assumes proper design layout to maximize time-of-concentration benefits. Proper layout essentially means that impervious surfaces must be located upstream from vegetated areas and stormwater structures.

With the swales and a stormwater detention area, this site design has a much smaller impact on city infrastructure – especially if all the adjacent properties are developed in a similar manner. If a green roof were incorporated into this design to manage and reduce some of this runoff leaving the site, the size of the required structural stormwater control measures would be reduced by over 25 percent.

This example calculated the **q** for each distinct area (**A**) then added these rates together. It is fairly straightforward and takes only a few steps. It is also simplified, and does not consider the relative locations between one area and the next, but assumes an evenly-distributed mix. The exact location of impervious surfaces on your site will have a significant effect on how quickly runoff will concentrate and exit the site, the above method offers an acceptable estimation of site runoff rate effects if your site is laid out according to the guidelines in this handbook.

This is a quick way to compare pre- and post-development peak runoff of your proposed construction, or to analyze portions of the site if construction is to be limited to specific areas. Remember, **q** is calculated for the area that will run off through a specified point on the site, or for the exit from the site, so you can consider runoff for the whole site or just portions of the site.

Below is a worksheet to help collect and estimate your pre- and post-development **q**.

Table 3 – Peak rate of runoff worksheet

	C *From table*	**i** *(constant)*	**A** *Area In* ***sq. ft.***	**A** *Area In* ***acres***	**q** *(C x I x A)*
Surface 1					
Surface 2					
Surface 3					
Surface 4					
Surface 5					
q total					

After you have minimized the impact through good design, and estimated the change in peak flow rates for your proposed construction, you can now estimate the sizes of any required stormwater mitigation structures, such as swales or basins using the techniques in Chapter 5. However, final design and size should be determined by an engineer.

Chapter 5: Selected structural stormwater controls in detail

This chapter goes into more detail on the benefits and design and construction considerations of a selection of constructed stormwater management strategies.

Each section is broken down into five parts:

1. **General description**
2. **Function rating**
3. **Pros and Cons**
4. **Maintenance considerations**
5. **Design considerations**
6. **Sizing guidelines.**

The function rating uses the following parameters:

- ***Runoff rate*** – good/moderate/poor this is the ability of the element to reduce or mitigate the runoff rate from a property or area
- ***TSS*** (Total Suspended Solids) – good/medium/fair/poor The ability of this element to reduce the total suspended solid or sediment load in runoff.
- ***Pollutant*** – good/moderate/poor the ability of pollutant reduction in runoff. This includes things such as fecal coliform, petrochemicals (gas, oil), etc.
- ***Overall Size*** – small/medium/large This is the general overall size of the element. More specific size requirements are described in the design criteria and procedures sections
- ***Cold Weather Function*** – good/moderate/fair the ability of this element to continue to function in cold and frozen conditions. Function is an overall rating related to the ability to reduce runoff rate and reduce TSS and pollutant load when frozen as compared to when growing season weather.

Bioswale – vegetated swale or ditch

General Description

This is a planted or rock lined earthen conveyance ditch or depression, usually used to convey surface runoff to a larger collection ditch, drain, or pond. Vegetation and soils, as well as limited slope help slow the water within the swale and increase sediment drop and pollutant filtration. This is a very effective and simple method to reduce pollution and runoff volume.

Swales can be fully vegetated or rock lined, each has its merit. Larger swales that frequently experience inundation may result in bare earth along the bottom. Not only is this not aesthetically pleasing, but it will limit its function as well. Lining the channel with rock will increase roughness, encouraging slowing and sediment drop, and can also be done in an aesthetic manner. However, rock lined swales may encourage re-suspension of sediments in high runoff events. In most cases a vegetated swale is a better performer as far as stormwater management. Widening and flattening the bottom of the channel will reduce erosion and encourage vegetation establishment. Careful plant choice based on soils and inundation frequency will also ensure successful vegetation coverage. In addition, a sub surface drainage material such as gravel, sand, or pervious soils can be incorporated to reduce surface water and ponding. This technique is often referred to as a dry swale, as it will only hold and convey surface water during large events.

Figure 10 - Swale at the Homer Library 2006 Peter

If a swale will be conveying high volumes, and has a slope steeper than 2%, a combination of rocks and vegetation can be used. Rock check dams to occasionally slow water along the route will reduce rate and volume.

During heavy snow and freeze the effectiveness of this element will be limited. While a swale can be used for snow storage, if possible snow should be stored adjacent to swales to reduce the possibility of ice jams and the effectiveness of this element. If the swale is channeling water to a pond or other mitigation element using the swale for snow storage makes good sense.

Function rating:

- Runoff rate - fair to good – can reduce runoff rates significantly with good design. For the best runoff rate swales should be shallow and wide, planted with thick, turf-type plants at least 4" tall (or over proposed water height) and have a slope of about 2%. If slopes are slightly steeper check dams to limit slope between dams to 2%.
- TSS – fair to good – good reduction with appropriate slope and planting. However, often not enough to reduce heavy TSS loads. If designed with pervious soils or subsurface drainage a much higher TSS reduction
- Pollutant – fair to good - If infiltration and/or subsurface drainage much higher rate, especially with well chosen plants. Soil preparation or
- Overall Size – linear – small but long. Good for linear islands or edge of drainage areas.
- Cold Weather Function – fair – The wider and shallower the better. Plants that still have presence when dormant will help.
- Flood control – good for initial attenuation, but limited to no effect on large flood events

Pro's

- Small size requirement
- Good function for light density and multiple areas
- Great filtration and TSS reduction with pervious soils and or enhanced subsurface soils
- Very effective pre-filtration
- Inexpensive

Con's

- Use limited by site slope
- Minor but regular maintenance
- Does not necessarily remove 80% TSS on its own

Maintenance Considerations

Occasional (annual or seasonal) mowing, sediment removal, and trash clean up may be necessary. While swales can be mowed regularly to have a lawn appearance, this will reduce function. If regular mowing is desired the grass should be kept at leat 4 inches tall. Occasional area re-grading may be necessary if there is localized settling or uplifting to ensure proper capacity and function.

Design Considerations

Swales require long linear areas with a low slope (2-4%). They can be located on steeper sites if designed parallel to the grade (along contours), or with check dams.

Slope of 2% is most desirable with 4% being the maximum. Steeper slopes will not reduce runoff rates, and can cause erosion and failure. Use check dams to slow flows and/or reduce slope when necessary. Maximize contact surface areas between water and plants and soil by limiting depth, increasing width and maximizing planting. Recommended swale dimensions for maximum efficiency are 2-10 feet wide with side slopes of 4:1.

Plants should be a minimum of 4-6 inches tall. Maximize plant establishment and infiltration where appropriate by tilling or scarifying the soil in the swales prior to final grading and planting. Wet swale will act as miniature wetland (especially with check-dams).

Densely planned grass type plants will have the best filtration and sediment trapping function if kept above 4" tall. Select plants that can take occasional inundation, and that can take salts, if adjacent to a paved area that is salted in winter. If salt accumulation is a concern for plants and not abated by spring melt a spring flush can dilute and reduce salt concentrations. For bunch type plants plant in rows across width of swale to act as check dams, but allow for ease of cleaning or maintenance between rows. Trees can be planted in or adjacent to swales, and can enhance infiltration and uptake of water. Choose species that can tolerate wet conditions. Avoid planting any trees in the middle of swale so that trunks and roots don't cause unwanted dams that block water drainage.

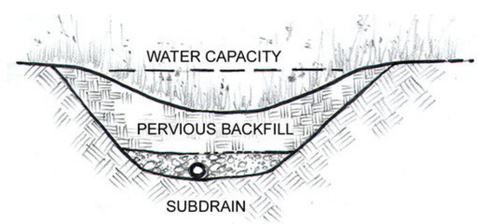
Careful location and design should be considered to limit frost heave of any adjacent paving. The long narrow dimension of a swale should be placed strategically to be effective and not interfere with snow removal on adjacent areas.

Sizing guidelines & formulae

Sizing of any proposed swales is important since they are basically an open surface drainpipe. Improper sizing can lead to failure. The swale will need to be able to handle the runoff volume it will convey or it will overflow causing a nuisance and possible safety issues. The Manning's equation is used to size swales as well as drain pipes. However, sizing swales requires careful calculations of the functional radius, the roughness coefficient determined by the plants, and the maximum velocity allowed to avoid erosion. These elements should be engineered, or at the very least greatly oversized.

