Coal Creek Delta
Landscape Restoration Design Proposal

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EHUF 480 winter 2003

Abstract

This Coal Creek Restoration Project has been prepared for Mr. Bill Weinstein, the Coal Creek Coalition, and the City of Bellevue. Bill Weinstein's property is located adjacent to Coal Creek. The intention is to provide a framework for plant selection, maintenance and management, and plant placement for the area of the Coal Creek Delta. We must jointly meet the needs of the client's private residence, as well as the stream's ecological function. Our primary goal is to restore salmon habitat using native vegetation. This is best accomplished with restoration and preservation techniques, which include: the eradication of non-native invasive species and recommendations for plant species that will tolerate conditions within the site. This will provide Mr. Weinstein and his design team with some ideas about landforms, materials, ecological function, invasive species concerns, and planting regimes for future development of the site.

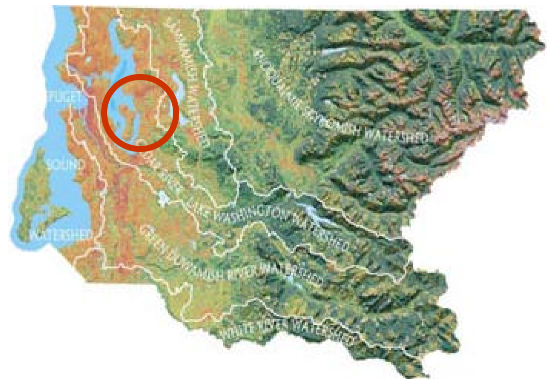
Introduction

Coal Creek Delta Project

Citizens of the Coal Creek Coalition are interested improving the health of the Coal Creek Watershed by developing a more ecologically diverse environment along the shoreline and its delta, mitigating scouring and sediment transport, restoring native vegetation and re-establishing salmon runs on the creek. The most critical part of the watershed is the river delta. Here, invasive species are in strong competition with native species. Moreover, the delta collects sediment from bank erosion. Two detention ponds were installed upstream, but they fail to collect the large amounts of sediment deposits during high flood stage. This results in the lack of habitat and diversity necessary for sustaining salmon runs. To create an environment that promotes ecological diversity and salmon habitat, this project proposes a plan that includes a study of the delta site (as well as the headwaters of Coal Creek), invasive removal, sediment mitigation and plant selection and management procedures.

The Coal Creek Drainage Basin

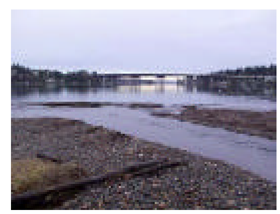
Coal Creek is part of the Cedar River-Lake Washington Watershed (Fig.1), which includes the area in which rainwater and groundwater drains into Lake Washington. Water then empties to Puget Sound through the Hiram M. Chittenden Locks. Kelsey Creek, May Creek, Lyon Creek, Thornton Creek, Ravenna Creek, Mercer Island, and McAleer Creek are other tributaries of the Cedar River-Lake Washington Watershed.

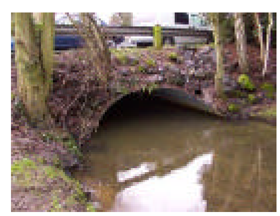


Coal Creek's headwaters originate in the steep slopes of Cougar Mountain at an elevation of approximately 1,400 feet. The creek flows through steep and narrow ravines and after 7 miles it enters Lake Washington at Newport Shores. In all, the drainage basin for Coal Creek encompasses about 5,820 acres. The delta of Coal Creek is bcated along the southeastern shoreline of Lake Washington, adjacent to the Newport Shores residential community in Bellevue, Washington (Streams Monitoring Program, King County, 2003).

Site Description

The initial site visit revealed that the area at the terminus of the delta showed sediment deposition, which includes coal deposits. An oblong sandbar-stretching north to south has accreted as a result of the wave movement of Lake Washington directly opposing the outflow of Coal Creek. Immediately south of the delta terminus a concrete wall protrudes two feet from the water and acts as a sediment deflector. It was constructed to minimize the spread of the delta northward and into adjacent canals.



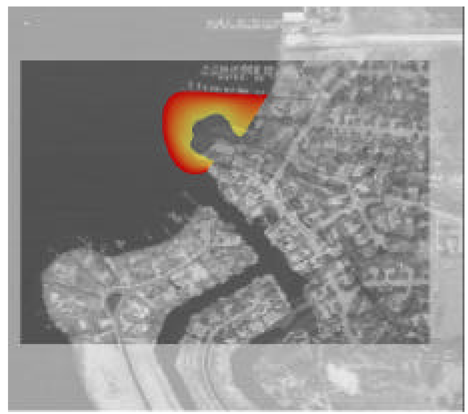


The Creek meanders slightly, but is flows in almost a straight line through the lower reaches of the delta. Looking up the creek from the tip of the delta, the area to the viewer's right (southwest) is a low-lying strip of lawn. Reed canary grass, Himalayan blackberry and alder dominate the other side of the creek. This northeast side of the creek also has evidence of recent planting. A variety of plants such as red alder have been installed within the past several years and some are still attached to their stakes.

Upstream about 300 feet, the stream disappears from view as it enters a culvert under a two-lane road bridge (Fig 3). Between this culvert and where the stream enters Lake Washington, there is little overhanging vegetation and the stream path is nearly straight. The creek bottom is rocky but possesses little turbidity. The banks on the northeast are gradual and look natural. On the other hand, the banks on the southwest side of the stream are nearly vertical due to sandbag walls placed as flood-prevention.

Site Background

In 1863, surveyors Phillip H. Lewis and Edwin Richardson discovered coal in the Newcastle area on the north bank of Coal Creek. By 1866, the first road open to wagons was developed in the area, and the coal was taken across Lake Washington to a landing near the east end of Yesler Way for market. Due to the relatively easy extraction of coal from this area, as well as a high demand for coal in such areas as San Francisco, the mining grew rapidly (Prosch,1900-1901). The extensive coal mining activities led to changes in the stream's course. The process channelized certain reaches dumped mine tailing along its banks (McDonald, 1987).



Urban development has spread throughout the basin in the last century, which has resulted in stream flow alteration. Soil removal and extensive paving had great affects on the hydrology of the area. Frequency and duration of peak flood events, bank erosion and streambed sedimentation all increased.

In the 1940s, Coal Creek's channel was moved southward from what is now known as Newcastle Beach Park, then northward in the 1950s because of an airstrip construction. Two canals were then constructed just north of the site in the 1960s as part of the Newport Shores residential development (Stream Monitoring Program, King County 2003).

