LITTLE SQUALICUM CREEK WETLANDS MITIGATION PLAN

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for
PORT OF BELLINGHAM

LITTLE SQUALICUM CREEK
OFF-SITE WETLANDS MITIGATION PLAN

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1.0 INTRODUCTION

The Port of Bellingham proposes to extend the south runway at Bellingham International Airport, in Whatcom County, Washington. This proposal also includes the provision of a safety zone which will extend 1000 feet to the south of the proposed runway extension. Development of this proposal will result in impacts to approximately 21.1 acres of wetlands located on the project site.

An on–site wetlands mitigation plan was developed as part of a 404(b)(1) permit application for filling wetlands on the project site. This mitigation proposal is presented in the Final Environmental Impact Statement for Bellingham International Airport (U.S. Dept. of Transportation, Federal Aviation Administration, April, 1991). Reviewing agencies determined that the proposed on–site mitigation was conceptually adequate, but that the number of replacement acres proposed in the plan were insufficient. As a result of this determination, the Port of Bellingham has pursued additional off–site wetland mitigation. This report proposes additional off–site wetlands mitigation at Little Sqaulicum Creek, Whatcom County, Washington.

Wetlands within the proposed project area are characterized in the Preliminary Wetland Analysis, Bellingham Airport Proposed Runway Extension (Jones & Stokes Associates, July, 1990). A summary of the existing conditions within the airport impact zone is provided in Section 2.0 of this document. Section 3.0 provides a summary of the on–site mitigation proposal. These two sections were included in this report to provide a better understanding of the anticipated wetlands impacts from the proposed project, and the total amount of wetlands mitigation proposed to compensate for such impacts to wetlands.

Existing conditions at the Little Squalicum Creek mitigation site are described in Section 4.0 of this report. Section 5.0 presents the Little Squalicum Creek Mitigation Plan. This section will address the goals of the off–site mitigation, the feasibility and practicality of the proposed mitigation, and the functions and values to be provided by the mitigation. Detailed construction drawings and technical specifications are not included with this document. These documents will be provided when the site design has been finalized, following permit issuance.

Section 6.0 defines performance standards to be used in evaluating the success of the mitigation effort, and Section 7.0 will briefly present a monitoring plan for assessing whether the mitigation is meeting the performance standards. Section 8.0 proposes a general schedule for final design and implementation of the mitigation plan. A contingency plan for failure of part or all of the mitigation proposal will be presented in Section 9.0 as an assurance of the Port of Bellingham's committment to provide compensation for impacts to wetlands. Finally, Section 10.0 will provide a summary of the total mitigation proposal for compensation of anticipated impacts to wetlands from the Port of Bellingham Runway Extension Project.

2.0 BACKGROUND SUMMARY: BELLINGHAM AIRPORT PROJECT IMPACT ZONE

2.1 General Overview

Following is a summary of the existing conditions of the project impact zone. This summary is based on the Preliminary Wetland Analysis, Bellingham Airport Proposed Runway Extension (Jones & Stokes Associates, 1990), which provides detailed analysis of the project impact zone, the wetland delineation of the impact zone, and the proposed on–site compensation sites.

The project site is located at Bellingham International Airport, north of the City of Bellingham in Whatcom County, Washington. See Figure 1: Vicinity Map, for the location of the project impact site and the proposed compensation sites.

The airport is located on an undulating plateau which drains generally south and west into Bellingham Bay. No open streams drain the impact area; drainage is primarily by sheet flow to the southwest into several openwater ponds located offsite, and from there into Bellingham Bay.