Sample Layouts

Swale cross-section



Dry swale cross-section

Bioretention area – rain garden

Figure 14: Rain garden with sculptural downspout in Portland

General Description

An area of landscaping that collects, stores and infiltrates stormwater. Area should be a slight basin with pervious or amended soils within the planted area. It will be somewhat like a detention basin but fully planted as a garden or field. This can be a great way to manage roof downspout drainage, or as a landscaped edge prior to runoff exiting a property.

Function rating:

- Runoff rate – moderate to good
- TSS – moderate to good – better with high infiltration rates in native soil, or large area
- Pollutant – moderate to good - varies with soil infiltration and planting
- Overall Size – varies. Size is somewhat intensive but serves double duty as landscaping
- Cold Weather Function – moderate to poor – plant interception, attenuation and surface detention will still be functional, surface infiltration will be minimal.
- Flood control - good for initial attenuation, but limited to no effect on large flood events

Pro's

- Dual function landscaping and stormwater management for commercial or residential properties
- Aesthetic
- Minimal maintenance beyond regular landscape maintenance

Con's

- Somewhat construction intensive
- Requires soil amendment or import
- Careful plant selection may be needed if frequent inundation occurs.

Maintenance Considerations

No additional maintenance other than required for landscaping.

Design Considerations

Landscaped edge or open area that can serve dual function as stormwater retention. Medium slope – the retention area bottom should have a 2-5% slope, but the planted surface should be less than 2%. Manage drainage from 2 acres at most for garden, larger area possible if creating a large field.

While a bioretention area of any size will help reduce runoff, most bioretention areas are sized according to area available, and not the input quantity. However if the area is not sized specifically to runoff being managed an overflow or bypass must be incorporated into the design, as well as a potential outlet for the infiltrated/filtered runoff.

A drainage area of up to 2 acres is the ideal treatment area. A general size rule is that the bioretention area should be approximately 5% of the impervious area draining into it. Most bioretention area can manage a drainage are of up to 5 acres max. If more than 5 acres needs runoff management multiple basins can be constructed. Generally basins can be between 2 and 4 feet deep, but at least 2' above the local water table. The deeper the basin the longer the area may hold water (unless sub-surface drainage is incorporated) which may affect plant choice and success. If you do not wish install sub-surface drainage you may keep the basin shallow, or design the area as a wetland. If you are interested in installing a sub-drain, a deeper basin will have better stormwater mitigation.

Water should be directed to the area either as overland sheet flow, or via a swale or drain-pipe (bubbler). If coming from a drain pipe or swale, a rock dissipation/spreading area should be incorporated to limit erosion and encourage sediment deposition and infiltration.

The bioretention area will need to be excavated and backfilled with amended soil or imported pervious soil. If surrounding soils are very impervious you will need to install a subsurface drainage layer of crushed rock or gravel at the bottom of the basin and an outlet. If installing a subsurface drainage make sure to place filter fabric/drain board between organic soils and gravel drain layers. The excavated area should be backfilled with sandy loam or loamy sand with an infiltration rate of 0.5in/hr. A mix of 50-60% sand, 20-30% compost and 20-30% topsoil is ideal. The surface of the planted area should be a slight depression to allow temporary surface ponding when necessary. If needed a low perimeter berm can be built. Construct the berm with shallow slopes and compact soil well.

Plant establishment is crucial for maximum effectiveness. When planting a rain plant creatively. Mix plants with different heights and sizes as much as possible. Careful select plants for areas that experience frequent inundation, as well as areas that might receive runoff with de-icing salts. It is best to use plants that do not require chemical fertilizers or herbicides.

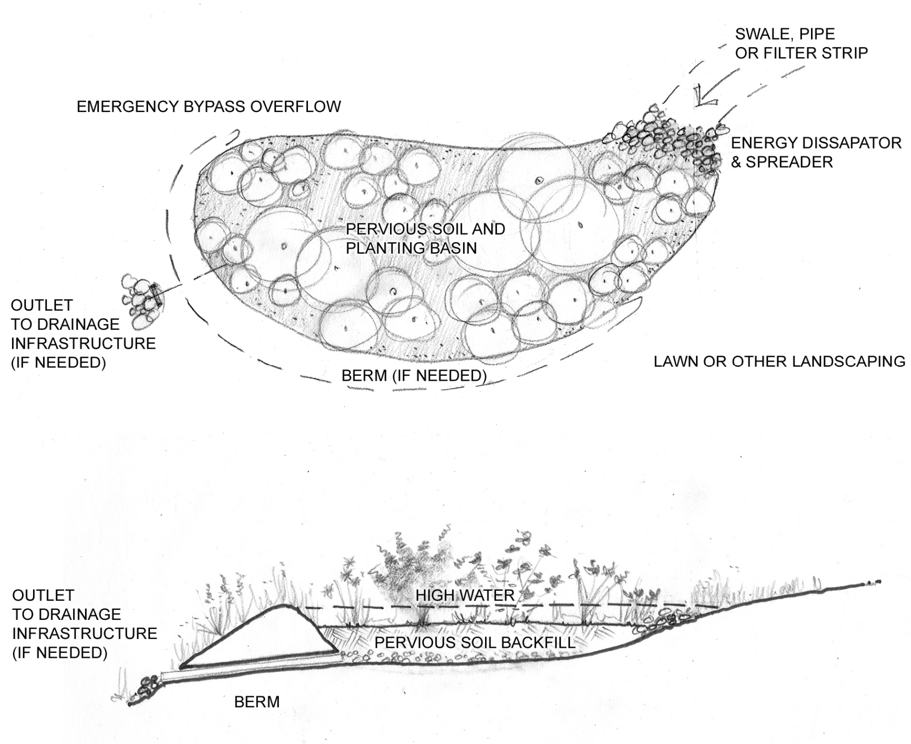
Sizing guidelines & formulae

While any size has a benefit, general size guidelines vary by existing native soils.
If the native soil is clayey and you are not installing any subsurface drainage, the size of the area being treated in relation to the bioretention area should be 5:1 (or multiply the area being treated by 0.2).

For a basin that is surrounded by clayey soils but will have subsurface drainage the ratio can be reduced to 3:1.

For larger areas and fields consult a landscape architect or engineer.

Sample Layout



Rain Garden

Note: For more information on rain gardens in Alaska check out the city of Anchorage rain garden web page www.anchorageraingardens.com.

Stormwater pond

Figure 11 - Stormwater pond at the Homer Library 2006 Peter Briggs

General Description

These are planted ponds designed to be wet year round. These ponds are designed to, slow (detention) and retain (hold) some water, thereby reducing the peak rate and flow as well as reducing pollutant and suspended solid loads. These allow the water to slow so that sediment and pollutants can drop out and be filtered by plants and managed on site. The basin should be designed to hold water permanently but also have capacity to hold more water during a rain event. Vegetated detention areas will filter and possibly flood during a runoff event. The permanent pond will also reduce the possibility of re-suspending sediment.

It is recommended for best function to include a forebay. A forebay is a small basin or pond that water enters prior to entering the main pond. If you incorporate a forebay, this may be the main area you will need to maintain, as much of the sediment will drop out in this area.

In cold climates the water in the pond may freeze partially having a slight reduction of function. A completely frozen pond will have limited function – only temporarily holding water, and possibly encouraging sediment drop. However, sediments may become re-suspended if deposited on the surface of ice. Careful design to incorporate additional detention area and ways to encourage surface ice to break up will increase the effectiveness of both slowing and sediment drop – even if there is limited plant material or capacity.

These are very beneficial as buffers and filters for runoff prior to entering a local creek, river, lake, etc. These are very effective for filtering sediment and light pollutant loads. Careful vegetation selection can greatly enhance pollutant filtering and uptake (bioremediation). Pervious soils will enhance function.