Planting zones

In order to simplify the planting design the site has been broken down into four main zones. The zones are separated by unique characteristics involving varying soil conditions, stream path and user needs, which are defined by view corridors and privacy considerations. Starting from the street on the east side of the site the soil conditions are drier due to the slightly higher elevation. As you move west through the site towards the lake, the soil becomes moist to saturated. There is a need for privacy on both the north and south edges of the site, while the west edge will has a potential lake view. The stream path moves through areas of riparian vegetation and flood plains. All of these considerations have been taken into account when distinguishing the four zones.

Site Analysis

Hydrology & Sedimentation

The Coal Creek delta consists of both emergent and submerged portions. The emergent portion includes all the low-lying terrain under the Newport Shores residential community, the total area of which is approximately 200 acres (Reinhart 1998). This sediment is a result of deposits from the creek following glacial retreat and melting. The development of the submerged portion of the Coal Creek Delta is the result of water and sediment discharge from the mouth of the creek.

Natural delta building processes involve lateral growth of the delta front from deposition of sediment from shallow channels and upward growth by deposition of fine sediment in non-channelized portions of the delta (Reinhart 1998). Historically, the delta was located in a shallow portion of the lake. Increased sediment loads have settled onto the shallow flat, decreasing the depth of the lake near the mouth of the creek. This sediment load spreads to areas with the least hydrological resistance. Due to opposing wave action from the lake, the most recent delta growth has to the northeast of the site, on the southern portion of the Newport Yacht Club. Geo Engineers estimate this deposition rate to be approximately 3600 cubic yards per year (1998). Consequently, the Newport Yacht Club, to attempt to alleviate this buildup, installed a sediment deflector on the edge of its property. Since this barrier was installed, sediment continues to accumulate outside the barrier and is advancing northward.

As indicated earlier, the extensive coal mining activities that took place in the upland areas of Coal Creek had significant impact on sedimentation. The mining resulted in the modification of the stream course and caused confined, narrow channels. Furthermore, mining dams blocked the stream, and debris was dumped along the stream banks.

Urban development within the basin has further altered the natural hydrologic characteristics: increasing the frequency, duration, and peak flood events, and further increasing stream-bank erosion and sedimentation (Kerwin 2001). The stream has been moved three times, and just to the south of the stream mouth, canals were excavated for mooring. In addition, the level of Lake Washington was lowered around 8 feet when the locks were built.

In 1987, a hydraulic model was developed by the city of Bellevue to understand and prepare a plan for remediation of the heavy sedimentation. It was found that base flows in Coal Creek are augmented approximately 10 % by source-flows from mine tunnels. In addition, Coal Creek was found to have extensive sedimentation resulting from stream bank erosion and slope failure from old mining activity (Streams Monitoring Program, King County 2003). Since 1997, the city of Bellevue has maintained two sediment ponds, one upstream of Coal

Creek Parkway and the other upstream of Interstate Highway 405. These ponds were built in response to delta growth along the Newport Shores coastline.

Installing the sediment ponds upstream has only been slightly successful in containing the high sedimentation flows during storm season. The majority of flooding occurs in the winter when the ponds are unable to be maintained (Kerwin 2001). As a result, sediment continues to move downstream during storm events. During peak flooding events, the velocity of the stream is strong and fast enough to scour and erode the streambed. Sediment is typically delivered to portions of the delta as a bedload and as a suspended load.

Bedload consists of larger particles (sand) and moves by rolling or sliding along the streambed. These loads are typically transported to lower surfaces, such as the channel floor as the stream loses energy. The suspended load consists of fine particles (silt and clay) that are typically deposited along the channel or within the delta area. Evaluations of the sediment deposits have verified the sediment deposits to consist of 80% sand and 20 % silt and clay.

Based on the high amount of sand, it appears that the majority of the sediment is transported primarily of the bedload. This accounts for the scouring of the streambed brought on by high-velocity floodwaters. High-velocity floodwaters are caused by the straight, narrow nature of the stream as well as its lack of edge diversity. Because of this high sedimentation rate, it is estimated that despite the sediment barriers, the rate of lateral growth of the delta will increase, potentially encroaching upon the entrance to the marina within the next 10 years (Reinhart 1998). The use of wetland plants will help facilitate the natural system of soils, hydrology and microclimate of the Coal Creek delta.

Scouring is a natural stream process that moves sediment to banks and pools to create habitat and meanders in stream. Coal Creek has minimal hydraulic complexity and the stream is straight due to man-made channelization. This has forced the sediment out to the mouth of the stream instead of at natural meanders within the stream.

Soils

The Coal Creek area has been classified as a Riverine Wetland, the streambed is classified as a Lower Perennial, Cobble/Gravel Bottom streambed, and the edge of the vegetated wetland is classified as a semi permanently flooded Lacustrine Wetland.

The soils in the Coal Creek delta and wetland are comprised primarily of Briscot soil loam (Br) and Urban land (Ur). Urban soils border both sides of the creek through the site; these types of soil are “fill” material and do not have specific soil characteristics. The Briscot soils are poorly drained soils, formed under conifers and grass in river or stream valleys. The hydrology of Coal Creek is comprised of two sources, Coal Creek and Lake Washington being the two dominant sources of water for the site.

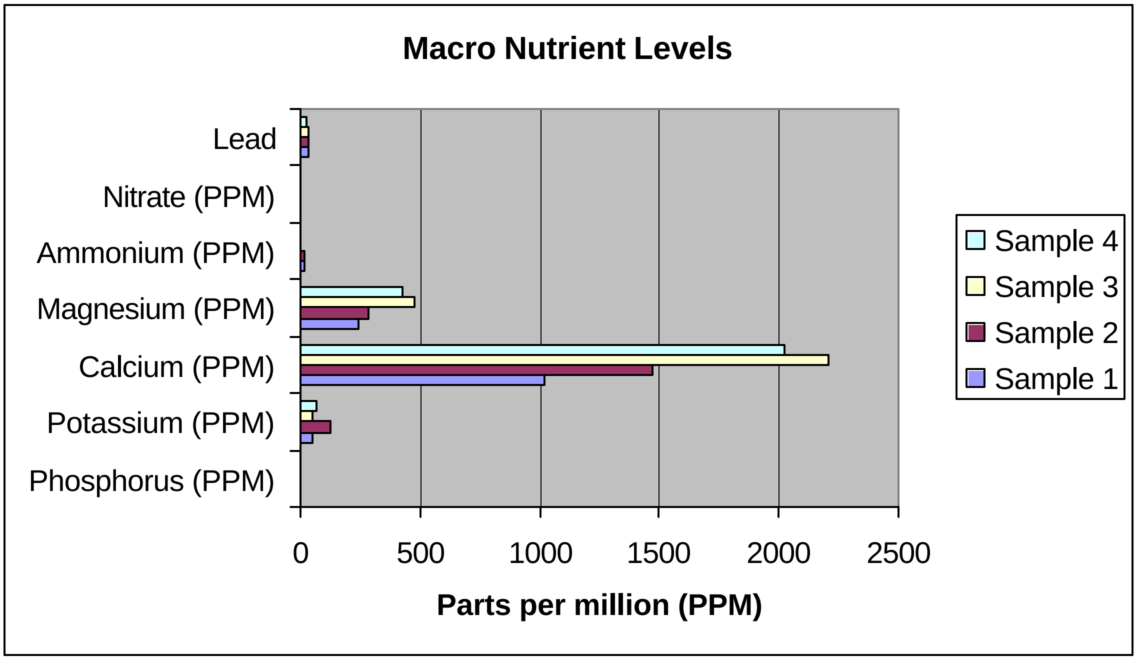
Soil pH Analysis

Soil samples were collected on January 19, 2004 for data updates on the macro and micro nutrient levels at Coal Creek Parkway. Four samples were collected and sent to the University of Massachusetts in Amherst, MA for a detailed soil analysis. Samples were collected from the upland area, the delta area on the north and south side of the delta and from the stream bank within the stream channel.

- Sample #1 was taken from the southwest edge of the Lakeside portion of the site (Zone 3) and has the following deficiencies. The soil pH was a high 7.3, the nitrogen and phosphorous levels were low and magnesium levels were high.
- Sample #2 was taken from the southeast edge of the Interior shrubland portion of the site(Zone 2). The pH for this portion was 6.3, which is a desirable range; nutrient levels of nitrogen and phosphorous are low and calcium and magnesium levels are high.
- Sample #3 was taken from the northeast portion of the Canopy portion of the site (Zone 1). The soil pH level was high at 6.7. Levels of phosphorous, nitrogen and ammonium were low, while magnesium and calcium levels were high.
- Sample #4 was taken from the northeast portion of the Lakeside area of the site (Zone 3). The soil pH level was high at 6.8. Levels of phosphorous, nitrogen and ammonium were low, while magnesium and calcium levels were high.

Macro Nutrient Levels

	Sample 1	Sample 2	Sample 3	Sample 4
Phosphorus (PPM)	4	7	5	5
Potassium (PPM)	52	124	49	64
Calcium (PPM)	1023	1472	2207	2025
Magnesium (PPM)	241	281	474	428
Ammonium (PPM)	16	18	1	3
Nitrate (PPM)	7	5	6	7
Lead	33	31	35	28
pH	7.3	6.3	6.7	6.8
CEC (MEQ/100G)	4.8	12.3	17.2	10.6



Existing Vegetation

Existing native vegetation

Existing native vegetation on site is primarily limited to young trees and shrubs installed in recent years. The majority of these young trees are poorly staked and showing signs of stress. The majority of the species appear to be surviving. Along the stream edge there are numerous mature Red alder trees creating the sites' only shade. Current native vegetation is listed below:

Acer circinatum (Vine maple)
Alnus rubra (red alder)
Picea sitchensis (Sitka spruce)
Prunus emarginata (Bitter cherry)
Pseudotsuga menziesii (Douglas fir)
Ribes sanguineum (Red-flowering currant)
Salix spp. (Willow species)
Typha latifolia (Cat tail)
Unknown Sedge spp.

Existing non-native vegetation

The site is currently dominated by Himalayan blackberry and reed canary grass. Reed Canary grass thrives in wet sunny conditions. The Himalayan blackberry has formed dense thickets in the drier portion of the site nearest the road. Reed canary grass is currently thriving in the wet sunny spots, primarily on the west side of the site. Although many non-native species were observed, six were recorded in substantial numbers and are listed below:

Agrostis stolonifera (creeping bent grass)
Circium arvense (Canada thistle)
Convolvulus arvensis (bindweed)
Phalaris arundinacea (reed canary grass)
Ranunculus repens (creeping buttercup)
Rubus discolor (Himalayan blackberry)

Site Biology

Project goals and objectives: Clients needs

We have examined this project's goals from the perspective of the salmon as our most important client. As arguably one of the most sensitive and important animals in the Pacific Northwest watersheds, the salmon runs of Coal Creek have been in decline. According to a fisheries impact paper written by Wayne J Daley, Sr. fisheries biologist for Daley Design, three salmon species are known, historically, to inhabit coal creek: Coho (*Oncorhynchus kitsuch*) cutthroat trout (*O. clarki*) and presumably sockeye, (*O. nerka*). Salmon use this creek as spawning grounds in the fall and winter months. Juvenile salmon then swim downstream through lake Washington and to Puget Sound (Daley).

Development of the Coal Creek area has had dramatic affects on salmon run health. Sedimentation has clogged the gravel beds in which eggs are laid and is also detrimental to fish gills. Higher peak flows scour creek banks and remove habitat and riparian vegetation and the vital invertebrates that salmon feed on. Culverts, houses, lawns, and roads also reduce riparian habitat. Furthermore, urbanization leads to polluted runoff, especially residual fossil fuel. Finally, unique to this stream, mine tailings from the historic coalmines discussed earlier litter the site and contribute greatly to the accretion of the delta, (Daley).

Light Analysis

Coal Creek waters flow from southeast to northwest through Mr. Weinstein's property. It has trees that create shade along the east side of the creek. These trees provide some shade for the creek's waters from morning to midday (mostly during summer months), but they do not provide a full day of shade for the water surface because the afternoon sun's rays enter from the southwest. Mr. Weinstein's house and garden do provide some shade for the creek's waters from west light; however, the shade is limited to the southwest end of the creek.

The land area west of the creek is covered only with low growing turf. Some shade arches over to the land area on the west side of the creek because of trees planted on the east bank of the creek, however, this is only morning to midday shade (mostly summer months). Aside from the minimal shade of these trees, the area at the southwest corner of the site, which is Mr. Weinstein's yard, has several shrubs and a few large deciduous trees, which keep this area in shade through most of the day (especially during spring through summer when foliage is present on large trees). Aside from the above mentioned shade areas, the majority of the west side of the creek is exposed to full light.

The area east of the creek has some shade cast on it from the house, immediately east of the site. This house has evergreen trees planted in its yard, which reach approximately 40 feet in height. From midday to late afternoon light is interrupted by the deciduous plants located immediately east of the creek. However, the shade cast by these trees does not extend through the entire land area east of the creek, and its extent depends on time of year. For example, winter months or winter solstice have a light arc from the sun that is further south, therefore creating long shadows through the site. Summer months, or summer solstice, brings a light source that is more directly overhead from the site, therefore casting shorter shadows through the site.

The southernmost portion of the east side of the creek is juxtaposed with a road bridge, which allows light to flood this area. Although some shade will occur in late afternoon, and especially during summer months, which is due to the large trees in the southwest corner of the site. Invasive, light thriving plants such as Himalayan blackberry are present.

The northernmost portion of the entire site receives the most light because it opens to Lake Washington, and has minimal (nearly none) vegetation. It is also absent of any structures that may block light.