Function rating:

- TSS – good removal of TSS with proper sizing and planting. Planting along edges and along entry channel can enhance function. Multiple basins the combination of other mitigation elements such as a swales and/or filter strips prior to a forebay will have maximum effect.
- Pollutant – good removal of pollutants with good soil preparation and planting. Rock lined basins or bare-membrane lined basins will have little to no effect on pollutants.
- Overall Size – filters large amount of water in relatively small area, but somewhat size intensive
- Cold Weather Function – good with additional size considerations
- Flood control - good

Pro's

- Aesthetic, visual amenity
- Excellent stormwater treatment
- Potential wildlife habitat
- Good function in freezing temperatures
- Good ability to manage spring melt

Con's

- Engineering required
- Can become attractive to Mosquitoes
- Some public safety concerns
- Wildlife concerns – possible undesirable wildlife/public safety concerns
- Outlet armament usually required
- Pond itself is not appropriate for snow storage, but adjacent detention areas can be

Maintenance Considerations

- Requires occasional weeding.
- Will require some sediment dredging – forebay may need dredging annually or more frequently, main pond may not need dredging often, especially with a forebay. Check forebay sedimentation in spring in areas where roads are sanded.
- Outlets, trash racks, drains, weirs, etc will require frequent inspection and maintenance as needed – especially prior to and during freezing temperatures.
- Do not drain in spring, this is usually when the water and sediment will have high pollutant (chloride) concentration and may have negative downstream effects.

Design Considerations

Ponds are useful for mitigating a large area, or an entire site with medium topography, somewhat impervious soils, and/or a high percentage of impervious cover. Fully planted ponds and detention areas have a much higher rate of reducing TSS and pollutants than unplanted or hard sided basins. If you are designing a pond with a liner to stop infiltration add a layer of topsoil (12"+) on top of the liner to accommodate planting and biofiltration.

If infiltration is being considered or desired, or if the property is adjacent to any bluffs, slopes, or other areas of potential high erosion or soil failure it is advisable to run a few specific tests including a falling head test and a double ring infiltrometer test. The falling head test will help determine the hydraulic conductivity and the double ring infiltrometer test will specifically test the vertical infiltration rate. In addition, tests can be run to specifically track the movement and possible reemergence of input water. Ponds should not be constructed on slopes greater than 15% or on unstable slopes or fill.

Structures specifically for infiltration are also discouraged if ground water, bedrock or other impervious layers are less than 4 feet below the infiltration surface. NRCS Class C or D soils commonly found in Homer have low or very slow infiltration rates. So in most locations in Homer infiltration should not be the *main* design intent, but encouraged as water is slowed and filtered.

Drains for a pond or basin can vary widely. The type used will be dependant of the size of the basin, the calculated outflow volume, and other engineering considerations. For smaller ponds, or carefully engineered outflows a simple overflow can be used. Weir drains can be used, and if adjustable can be managed proactively to accommodate different runoff conditions. An engineered drain can also be used that incorporates a limited outflow main drain to only allow a determined outflow rate, but also incorporate an overflow drain, and a maintenance drain. Make sure there is a safe emergency overflow route for extreme flood conditions.

If the pond will have a drain pipe the drain grate or riser hood must be designed to be able to function in freezing temperatures. All outflow pipes should be 18" to reduce the possibility of freezing. Riser hoods on outlets should be designed to extend at least 6" below typical ice line. Drain grates (sometimes called trash-racks) should be designed at a shallow angle to prevent damming and possible blockage due to ice – avoid vertical alignments.

For better storage capacity, especially in cold climates (spring melt) it is beneficial to incorporate extended dry storage. This is the stormwater pond but with an additional larger edge that allows normally dry areas immediately adjacent to the pond to flood during high water events. This requires a slightly larger area, but is often dual duty of open landscaped area adjacent to a pond. This can be seen in the Homer Library pond in Figure 13 on page 37; the rocks define the larger basin capacity. Also consider where you store snow, so that when it melts it will flow into the system, but not cause ice jams

Sizing guidelines & formulae

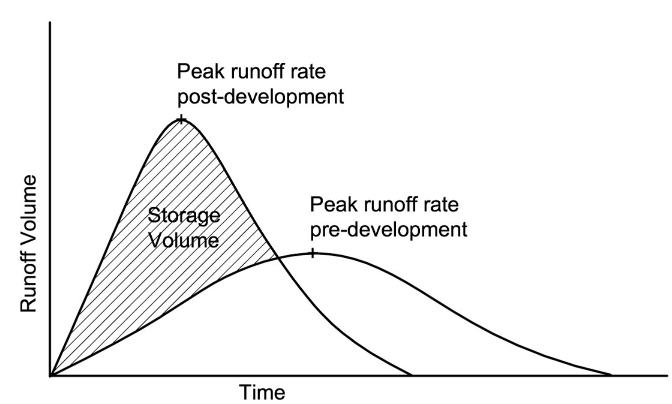


Fig 16. Hydrograph

As an initial rough size calculation to locate and dimension your stormwater pond/basin can be done using the rational method. However it is important to note that this is an rough calculation strictly as an initial guide for design layout. This is not sufficient for true sizing for critical runoff volume control, especially in areas where a failure would cause serious damage and liability. If this initial calculation helps you determine that a pond or basin is an option, you will need to contact an engineer to perform the exact volume calculations and design.

This calculation essentially compares pre and post peak runoff rates. Looking at the hydrograph in Figure 1, the area under the post development curve that falls above and outside the pre development curve is the volume of water the basin should hold. If this water is collected and held, only allowing the outflow from the pond or basin to match the pre-development peak runoff rate (q) the property (or area being mitigated) will essentially have the same pre and post development runoff rate. Regulations and intentions will determine if the predevelopment q is the maximum runoff rate allowable, or if there is another standard to be met.

Begin with the pre-development peak runoff rate and post-development peak runoff rate, which was described in the previous chapter. With these numbers you can calculate the inflow and outflow volume for the basin, and thereby the storage volume of the basin required to detain the increased runoff created by development.

V = q x d

V – volume (cubic feet)

q – peak runoff rate (cubic feet/second)

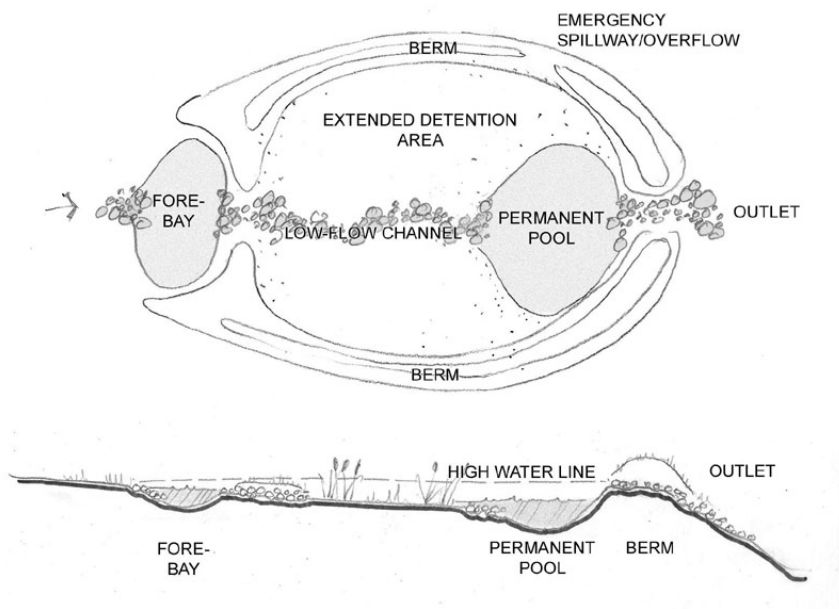
d – duration of the storm (seconds)

Calculate the volume of the pre-development runoff and the volume of the post-development runoff, then subtract to get a rough estimate of required storage volume. This estimation assumes proper site design, with areas of high runoff coefficient (**C**) located upstream of areas with low **C**. This will give you a ballpark figure for the space-needs for these structures so you can complete rough site design before consulting with an engineer on final stormwater design.