View corridors

Coal Creek Delta offers views towards Lake Washington, the Newport Yacht Club, and Mercer Island. All three view-areas are towards the north end of the delta, and are visible from most areas of the site. A concern for preserving these views has been expressed by the client, and he advocates for a visual axis that will give viewers from the site a sightline that goes out directly to Lake Washington.

The I-90 Freeway is also immediately north of the site and is in direct view. Another concern from the client is to buffer the views to the I-90 bridge without eliminating views to the lake. Another desired view buffer could include providing privacy, yet permeability, from neighboring homes. Preserving views to the northwest from the residence to the east of the site will require transparency in the planting palette at the northeast portion of the site. The client mentioned that views west of the site are not as vital, and that dense planting palettes would work well in that area.

To the south of the site a road bridge crosses over the creek. The views towards this area include residential properties, the street and a green corridor along the creek to the southeast of the bridge. The client desires privacy from the street.

Design Proposal

Goals

There are several major goals for this project. Our primary goal is to restore salmon habitat using native vegetation. While the scope of our project, technically, revolves around the planting issues, the client, Bill Weinstein, would like us to design the site in aspects other than planting as well. These two agendas are for the most part cohesive; Mr. Weinstein wants a functioning salmon habitat as well as a beautiful yard.

However, our time is limited and our principal focus is the understanding of plant selection and maintenance Therefore, we will only be able to provide a rough, conceptual plan of the site. This plan will serve as a framework for our planting choices, locations, and maintenance. Hopefully, it will also provide Mr. Weinstein and his design team with some ideas about landforms, materials, ecological function, invasive species concerns, and specifically planting regimes.

While we are only designing the delta site, we want to emphasize the importance of a watershed-wide response to effectively mitigate the problems discussed herein. It is imperative that comprehensive watershed action plans continue to be developed and growth-impact be assessed. While sediment ponds upstream have been begun to deal with the headwaters of the problem, their effectiveness remains questionable. On the other hand, what is certain is the significance of the delta area on creek ecology.

The Site

The framework for our design is based on an initial schematic plan produced by Battelle Engineers. The goal of the Battelle plan is to capture sediment before it enters Lake Washington. Consisting of sediment pools and channels, the idea is that water will enter pools, slow down, drop its sediment, and proceed into the lake, thereby minimizing the growth of the delta. Several major site-design limitations restrict the path of the stream. For one, the Battelle proposal suggests a 20’ wide road down each side of the creek so that the pools can be accessed and the deposited sediment removed by machinery as needed. Also, the sediment ponds are 75’ wide. This causes the total width of the system to be 115’ wide on a site that is only around 130‘ wide.

Our goals are primarily to create a planting plan that can in some way inform and augment future design decisions. This could have been done typologically—by providing a palette and suggestions for implementation into any similar site.

However, we decided that more could be accomplished by producing a rough schematic design, which could then apply to the critical planting zones we have designated. This design is based upon the site specifications found on the Battelle plant including stream paths and elevation gradients. We want to be clear that for reasons that include the complexity of the site, our own time constraints, and the intended scope of the project, that this design is only a framework for further iterations of design.

The plan we suggest works mostly within the parameters of the Battelle schematic, but we also offer alternatives to ideas that we feel don't best suit the project goals. Our primary concern is salmon health. Canopy, overhanging foliage, stream complexity, bank stability and other issues of stream ecology are greatly influenced by a stream's flora. Our design strives to meet these needs.

Accessibility: Paths and Pavers

Accessing the site is a major concern. Current sediment pond plans suggest that ponds will have to be cleaned periodically by backhoes or other heavy machinery. The ponds have been designed to be maximally 75' wide. It has been suggested that an access road lie immediately adjacent to the stream on either side so that the equipment can move in periodically and remove sediment. The schematic plan provided by Battelle Engineers suggests that the roads be 20 feet wide each. While we agree with the necessity of accessing the ponds for sediment removal, we feel that there are better approaches that may be less obtrusive. The stream edge is critical habitat for salmon and other important biota and the following suggestions may help to preserve the fecundity of the site.

It has been implied that each side of the creek needs an access road so that sediment can be removed without driving equipment into the sediment pond. It is our contention that the benefits of having smaller access roads and driving equipment into the creek to remove sediment would be far greater than having two 20' wide roads running down either side of the creek. The effect of scooping sediment out of a pond from the shore would have equal impact to driving through it with heavy machinery. Thus, we recommend implementing small access roads leading to the sediment ponds as opposed to roads that border the stream channel.

Paths and roads through the site will have some impact on runoff and site hydrology. To minimize this impact, we recommend pavers that are pervious and that allow water to filtrate through them. Ecostone brand pavers are a good example of the industry standard. They allow for a great deal of weight and may therefore be suitable for the recommended access roads. We recommend further consultation for the use of this product.

Hydrological Considerations

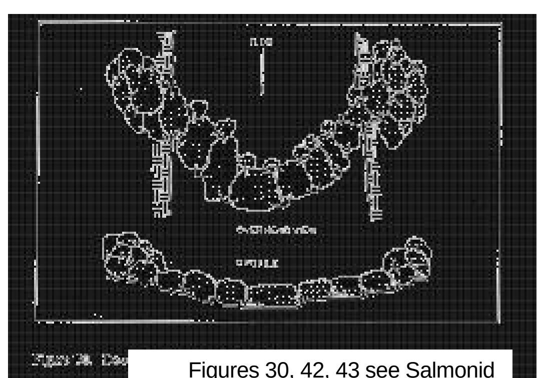
In order to increase hydraulic complexity of the stream, designs for instream structures, additional channels and sedimentation ponds have been proposed. This will begin the process of slowing down the velocity of the stream by creating more curvature or meander and variation in the stream path. Also, a stream's velocity is inversely proportional to it width, so water will slow and allow sediment to fall into the wide, pooling areas, (Terry Swanson, lectures). Other engineered applications should be included in this plan, such as the installation of large woody debris. Large woody debris serves many functions in restoring hydraulic complexity in streams.

ELWd Systems manufactures structures made of native logs that are bound together into a hollow tube and filled with cobbles or gravel to decrease buoyancy and help the structure stay in place during high floods. These structures can be placed along stream channels to assist in the formation of scour pools, sediment storage, bank protection and high flow refuge. There are also structures designed for placement along lakes and ponds to decrease effects of breakwater and provide biomass for vegetation growth (ELWd Systems 2004). Due to the organic quality of these structures, ELWd also provide nutrients for microbiological organisms important to aquatic systems provide a flux of woody organic matter within the stream and provide habitat for birds, insects and other riparian mammals. They also provide visual aesthetics suggesting natural stream conditions. The placement of these would provide structure and stream diversity, in addition to the proposed rock weirs.

Degradation of the streambed is a key factor in the lack of salmonid species in waterways. The lower reaches of the stream are composed of larger cobbles and small boulders, compacted with fine particles. A high concentration of fine particles causes damage not only to the delta, but also to the gills of salmonids. With this understanding, it is possible to "create" an artificial sediment deposit system using the variety of hydraulic changes.

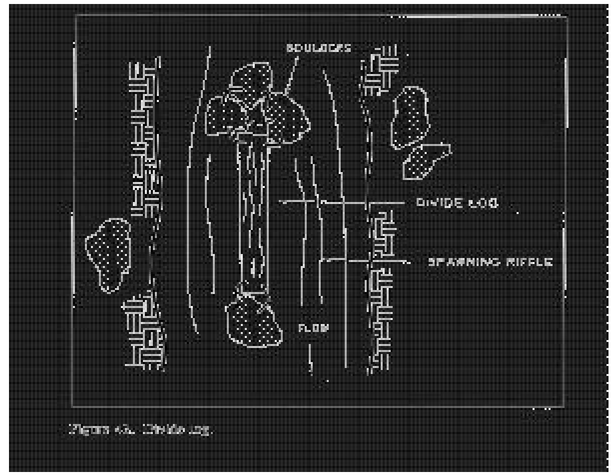
Hydrological Applications

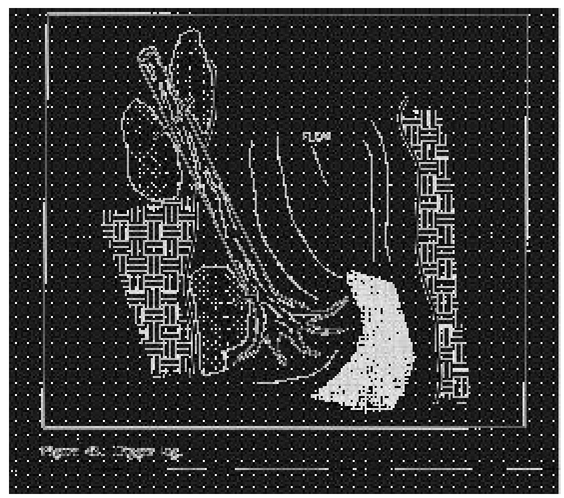
In order to increase hydraulic complexity of the stream, designs for instream structures, additional channels and sedimentation ponds have been proposed. This will begin the process of slowing down the velocity of the stream by creating more curvature or meander and variation in the stream path. There are three general categories of the most commonly used instream structures: 1) boulder structures; 2). log structures; 3). cover structures (Salmonid Stream Manual VII-24 1994). Boulder weirs are primarily used to collect gravel for spawning habitat, or to create one or more jump pools (Salmonid Stream Manual VII-25 1994). It is important to choose large angular boulders and place



Figures 30, 42, 43 see Salmonid Stream manual VII-30,42,43. 1994 them in-flow of the stream, so they do not roll into the scour pool downstream. Cabling boulders together will help reduce the tendency of the boulders to roll. Where possible, boulders should be imbedded into the substrate to a depth one third of their diameter to compensate for their downstream (Salmonid Stream Manual 1994).

Log structures have similar functions of boulder structures. They are beneficial in the creation of riffles in streams. Riffles are shallow, broken water sections in a stream that function as a collection site for invertebrates. These riffles are feeding sources for salmon. Logs are successful structures for riffles as a source for woody debris, to encourage invertebrate populations. Two examples of structure design include divide and digger logs. Divide logs are beneficial in streams that support several species of salmon to decrease competition in spawning grounds. They are installed mid-channel in spawning riffles to provide visual barrier between adjacent spawning areas (Salmonid Stream Manual VII-40 1994). Digger logs are anchored onto the bank and the end is place in the bottom of a pool. This offers overhead cover for juvenile salmon as well as for migrating adults (Salmonid Stream Manual VII-41 1994). This structure is useful when placed on the inside of bends; this creates sediment deposition downstream and scouring on the outside of the bend.





Construction Considerations

Before the planting design may be implemented, the site is expected to go undergo a substantial transformation. The current residence will be relocated and the stream channel will be moved. During this construction process, both the soil and plants will be vulnerable to damage that could negatively effect the site well after construction has ended. Protecting the soil and preserving some of the existing vegetation will lower costs and improve plant health in the long term.

Soil protection

It will be important to minimize negative impacts on the soil structure. Construction will result in soil compaction, which will create a hostile environment for root growth. Recommendations for protecting the native soil include

- Reduce the removal and disturbance of native soil (Marx 1999)
- Minimize compaction of soil by heavy equipment by limiting the construction activity “footprint” on sites and leaving as much area undisturbed (Marx 1999)
- Store topsoil on-site for replacing after construction (Marx 1999)

- Applying a thick layer of mulch (>6”) to the site will help to redistribute the weight of construction vehicles, and thus decrease compaction. This may also be accomplished with “double, overlapping, thick plywood sheets.” (Harris 2004)

Plant preservation

Because of the substantial amount of construction planned, protecting and or preserving existing vegetation will be necessary. It is recommended that as many plants as possible be salvaged during construction. Because the majority of the plantings are less than 4” in diameter it would be most cost effective to relocate them during construction. An area away from construction should be set up as a holding area for the plants and heeling these plants in moist sawdust will prevent desiccation until the plants can be relocated. When construction is complete the plants can then be put back in place. Care should be taken not to stress or damage trees in this process. Setting up a temporary fence will keep plants safe from construction traffic (Harris 2004).

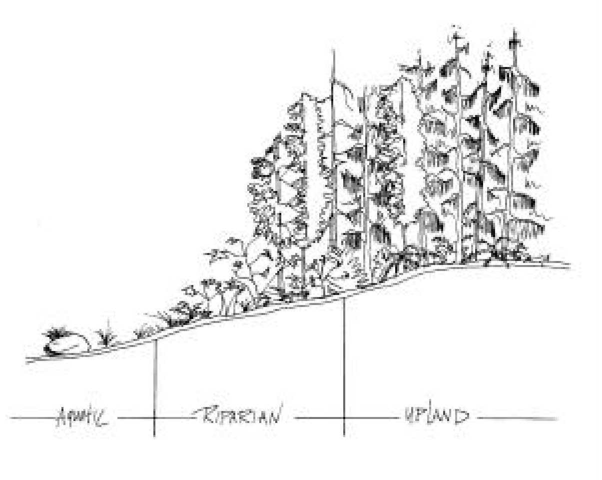
Invasive Plant Removal

The site is currently dominated with *Phalaris arundinacea* (reed canary grass) and *Rubus discolor* (Himalayan blackberry). Both of these are invasive species that compete with native plants. It is important to remove and control these invasives prior to installing a new landscape. Removing the tops of the plants is often not enough, as both species vigorous root systems that will produce new plants. Removing as much of the root system as possible will reduce the chance of reinvasion. While chemical control may be required in some situations, many herbicides are highly toxic to aquatic organisms. In any case, it is desirable to limit the use of any pesticide near water bodies to reduce the chance of water contamination (Johnson 1993). Glyphosate, commonly known as Rodeo, is an herbicide that is effective in controlling invasive aquatic vegetation, such as reed canary grass. The Washington State Department of Ecology allows for application of this herbicide following the approval of a permit application. The Department of Ecology has issued this statement regarding the use of this herbicide: “Glyphosate is an herbicide that is effective in controlling invasive aquatic vegetation, such as reed canary grass. Glyphosate is not applied directly to water for weed control, but when it does enter the water it is bound tightly to dissolved and suspended particles and to bottom sediments and becomes inactive. This chemical is approved for use in this permit” (Department of Ecology 2002).