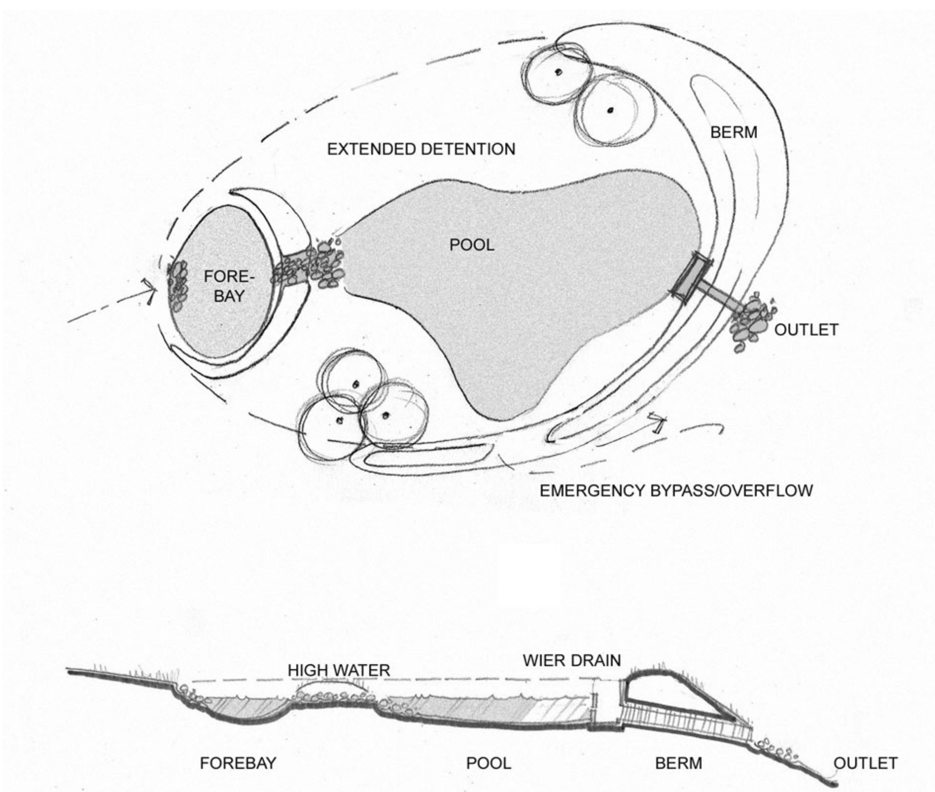
Storage Volume = (post-development volume) – (pre development volume) x 1.2

When designing ponds and basins in cold climates you must increase the detention volume capacity if you plan to address spring-melt. A common size adjustment used to accommodate spring melt and increased volume of ice is to oversize the basin by 10-25%. Some other considerations used are to calculate the snow volume, and to consider the frozen ground conditions during spring thaw as an impervious surface for runoff rate (q) calculations. If the drain is adjustable another management technique would be to lower water level prior to freezing temperatures to allow for more storage during winter.

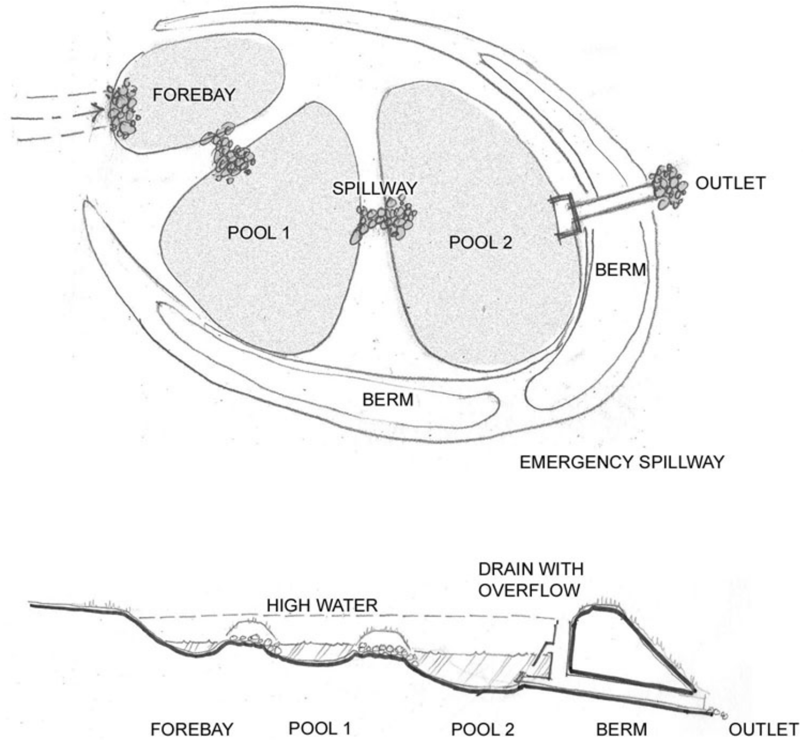
Sample Layouts



Stormwater Pond



Stormwater Pond



Stormwater Pond

Note: The berms are exaggerated in the example layout drawings. Extended detention can be designed with a constant elevation edge carefully laid out and sculpted in the field to not be a noticeable rise.

Stormwater ponds do not need to be oval in shape, but can also be linear or irregular shaped.

Dry well or vault– subsurface detention

General Description

These are usually gravel beds, subsurface vaults or other containment structures installed underground. Depending on the existing soils and stormwater systems in place these can be designed for infiltration and/or detention. These can be simple small-buried cells that accept roof downspout drainage to large structurally reinforced areas below surface parking to capture surface and rooftop runoff in commercial developments. They will act like a buried cistern that leaks, functioning by detaining runoff underground for slow delayed release and/or infiltration. These need to be sized and engineered to ensure soil and structural stability as well as water inlets and overflows and possible infiltration. All should have an overflow outlet, and a complete bypass route for emergency and/or maintenance needs. In addition careful planning and construction need to be considered for parking lot runoff to limit the possibility of ground water pollution.

Function rating:

- Runoff rate – good
- TSS – good - may require sediment trap or filter to limit any clogging
- Pollutant – fair to good - drainage pollutant load may require oil/water separator or other pre-filter depending n location weather an open or vault or course drainage material
- Overall Size – varies but completely underground, can be placed under parking
- Cold Weather Function – good – when below freeze line function continues. Careful sizing and engineering of inlet and overflow to maintain function.
- Flood control - good

Pro's

- Can be placed under parking or other open area
- No surface management
- Many prefabricated systems are available.

Con's

- Intensive construction
- Higher cost

Maintenance Considerations

Depending on size and structure clean out access may be desired. In addition sediment trap or oil-water pre-filter may be desired to reduce vault maintenance. However, pre-filter maintenance may be intense.

Design Considerations

This element requires limited surface space on a fully developed lot. However, the area must be cleared and excavated for installation. This is an excellent dual use of space with parking lots or other desired open space. A geotechical investigation and report is required to determine if infiltration is desired or feasible, or if liners are needed. Prefabricated systems will have calculation and installation specifications, as well as load capacity/bearing strength. In homer careful site selection and geotechnical evaluation should be performed to ensure the vault remains 2-4 feet above existing groundwater, especially when managing parking or other vehicular surface runoff. This should not be constructed in fill soils. When designing for infiltration it is advisable to install an initial observation well to ensure adequate infiltration rate and ground water levels.

Sample prefabricated units:
Invisible Structures - Rainstore3 - a rigid plastic stackable frame www.invisiblestructures.com
ADS – Stormtech or N12 pipe - a large plastic arch and pipe systems www.ads-pipe.com
StormTrap - a precast concrete modular system www.stormtrap.com

These are simply listed as product examples are in no means an endorsement by the City of Homer or the Authors.

<u>Appendix A</u> - Glossary of terms

Buffers. "Buffers" means open spaces, landscaped areas, fences, walls, berms, or any combination thereof used to physically separate or screen one use or property from another so as to visually shield or block noise, lights, or other nuisances.

Channel protection storage volume (Cpv). "Channel Protection Storage Volume (Cpv)" means the volume used to design structural management practices to control stream channel erosion.

Clearing. "Clearing" means the removal of trees and brush from the land, but shall not include the ordinary mowing of grass.

Detention structure. "Detention structure" means a permanent structure for the temporary storage of runoff, which is designed so as not to create a permanent pool of water.

Development activity plan. "Development activity plan" means a plan that provides for the control of stormwater discharges, the control of total suspended solids, and the control of other pollutants carried in runoff during construction and the use of the development.