Mulch

Mulch serves many purposes in the landscape. Not only will it help to reduce compaction during construction but it will also suppress weeds, conserve soil moisture, moderate soil temperature, and reduce soil erosion and water runoff. Over time the mulch will also help to improve “soil structure, permeability, aeration, fertility, and biological activity” (Harris 2004). All of these benefits create healthy soils to support healthy plants. Applying wood chips to a depth of 4" is recommended, however a thicker layer will be more beneficial (Harris 2004). For plant health avoid applying mulch within 4" of the trunk.

Planting design



Plant palettes suggested below have been chosen based on the high light and water conditions of the site. For a detailed description of site placement, light requirements, and heights of each species see Appendix A. The plant palettes suggested consists mainly of trees and shrubs. Other herbaceous species have not been listed. Planting herbaceous species should be postponed until all invasive species are under control. A list of appropriate herbaceous species has been provided in Appendix A. These plants may be installed in Zone 4 given sufficient maintenance is available.

Zone 1- Canopy: privacy buffer - Sections in dark green (Figure) along the northern and southern edges of the site are considered to be zone 1. These areas will create a visual barrier between the site and neighboring property as well as introduce a mixed canopy of trees to create shade on the site. The visual barrier created by the zone 1 canopy will help direct the attention to the more desirable lake and stream views. Mixes of conifers and evergreens have been selected to create a year-round visual barrier. Fast growing species will be important in creating shade to suppress invasive species that thrive in sunny conditions. These fast growing species will also create an environment suitable for many shade loving native plants.

Suggested plant palette:

Scientific Name	**Common Name**
Alnus rubra	Red alder
Betula papyrifera	paper birch
Fraxinus latifolia	Oregon ash
Picea sitchensis	Sitka spruce
Pseudotsuga menziesii	Douglas fir
Thuja plicata	western red cedar

***Zone* 2- Interior shrub layer** – The lighter-green section, surrounding zone one, will be considered zone 2. This zone creates a visual step-down from the over-story layer and creates a transition to the riparian zone. This area will be planted with larger deciduous shrubs. Many of the species have been chosen for their visual interest, as they will be visible from the residence and the service road.

Suggested plant palette:

Scientific Name	**Common Name**
Acer circinatum	vine maple
Amelanchier alnifolia	serviceberry
Cornus stolonifera	red-osier dogwood
Corylus cornuta	hazelnut
Holodiscus discolor	ocean spray
Oemleria cerasiformis	Indian plum
Philadelphus lewisii	mock orange
Physocarpus capitatus	Pacific ninebark
Ribes sanguineum	red-flowering currant
Rosa gymnocarpa	Wood rose
Rosa nutkana	Nootka rose
Rosa pisocarpa	cluster rose
Rubus spectablis	salmonberry
Salix lasiandra	Pacific willow
Salix sitchensis	Sitka willow
Sambucus racemosa	red elderberry

Zone 3- Riparian area/lakeside- Zone three is the area adjacent to the stream and along the lake's shore. Emergent plants will be installed along the edges of the ponds. This will allow for annual access to the site for dredging. The stream banks closer to the channels may be planted with larger shrubs to help create shade over the stream. Species chosen for this zone must be well adapted to wet conditions. Trees planted in this zone will create shade over the river, which will benefit salmon habitat.

Suggested plant palette:

Scientific Name	**Common Name**
Alnus rubra	Red alder
Cornus stolonifera	red-osier dogwood
Myrica gale	sweet gale
Rosa pisocarpa	cluster rose
Rubus spectablis	salmonberry
Salix lasiandra	Pacific willow
Salix sitchensis	Sitka willow

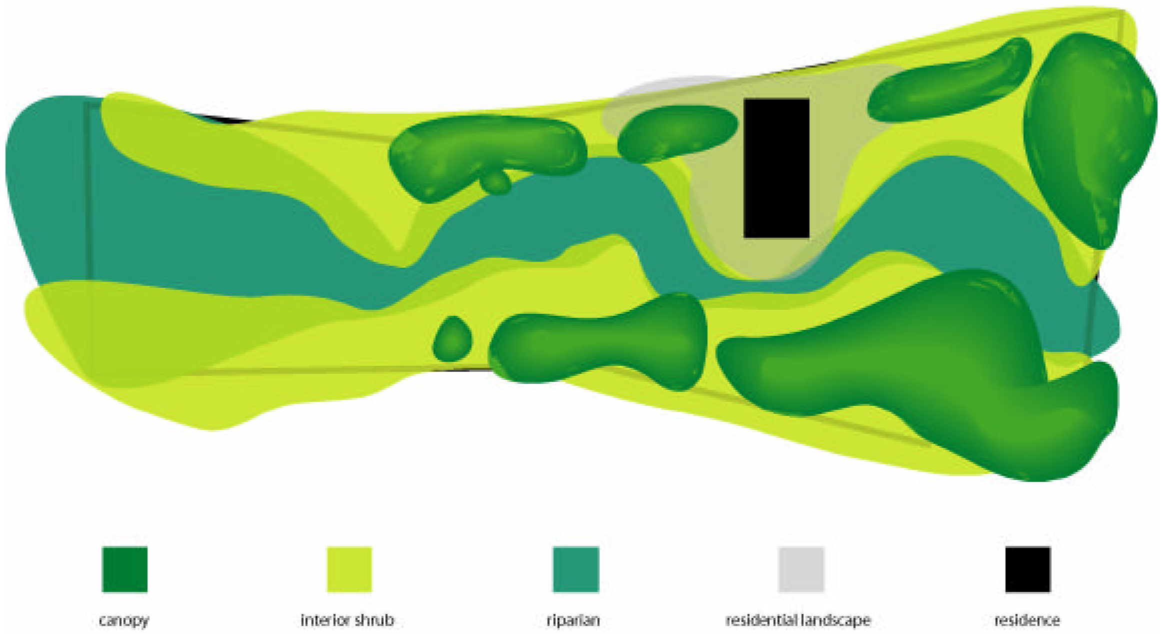
Carex obnupta	slough sedge
Carex stipata	sawbeak sedge
Eleocharis palustris	common spikerush
Juncus ensifolius	dagger leaf rush
Scirpus acutus	hardstem bulrush
Scirpus microcarpus	small fruited bulrush
Thypa latifolia	cattail
Athyrium filix-femina	lady fern

Zone 4- Residence- The area surrounding the new residence is considered a separate zone. This area will reflect a more traditional residential landscape. Because this area is so highly visible from the residence, species have been chosen mainly for visual appeal (Chalker-Scott). Planting smaller species on the south and west sides of the house will provide views of the lake and stream. Taller species may be planted on the north and east sides to increase privacy.