Drainage area. "Drainage area" means that area contributing runoff to a single point measured in a horizontal plane, which is enclosed by a ridge line.

Dredging/filling. "Dredging/filling" means an activity which involves excavating along the bottom of a water body for the purpose of channeling, creating a harbor, mineral extraction, etc., and the subsequent deposition of the dredge material to build up or expand an existing land mass or to create a new one.

Extended detention. "Extended detention" means a stormwater design feature that provides gradual release of a volume of water in order to increase settling of pollutants and protect downstream channels from frequent storm events.

Extreme flood volume (Qf). "Extreme flood volume (Qf)" means the storage volume required to control those infrequent but large storm events in which overbank flows reach or exceed the boundaries of the 100-year (one hundred year) flood plan.

"***Flood hazard area***" means the land area covered by the flood, having a one percent chance of occurring in any given year. See also "100-year flood".

"Floodway" means the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height, usually one foot, at any point.

Infiltration. "Infiltration" means the passage or movement of water into the soil surface.

Islands. "Islands" when used to describe landscaped areas within parking lots, means compact areas of landscaping within parking lots designed to support mature trees and plants.

Landscaping. "Landscaping:" means areas of lawns, trees, plants and other natural materials, such as rock and wood chips, and decorative features including sculpture.

Native vegetation. "Native vegetation" means undisturbed indigenous plant communities, or plants which indigenous to the area.

Natural or man-made features. "Natural or man-made features" means elements in the landscaping other than plants. Including but not limited to, boulders, or planters.

Nonpoint source pollution. "Nonpoint source pollution" means pollution from any source other than from a discernible, confined, and/or discrete conveyances. This includes runoff from parking lots, roof tops and other paved or unpaved surface that includes substances such as pathogens, petro-chemicals, sediments, debris, toxic contaminants, or nutrients.

Off-site stormwater management. "Off-site stormwater management" means the design and construction of a facility necessary to control stormwater from more than one development.

Oil water separators. "Oil water separators" means passive, physical separation systems, designed for removal of oils, fuels, hydraulic fluids, and similar products from water. They are generally large-capacity, underground cement vaults installed between a drain and the connecting storm drain pipe. These vaults are designed with baffles to trap sediments and retain floating oils. The large capacity of the vault slows down the wastewater, allowing oil to float to the surface and solid material to settle out.

On-site stormwater management. "On-site stormwater management" means the design and construction of systems necessary to control stormwater within an immediate development.

Open space. "Open space" means areas of varying sizes which generally are developed for a variety of recreational uses or are preserved for their natural amenities. Open spaces may be for use by the public, by private development, or cooperatively owned for use by members of a homeowners association, and include squares, parks, bicycle/pedestrian paths, refuges, campgrounds, picnic areas and outdoor recreation facilities.

Overbank flood protection volume (Qp). "Overbank flood protection volume (Qp)" means the volume controlled by structural practices to prevent an increase in the frequency of out of bank flooding generated by development.

Point Source Pollution. "Point Source Pollution" means pollution from any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, landfill leachate collection system, vessel or other floating craft which pollutants are or may be discharged.

Pollutant. "Pollutant" means contamination or other alteration of the physical, chemical, or biological properties of waters including change in temperature, taste, color, turbidity, or odor of the waters, or such discharge of any liquid, gaseous, solid, radioactive or other substance into the waters that will or is likely to create a nuisance or render such waters harmful. These substances include, but are not limited to any dredge, spoil, solid waste, incinerator residue, oil, grease, garbage, sewage, sludge, medical waste, chemical waste, biological materials, heat, petro chemical, and sediment.

Recharge volume (Rev). "Recharge volume (Rev)" means that portion of the water quality volume used to maintain groundwater recharge rates at development sites.

Retention structure. "Retention structure" means a permanent structure that provides for the storage of runoff.

Sediment "Sediment" means soils or other surficial materials transported or deposited by the action of wind, water, ice, or gravity as a product of erosion.

Site plan. "Site plan" means a plan, to scale, showing the proposed use and development of a parcel of land. The plan generally includes lot lines, streets, building sites, reserved open space, buildings, major landscape features, both natural and man-made, and the locations of proposed utility lines.

Stabilization. "Stabilization" means the prevention of soil movement by any of various vegetative and/or structural means.

Stormwater management. "Stormwater management" means:

a. For quantitative control, a system of vegetative and structural measures that control the increased volume and rate of surface runoff caused by man-made changes to the land; and

b. For qualitative control, a system of vegetative, structural, and other measures that reduce or eliminate pollutants that might otherwise be carried by surface runoff.

Stormwater management plan (SWP). "Stormwater management plan (SWP)" means a set of drawings or other documents submitted by a person as a prerequisite to obtaining a stormwater management approval, which contain all of the information and specifications pertaining to stormwater management.

Stormwater runoff. "Stormwater runoff" means flow on the surface of the ground, resulting from precipitation or snow melt.

Total suspended solids. **(TSS)** "Total suspended solids" means the sum of the organic and inorganic particles (sediment) suspended in and carried by a fluid (water).

Watercourse. "Watercourse" means any natural or artificial stream, river, creek, ditch, channel, canal, conduit, culvert, drain, waterway, gully, ravine or wash, in and including any adjacent area that is subject to inundation from overflow or flood water.

Water quality volume (WQv). "Water quality volume (WQv)" means the volume needed to capture and treat 90 percent of the average annual runoff volume at a development site.

Water-related. "Water-related" means a use or activity which is not directly dependent upon access to a water body, but which provides goods and services that are directly associated with water-dependent uses or activities.

"***Flood"*** or ***"flooding"*** means a general and temporary condition of partial or complete inundation of normally dry land areas from one or both of the following:

1.The overflow of inland or tidal waters.

2.The unusual and rapid accumulation of runoff of surface waters from any source.

"100-year flood" (also called "regulatory flood," "base flood" or "1% flood event") means a flood of a magnitude which can be expected to occur on an average of once every 100 years. It is possible for this size flood to occur during any year, and possibly in successive years. It would have a one percent chance of being equaled or exceeded in any year. Statistical analysis of available stream flow or storm records, or analysis of rainfall and runoff characteristics of the watershed, or topography and storm characteristics are used to determine the extent and depth of the 100-year flood.