Suggested plant palette:

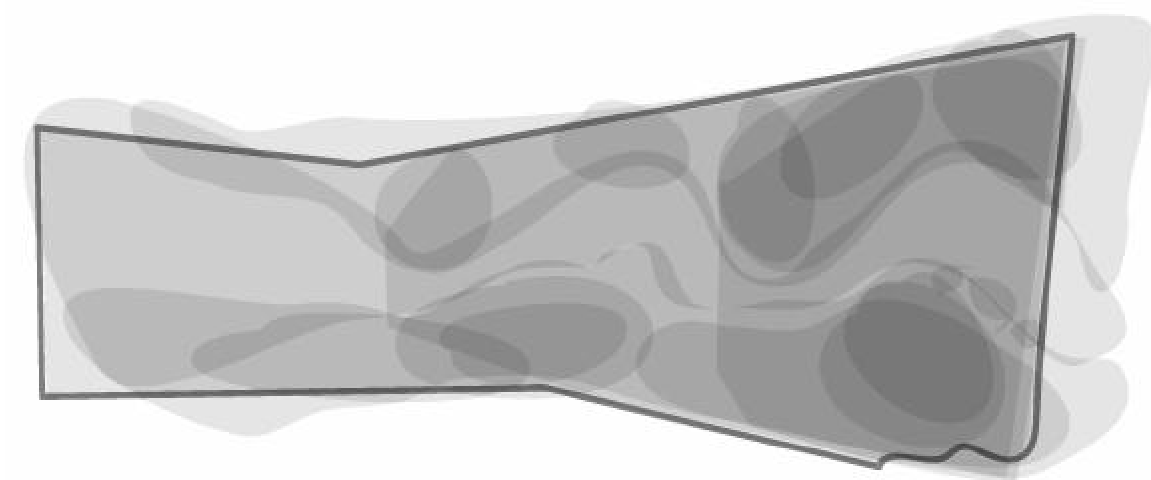
Scientific Name	**Common Name**
Acer circinatum	vine maple
Amelanchier alnifolia	serviceberry
Cornus stolonifera	red-osier dogwood
Gaultheria shallon	salal
Holodiscus discolor	ocean spray
Oemleria cerasiformis	Indian plum
Philadelphus lewisii	mock orange
Rhododendron macrophyllum	Pacific rhododendron
Ribes sanguineum	red-flowering currant
Rubus spectablis	salmonberry
Blechnum spicant	deer fern
Polystichum munitum	western sword fern

planting zone diagram



elevation diagram

relative elevations, darker areas relating to higher ground



Preparation and Installation

Preparation

In the early fall or early spring preceding planting, incorporate 1 part finished compost or composted manure into 10parts soil along with 6 cups bone meal and 4 cups wood ash per cubic yard of backfill (UMASS). It is important to provide compost at this site due to the low nutrient value and high deposits from urban runoff and mining deposits. Soil health is an important component in the food web between plants, microorganisms and salmon. This food web is a natural process known as biofiltration, "The multitude of biochemical pathways used by this diverse soil life also enables it to break down hydrocarbon and pesticide pollutants, bind heavy metals into immobile forms, and convert excess soluble fertilizers into complex stored organic forms before they can run off into streams" (Marx 1999).

Low nitrogen content is common in most urban soils. Remediating this problem can increase health and vigor of plants and increase their ability to out compete other species. A top-dressing of ammonium sulfate, at 3 to 4 cups/100 sq. ft. two times during the year, is recommended. Once during the late fall-early winter while grasses are dormant and then in the early spring before growth of turf and other herbaceous vegetation occurs. This will ensure uptake of nutrients for the desired plant species. It is also important to use and maintain acidic organic mulch at the site, such as pine needles. Treatment for phosphate is not recommended due to the potential of out competing beneficial microorganisms that assist in the mobility of this nutrient (Linda Chalker-Scott 2004). Instead, it is recommended to treat the soils with beneficial mycorrhizae to increase nutrient uptake and mobility in the soil.

Installation

Proper methods for planting are important for the health and longevity of landscape plants. Plant material needs direct contact with the soil and proper aeration to ensure adequate root development. Soil compaction will occur with the presence of heavy machinery. Where compaction is unavoidable or soil is already compacted, tillage can alleviate the condition following earthmoving and prior to planting. It is necessary to loosen the soil to a depth of at least 12 and preferably 24 inches for satisfactory results (Johnson 1993). Plants should be removed from container/burlap material and the surrounding soil media should be loosened and removed to expose root ball. Roots should have adequate, even growth and there should be no kinks or circling growth. Kinked or circling roots will inhibit root development and cause problems with anchoring and stabilization. Minimal defects can be remedied by cutting away circling or uneven roots. Prepare the hole by removing all surrounding vegetation and dig the hole two-three times the diameter of the root ball and as deep as the length of the root system. Prepare a mound at the bottom of the hole as a platform for the roots and to minimize water saturation of the roots. Backfill the hole with native soil that was removed and create a moat around the trunk of the tree.

Water the plants in well and place a thick layer (4") of mulch over the planting site (Linda Chalker-Scott 2004).

Maintenance and Monitoring

Maintenance

Invasive control

To ensure the success of the plantings, it is critical to prevent re-invasion by non-native plants. Until shade is established, invasive plants still have an opportunity to thrive. Invasive control may need to be done multiple times throughout the growing season to account for the reproductive cycles of different plant species. Removing invasive plants before they go to seed will reduce the need for future maintenance by decreasing invasion potential. For further information on control and removal techniques see the *Invasive Plant Removal* section of this paper (PAGE)

Monitoring

In order to determine the success of the project it is helpful to monitor the site annually. Maybe mention that this could be beneficial both to document plant success/mortality as well as stream and sediment changes. Two types of monitoring that may be useful to this project are photo point monitoring and the line intercept method. Monitoring should be conducted in late summer or early fall prior to leaf drop.

Photo-point monitoring supplies a visual record of changes in the site over time. Several points are chosen throughout the site and marked so that they may be found from year to year. These points should capture key views throughout the site. The orientation of the photo (facing due east etc.) should be noted along with the location of the photopoint.