Appendix B – Maps – Soils & Zoning

USDA NRCS Hydrologic Soils Groups

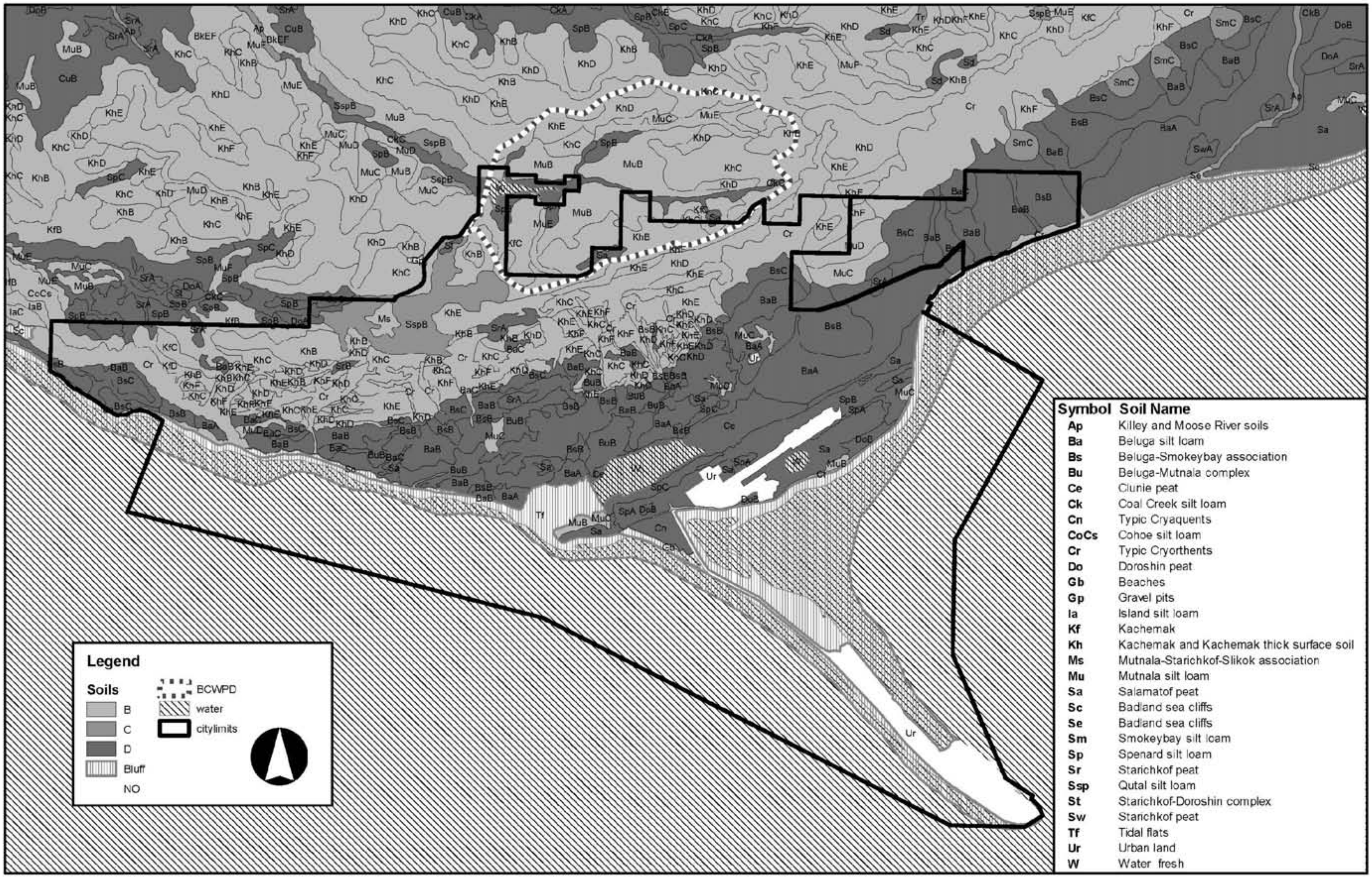
- **Group A** is usually classified as being well drained deep sands or gravels. These soils have high infiltration rates, and high water transmission rates. Minimum infiltration rate is 0.30 to 0.45 inches per hour
- **Group B** soils are moderately well to well draining sandy loam. These have moderate infiltration rates and transmission rates. Minimum infiltration rate is 0.15 to 0.30 inches per hour.
- **Group C** soils are mainly silty-loam soils with a subsurface layer that restricts downward movement of water. These have a moderate to slow rate of infiltration and transmission, increasing runoff when saturated. Minimum infiltration rate of 0.05-0.15 inches per hour.

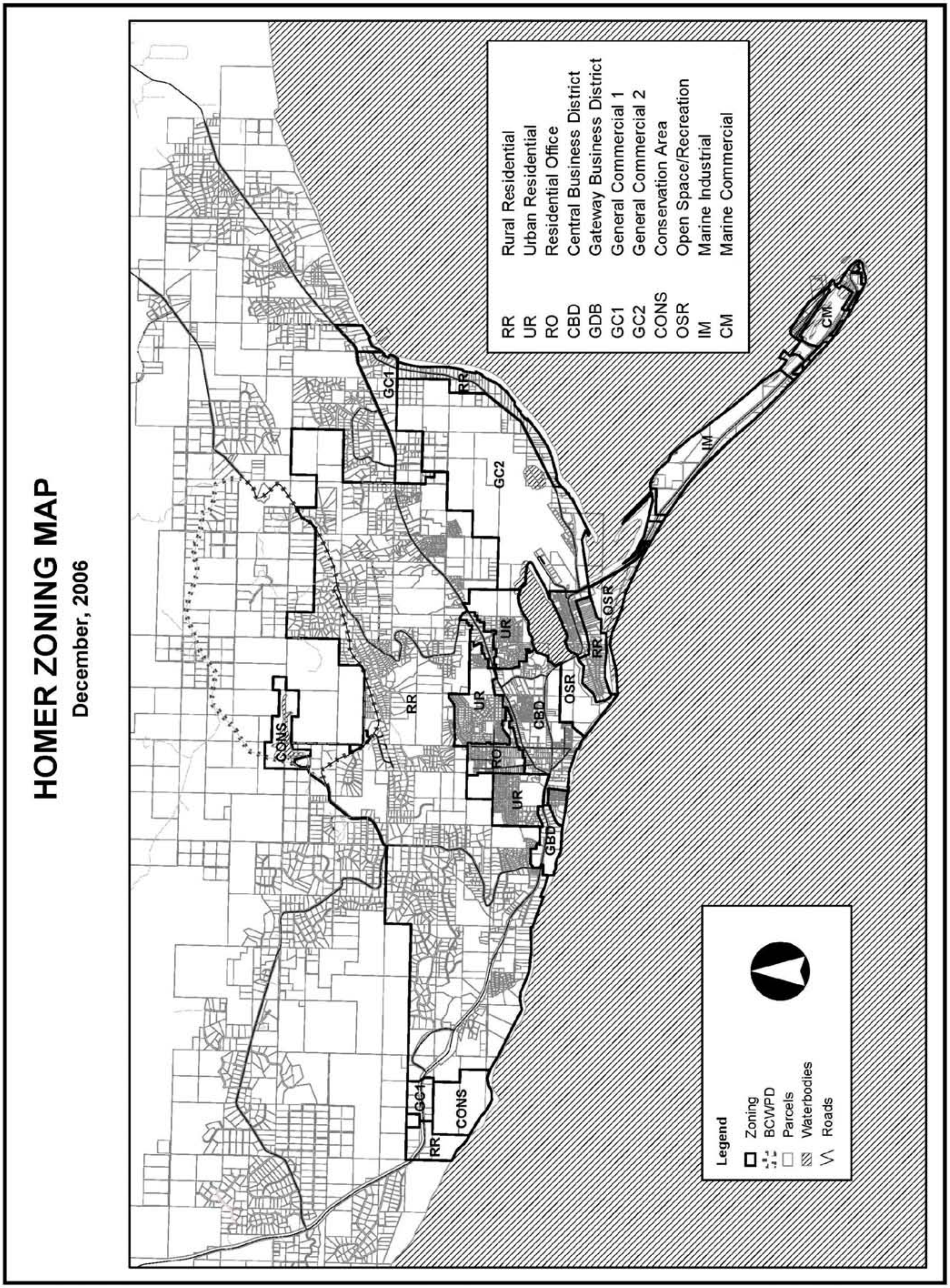
Group D soils chiefly clay or have a shallow clay layer or claypan with a high swelling potential. These soils have a high runoff potential as they have slow infiltration rates, slow transmission rates, and are easily saturated. Minimum infiltration rates are 0 to 0.05 inches per hour

Map Symbol	Soil Name	Description	Hydrologic Group
Ap	Killey and Moose River soils	0 to 2 percent slopes	**C**
BaA	Beluga silt loam	0 to 4 percent slopes	**D**
BaB	Beluga silt loam	4 to 8 percent slopes	**D**
BaC	Beluga silt loam	8 to 15 percent slopes	**D**
BsB	Beluga-Smokeybay association	4 to 8 percent slopes	**D**
BsC	Beluga-Smokeybay association	8 to 15 percent slopes	**D**
BuB	Beluga-Mutnala complex	0 to 8 percent slopes	**D**
Ce	Clunie peat	0 to 2 percent slopes	**D**
CkC	Coal Creek silt loam	8 to 15 percent slo	**D**
Cn	Typic Cryaquents	0 to 2 percent slopes	**D**
CoCs	Cohoe silt loam	8 to 15 percent slopes	**B**
Cr	Typic Cryorthents	100 to 150 percent slop	**B**
DoA	Doroshin peat	0 to 4 percent slopes	**D**
DoB	Doroshin peat	4 to 8 percent slopes	**D**
Gb	Beaches		**NL**
Gp	Gravel pits		**NL**
IaB	Island silt loam	4 to 8 percent slopes	**B**
KfB	Kachemak	forested 4 to 8 percent	**B**
KfC	Kachemak	forested 8 to 15 percer	**B**
KfD	Kachemak	forested 15 to 25 perce	**B**
KhB	Kachemak and Kachemak thick surface soil		**B**
KhC	Kachemak and Kachemak thick surface soil		**B**
KhD	Kachemak and Kachemak thick surface soil		**B**
KhE	Kachemak and Kachemak thick surface soil		**B**
KhF	Kachemak and Kachemak thick surface soil		**B**
Ms	Mutnala-Starichkof-Slikok association		**B**
MuB	Mutnala silt loam	4 to 8 percent slopes	**B**
MuC	Mutnala silt loam	8 to 15 percent slopes	**B**
MuD	Mutnala silt loam	15 to 25 percent slopes	**B**
MuE	Mutnala silt loam	25 to 45 percent slopes	**B**
Sa	Salamatof peat	0 to 4 percent slopes	**D**
Sc	Badland sea cliffs		**NL**
Se	Badland sea cliffs	Typic Cryorthents	**B**
SmC	Smokeybay silt loam	8 to 15 percent slopes	**C**
SpA	Spenard silt loam	0 to 4 percent slopes	**D**
SpB	Spenard silt loam	4 to 8 percent slopes	**D**
SpC	Spenard silt loam	8 to 15 percent slopes	**D**
SrA	Starichkof peat	0 to 4 percent slopes	**D**
SrB	Starichkof peat	4 to 8 percent slopes	**D**
SspB	Qutal silt loam	4 to 8 percent slopes	**C**
St	Starichkof-Doroshin complex	0 to 4 percent slopes	**D**
SwA	Starichkof peat	forested 0 to 6 percent	**D**
Tf	Tidal flats		**NL**

HOMER SOILS

2005 NRCS Soil Survey of the Western Kenai Peninsula




HOMER ZONING MAP
December, 2006
RR Rural Residential
UR Urban Residential
RO Residential Office
CBD Central Business District
GDB Gateway Business District
GC1 General Commercial 1
GC2 General Commercial 2
CONS Conservation Area
OSR Open Space/Recreation
IM Marine Industrial
CM Marine Commercial
Legend
Zoning
BCWPD
Parcels
Waterbodies
Roads
GC1
RR
GC2
OSR
UR
RR
CBD
UR
RO
UR
GBD
CONS
IM
CM
GC1
CONS
RR

Appendix C - Regulations

The Clean Water Act (CWA)

Initially passed in 1972, and amended in 1977 and 1987, the CWA prohibits the discharge of pollutants into "Waters of the United States" without a permit designed to mitigate adverse impacts. Regulations under this act are intended to minimize long-term losses of wetlands, waterways and other important water transport mechanisms, and also to limit pollution, sedimentation and other damage to waterbodies.

Section 404, Dredge and Fill Permits

The United States Army Corps of Engineers (Corps) administers this permit program with input from the Environmental Protection Agency, US Fish and Wildlife Service, and state and local government. The program requires a permit any time someone proposes to discharge fill or dredged material into a "Water of the United States." Waters of the United States include the ocean, rivers, streams, lakes, ponds, and wetlands that are integrally connected to that hydrologic system.

Regulation of development within wetlands is the most noticeable application of Section 404. Permits are required before any dredge or fill activity occurs in a wetland. In a recent mapping of the western Kenai Peninsula, approximately 41% of the land area was classified as wetlands, so it is prudent to contact the Corps any time you plan to develop a piece of property. General wetland mapping is accessible through the Kenai Borough website or planning department, and the Corps may inspect your site free of charge to determine whether you have wetlands on your property. A private consultant may have to be hired to accelerate the delineation of the wetland boundaries.

National Pollutant Discharge Elimination System (NPDES)

NPDES is a system created and overseen by the Environmental Protection Agency (EPA) that regulates under the Clean Water Act by setting rules and requiring permits for a variety of discharges, including construction activities. The specific regulations are known as NDPES Phase I Stormwater regulations (1990) for projects over five acres, and NDPES Phase II stormwater regulations (1999) for projects between 1 and five acres. These require the submission of a "Notice of Intent" **(NOI)** and the creation of a "Stormwater Pollution Prevention Plan" **(SWPPP)** for any proposed construction over one acre to a local regulatory board and/or the EPA.

FEMA/insurance

In 1968 the National Flood Insurance Program (NFIP) was created to reduce flood damage and loss, and to reduce flood relief costs by guiding development out of floodplains and helping develop flood resistant design and construction practices. In 1973 NFIP was modified to require flood insurance as a condition to receiving federal financial assistance in the form of mortgage loans. This insurance is regulated and administered by the Federal Emergency Management Agency (FEMA). Most municipalities, including Homer, incorporate FEMA guidelines as part of their regulatory framework. In Homer, this can be found in Chapter 12.12 of the Homer City Code.

City of Homer Regulations & Code

Homer City Code contains a variety of sections that address stormwater management issues. The following is a brief description of the potential requirements, as well as some code sections that may be complementary when planning a site for stormwater management.

Long-Term/Permanent Stormwater Management Required:

Permanent, formal stormwater management systems are required as part of site planning in certain districts and circumstances. Though proper stormwater management should be designed into every project according to the guidelines in this manual, the City of Homer has specific requirements in some cases. These requirements are listed in the "Standards for Stormwater Plan (SWP)" in sections 21.48.060(g) and 21.49.060(g) of Homer City Code.

Design and permit application requirements that should reflect stormwater plans:

- If required, the site plan included in a permit application must include a Stormwater Plan and/or Development Activity Plan.
- All districts require that pre-existing and proposed drainage be shown on the site plan.
- Some districts require a grading plan as part of the drainage plan, showing all cuts, fills and areas of disturbance, elevation changes and cut/fill quantities. Disturbed areas may be replanted to benefit open space and stormwater management goals or requirements.
- All districts require that other permits be provided with the zoning permit application. For Stormwater, this will include applicable State and Federal permits.
- Bridge Creek Watershed Protection District has very strict stormwater and sediment control requirements, and any applicant project located in that area should carefully read that section of HCC 21.59.
- A project with certain characteristics located in any district may require a Conditional Use Permit (CUP). A CUP has additional requirements for site plan information and may require additional open space, landscaping, buffer areas and/or snow storage areas.

Sediment and Erosion control during construction:

This document does not address the special topic of construction activities. Where state and federal regulation may or may not apply, the City of Homer regulates sediment and erosion control during construction in certain districts and types of projects through the Development Activity Plan (DAP). It is important to note that the DAP must be approved by the City, and clearing limits be inspected on site prior to any land clearing activities.

General requirements where Stormwater Management is considered

Protection of neighboring properties - City code states that "development activities shall not adversely impact other properties by causing damaging alteration of surface water drainage, surface water ponding, slope failure, erosion, situation, …." This essentially requires the developer to be responsible for maintaining pre-development on-site stormwater function in the post-development condition, and highlights the responsibilities of developers to the rights of other property owners.

Requirements that complement Stormwater Management:

The following are Homer City code requirements that complement stormwater codes, or provide an opportunity for the developer to address stormwater in the course of satisfying other Homer City Code requirements. In all cases it should be remembered that any change from native conditions will naturally have a negative impact on the site's ability to control stormwater, and all remaining open space should be designed with water control in mind. For example, landscaping requirements may also be able to function as stormwater control areas.

- Open space requirements – Requirements vary by project and district. Most stormwater management structures and best practices can be counted as part of the open space requirements.
- Drainage requirements – All districts require a drainage plan, and that the drainage 'system' is designed to "deposit all runoff into an engineered or natural drainage." An engineered drainage should be designed with check dams to slow the movement of water

and drop sediments. If draining into a natural drainage, particularly a surficial stream, runoff should first flow through a sediment basin or detention structure to avoid contaminating or clogging the drainage channel.