Line intercept method may be used to determine the percent cover of various plant species. A number of 50ft. transect lines may be established on site. To establish a transect line simply stretch a 50ft. tape between any two points on the site. As you walk along the tape, record the distance each plant intercepts the line (e.g. - a 10' patch of Carex is directly under the tape, Carex would have a 20% cover on that transect). Each species should be recorded in a table and averaged out to determine % cover for the entire site. This method of monitoring will help determine which species are thriving, and which are failing (King County 2003).

Plant Pricing

Scientific Name	Common Name	Spacing	Size	Price
Acer circinatum	vine maple	6' oc	5 gl	$12.00
Alnus rubra	Red alder	10' oc	5 gl	$12.00
Amelanchier alnifolia	serviceberry	6' oc	1 gl	$2.75
Athyrium filix-femina	lady fern	1' oc	1 gl	$2.75
Betula papyrifera	paper birch	10' oc	5 gl	$12.00
Blechnum spicant	deer fern	1' oc	1 gl	$2.75
Carex obnupta	slough sedge	6" oc	br	$0.50
Carex stipata	sawbeak sedge	6" oc	br	$0.50
Cornus stolonifera	red-osier dogwood	3' oc	1 gl	$2.75
Corylus cornuta	hazelnut	6' oc	2 gl	$6.00
Eleocharis palustris	common spikerush	6" oc	br	$0.50
Fraxinus latifolia	Oregon ash	10' oc	2 gl	$6.00
Gaultheria shallon	salal	1' oc	1 gl	$2.75
holodiscus discolor	ocean spray	6' oc	2 gl	$6.00
Juncus ensifolius	dagger leaf rush	6" oc	br	$0.50
Myrica gale	sweet gale	6' oc	1 gl	$2.75
Oemleria cerasiformis	Indian plum	6' oc	2 gl	$6.00
Philadelphus lewisii	mock orange	6' oc	2 gl	$6.00
Physocarpus capitatus	Pacific ninebark	6' oc	2 gl	$6.00
Picea sitchensis	Sitka spruce	10' oc	5 gl	$12.00
Polystichum munitum	western sword fern	1' oc	2 gl	$6.00
Pseudotsuga menziesii	Douglas fir	10' oc	5 gl	$12.00
Ribes sanguineum	red-flowering currant	6' oc	2 gl	$7.00
Rosa gymnocarpa	Wood rose	3' oc	1 gl	$2.75
Rosa nutkana	Nootka rose	3' oc	1 gl	$2.75
Rosa pisocarpa	cluster rose	3' oc	1 gl	$2.75
Rubus spectablis	salmonberry	3' oc	1 gl	$2.75
Salix lasiandra	Pacific willow	3' oc	1 gl	$2.75
Salix sitchensis	Sitka willow	3' oc	1 gl	$2.75
Sambucus racemosa	red elderberry	6' oc	2 gl	$6.00
Scirpus acutus	hardstem bulrush	6" oc	br	$0.50
Scirpus microcarpus	small fruited bulrush	6" oc	br	$0.50
Thuja plicata	western red cedar	10' oc	5 gl	$12.00
Thypa latifolia	cattail	1' oc	br	$0.50

*prices based on Storm Lake Growers spring pricing
*br: bare root stock
*gl: gallon container

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Other Sources:

Storm Lake Growers 21809 89th St. SE Snohomish, WA 98290 (360) 794-4842. terra@slgrowers.com

Appendix A

Plant list/descriptions

rees **Light** **Site Placement**

cientific Name	Common Name	Max. Ht. (ft.)	Sun	Part Sun	Shade	Shallow Water	Water's Edge	Saturated Soil	Wetter Buffer	Drier Buffer	Notes
lnus rubra	Red alder	80	x	x					x	x	
etula papyrifera	paper birch	80	x				x	x			
raxinus latifolia	Oregon ash	80	x	x			x	x			
icea sitchensis	Sitka spruce	230	x				x	x			can tolerate wettest sites. Sun/shade
seudotsuga menziesii	Douglas fir	300	x						x	x	
huja plicata	western red cedar	230			x		x	x	x		grows best on seepage sites

hrubs **Light** **Site Placement**

cientific Name	Common Name	Max. ht. (ft.)	Sun	Part Sun	Shade	Shallow Water	Water's Edge	Saturated Soil	Wetter Buffer	Drier Buffer	Notes
cer circinatum	vine maple	25			x				x	x	
melanchier alnifolia	serviceberry	20	x							x	
ornus stolonifera	red-osier dogwood	20		x			x	x	x		
orylus cornuta	hazelnut	15		x						x	
aultheria shallon	salal	7		x	x					x	
olodiscus discolor	ocean spray	10	x	x						x	
lyrica gale	sweet gale	6	x				x	x			
emleria cerasiformis	Indian plum	15			x				x	x	important source of nectar
hiladelphus lewisii	mock orange	10	x	x					x	x	
hysocarpus capitatus	Pacific ninebark	20	x	x					x	x	
ibes sanguineum	red-flowering currant	7	x						x	x	berries eaten by wildlife, hummingbird
osa gymnocarpa	Wood rose	7		x						x	
osa nutkana	Nootka rose	10		x				x	x		
osa pisocarpa	cluster rose	7		x			x	x	x		
ubus spectablis	salmonberry	15	x	x	x		x		x	x	thicket forming
alix lasiandra	Pacific willow	50	x	x	x		x	x	x		
alix sitchensis	Sitka willow	25	x	x	x		x	x	x		
ambucus racemosa	red elderberry	20	x	x	x				x	x	forest edge, w/ A. rubra

Sedges & Rushes — **Light** — **Site Placement**

Scientific Name	Common Name	Max. ht. (ft.)	Sun	Part Sun	Shade	Shallow Water	Water's Edge	Saturated Soil	Wetter Buffer	Drier Buffer	Notes
Carex obnupta	slough sedge	4.5		x		x	x	x			streambanks/lakeshores
Carex stipata	sawbeak sedge	3	x	x		x	x	x			wet meadows, lake-shores, streamsid
Eleocharis palustris	common spikerush	1	x			x	x				shorelines, shallow water
Juncus ensifolius	dagger leaf rush	2	x			x	x	x			sandy soils, lake shore, stream banks
Scirpus acutus	hardstem bulrush	6	x			x	x				muddy shores
Scirpus microcarpus	small fruited bulrush	6		x			x	x			sloughs, streams
Other											
Thypa latifolia	cattail	9	x			x	x				lakeshores

Ferns — **Light** — **Site Placement**

Scientific Name	Common Name	Max. ht. (ft.)	Sun	Part Sun	Shade	Shallow Water	Water's Edge	Saturated Soil	Wetter Buffer	Drier Buffer	Notes
Athyrium filix-femina	lady fern	3		x				x	x		
Blechnum spicant	deer fern	2			x				x		
Polystichum munitum	western sword fern	5		x						x	

based on information found in King County's Plant Selection Worksheet (2003)