- Buffer requirements – where buffers are required, consider locating buffers for stormwater management. Typical buffers required include:
  - "3 feet minimum width along all lot lines where setbacks permit; except where a single use is contiguous across common lot lines" – Unless required for privacy or noise protection, the applicant is strongly encouraged to ask the City that this buffer area be located where it will function for stormwater management.
  - "15 feet minimum from the top of the bank of any defined drainage channel or stream." This is a good general rule in any site plan for protecting streams and drainages from damaging sedimentation or pollution. Where it is required, care should be taken to protect native vegetation in this buffer to retain maximum natural function and save in landscaping costs.
- Ditch/drainage system setbacks
  - Open ditch construction – Structures are required to be at least 15 feet from the top of the bank of the channel, which leaves plenty of room for filtering vegetation or a detention berm.
  - Closed system – This may include a subsurface detention basin, French drain, or culvert. Structures are required to be at least 10 feet from these structures. Closed systems thus allow a higher density of development. Simple culverts should be avoided unless they daylight into a detention structure, sediment trap or open channel with check dams.
- Drainage stabilization – Though drainages can be stabilized "by methods other than vegetation, subject to approval by the City Engineer," vegetation is cheaper and more effective for stormwater management, and will not hold up the permitting process waiting for approval from the City Engineer.
- Parking dividers – Some larger parking lots require a minimum area of landscaping. Parking lots are a highly valuable place to locate a vegetated stormwater management structure, as it will help filter pollutants from the oily runoff from paved areas. This is also an area that is generally fully disturbed and clear of obstacles to construction, so it is much easier to install a constructed stormwater system in these locations. Generally, the requirement is for landscaping over 10% of the parking area, and a 10 foot landscaped buffer adjacent to the road right-of-way.
- Landscaping requirements – All districts have basic landscaping requirements that are beneficial to the natural stormwater control function of open spaces. Consider locating and enhancing these undisturbed or revegetated areas on the site plan for functional stormwater management. Areas that are required to be undisturbed, landscaped or revegetated can always be counted as a credit toward stormwater function, but can be much more valuable if located downstream on a site.
- General - All exposed, cleared, filled and disturbed soils shall be revegetated within the next growing season.

References

GENERAL INFORMATION SOURCES:

Anchorage MUNI Design Criteria Manual http://www.muni.org/projectmgmt/publications.cfm
specific calculations and design guidance for drainage and stormwater management based on Anchorage Codes – quite technical.

Alaska Department of Environmental Conservation. http://www.dec.state.ak.us/index.htm.
Resource for BMPs and other regulatory guidelines. Stormwater information at http://www.dec.state.ak.us/water/wnpspc/stormwater/stormwater.htm.

Center for Watershed Protection. http://www.cwp.org/.
Non-profit 501(c)3 corporation providing technical tool and resources for managing watersheds and protecting streams, lakes and rivers.

Construction Industry Compliance Assistance Center (CICA). http://www.cicacenter.org.
Industry organization funded by the EPA with assistance by the National Association of Home Builders and the Associated General Contractors of America. Provides industry-wide information about regulatory processes and compliance by state and category.

Landscape Architecture Magazine. http://www.asla.org/nonmembers/lam.html.
Monthly publication of the American Society of Landscape Architects. Source for design and science of stormwater, wetlands and gardens.

Natural Resources Conservation Service. http://www.nrcs.usda.gov/.
Branch of U. S. Department of Agriculture providing information and assistance on soils and water management.

Stormwater Magazine. http://www.stormh20.com/sw.html.
Free publication. Reference for current products and practices for surface water quality management.

Stormwater Manager's Resource Center. http://www.stormwatercenter.net/.
Information related to stormwater science, techniques, management guides and regulations.

U. S. Environmental Protection Agency. http://epa.gov/.
Regulatory agency for Clean Water Act section 401 and 404 permits. Resource for many free publications on stormwater management. See also: http://www.epa.gov/npdes/stormwater & http://cfpub.epa.gov/npdes/greeninfrastructure.cfm

U. S. Geological Survey. http://www.usgs.gov/.
Extensive resource for scientific and spatially referenced information on Earth sciences, including GIS information on natural resources and soils information, and links to related governmental agencies.

DOCUMENT REFERENCES:

Alaska Stormwater Pollution Prevention Plan Guide. Alaska Department of Transportation and Public Facilities, 2005.
http://www.dot.state.ak.us/stwddes/dcsenviron/assets/pdf/swppp/english/eng_guide_all.pdf

An Overview of Major Wetland Functions and Values . U.S. Fish and Wildlife Service. 1984..

Balmori, Diana & Benoit, Gaboury. (eds) The Land Code: Guidelines for Environmentally Sustainable Land Development. Yale Publishing Services, 2004.
http://environment.yale.edu/doc/962/the_land_code/.

Caraco, Deb & Clayton, Richard. Stormwater BMP Design Supplement for Cold Climates for US EPA Region 5. Ellicot City, MD: Center for Watershed Protection, 1997
http://www.cwp.org/cold-climates.htm.

Georgia Stormwater Management Manual, vols 1 & 2. AMEC Earth and Environmental Center for Watershed Protection. Atlanta, GA: Atlanta Regional Commission, 2001.

Granger, R., D. Gray and D. Dyck. Snowmelt Infiltration to frozen Prarie Soils. Canadian Journal of Earth Science, 21:669-677. 1984

Green Streets: Innovative Solutions for Stormwater and Stream Crossings. Portland: Metro, 2002

Juneau Wetlands Functions and Values. Adamus Resource Assessment, Inc. Prepared for the City and Borough of Juneau, Department of Community Development. 1987

Kays, Barrett L. Problem Solving in Stormwater Bioretention Systems: Pitfalls in Bioretention systems and How to Avoid Them. Landscape Architecture Magazine V 96 No.05, 94-105. May 2006.

LEED Green Building Rating System for New Construction and Major Renovations (LEED-NC), Ver 2.2. Washington, D.C.: U.S. Green Building Council. 2005.

Low-Impact Development Design Strategies: An Integrated Design Approach. EPA 841-B-00-003. Environmental Protection Agency, 2000. http://www.epa.gov/owow/nps/lid/lidnatl.pdf.

Low-Impact Development Hydrologic Analysis. EPA 841-B-00-002. Environmental Protection Agency, 2000. http://www.epa.gov/owow/nps/lid/lid_hydr.pdf.

Marble, Anne D. Guide to Wetland Functional Design. Lewis Publishers, CRC Press, 1992.

McCuen, R. H., Hydrologic Analysis and Design. Third edn. New Jersey: Prentice Hall, 2004.

Miller J.F. Probabale Maximum Precipitstion and Rainfall-Frequency Data for Alaska. U.S. Weather Bureau: Technical Paper No. 47, Washington, DC, 1963.

Minnesota Urban Small Sites BMP Manual: Stormwater Best Management Practices for Cold Climates. Metropolitan Council Environmental Services & Barr Engineering Co., 2001.

Moshiri, Gerald. Constructed Wetlands for Water Quality Improvement. Lewis Publishers, CRC Press, 1993

New York State Stormwater Management Design. Ellicott City, MD: Center for Watershed Protection, 2003. http://www.dec.state.ny.us/website/dow/toolbox/swmanual/.

R. L. France (ed). Handbook of Water Sensitive Planning and Design. Lewis Publishers, CRC Press, 2002

Schueler, Thomas R., and Heather K. Holland (eds). Watershed Protection Techniques. Ellicott City, MD: Center for Watershed Protection. 2002

Schueler, Thomas R., and Heather K. Holland (eds). The Practice of Watershed Protection. Ellicott City, MD: Center for Watershed Protection, 2000.

Start at the Source: Design Guidance Manual for Stormwater Quality. Bay Area Stormwater Management Agencies Association (BASMAA), 1999 http://www.scvurppp-w2k.com/basmaa_satsm.htm.

Stein, Benjamin & Reynolds, John S.. Mechanical and Electrical Equipment for Buildings. 9th Ed. New York: John Wiley & Sons, Inc., 2000.

Stormwater Management for Construction Activities: Developing Pollution Prevention Plans and Best Management Practices. EPA 832-R-92-005. United States Environmental Protection Agency. 1992. http://cfpub.epa.gov/npdes/stormwater/swppp.cfm.

Strom, Steven & Nathan, Kurt. Site Engineering for Landscape Architects Third Ed. New York: John Wiley & Sons, Inc., 1998.

Urban Runoff Quality Management: WEF Manual of Practice No. 23 & ASCE Manual and Report on Engineering Practive No. 87. Alexandria VA: Water Environment Federation, Reston, VA: American Society of Civil Engineers. 1998.

Using Site Design Techniques to Meet Development Standards for Stormwater Quality: A Companion Document to Start at the Source. Bay Area Stormwater Management Agencies Association (BASMAA), 2003. http://www.scvurppp-w2k.com/basmaa_satsm.htm.