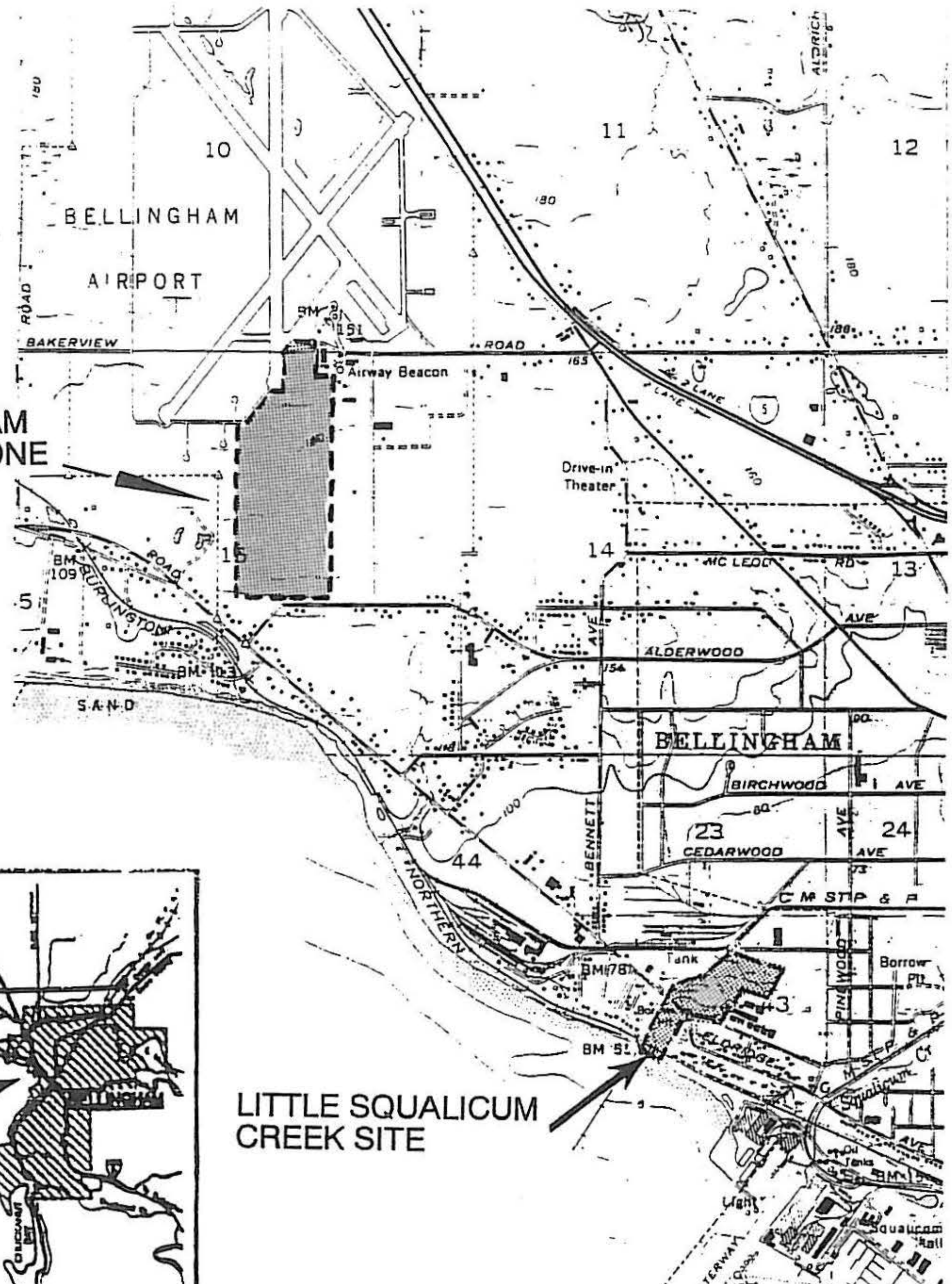
The project impact area is located on the southern portion of the airport properties, within Section 15. The location of the airport project impact zone and the location and identification numbers of the wetlands delineated within the impact zone are shown on Figure 2: Proposed Wetlands Impacts.

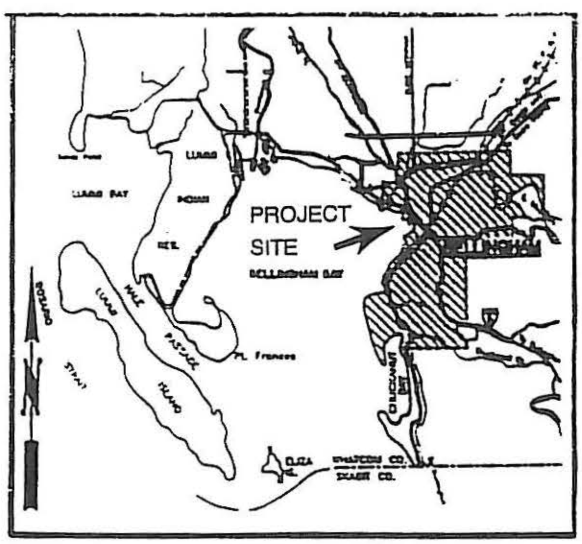
The area surrounding the existing runways and taxiways is predominantly open meadow. The meadow is maintained by mowing which is part of ongoing maintenance required by the airport operations to maintain the safety zone. According to Federal Aviation Authority (FAA) requirements, areas adjacent to functioning runways and taxiways must be kept free of shrubby and woody vegetation.

Surrounding the meadow community to the east and west, is a mixed deciduous and coniferous forested zone. To the south, the forested community is predominantly a deciduous forest.

2.2 Wetlands – Impact Zone

Wetlands # 2, 4, 5, 6, 7, 8, 9, 11, 12, and 14 are all wet meadow communities. The dominant wetland type within the impact zone is palustrine wet meadow, some of which contains discrete





LOCATION MAP

2 0 2

SCALE IN MILES

OFF-SITE MITIGATION PLAN
Little Squalicum Creek

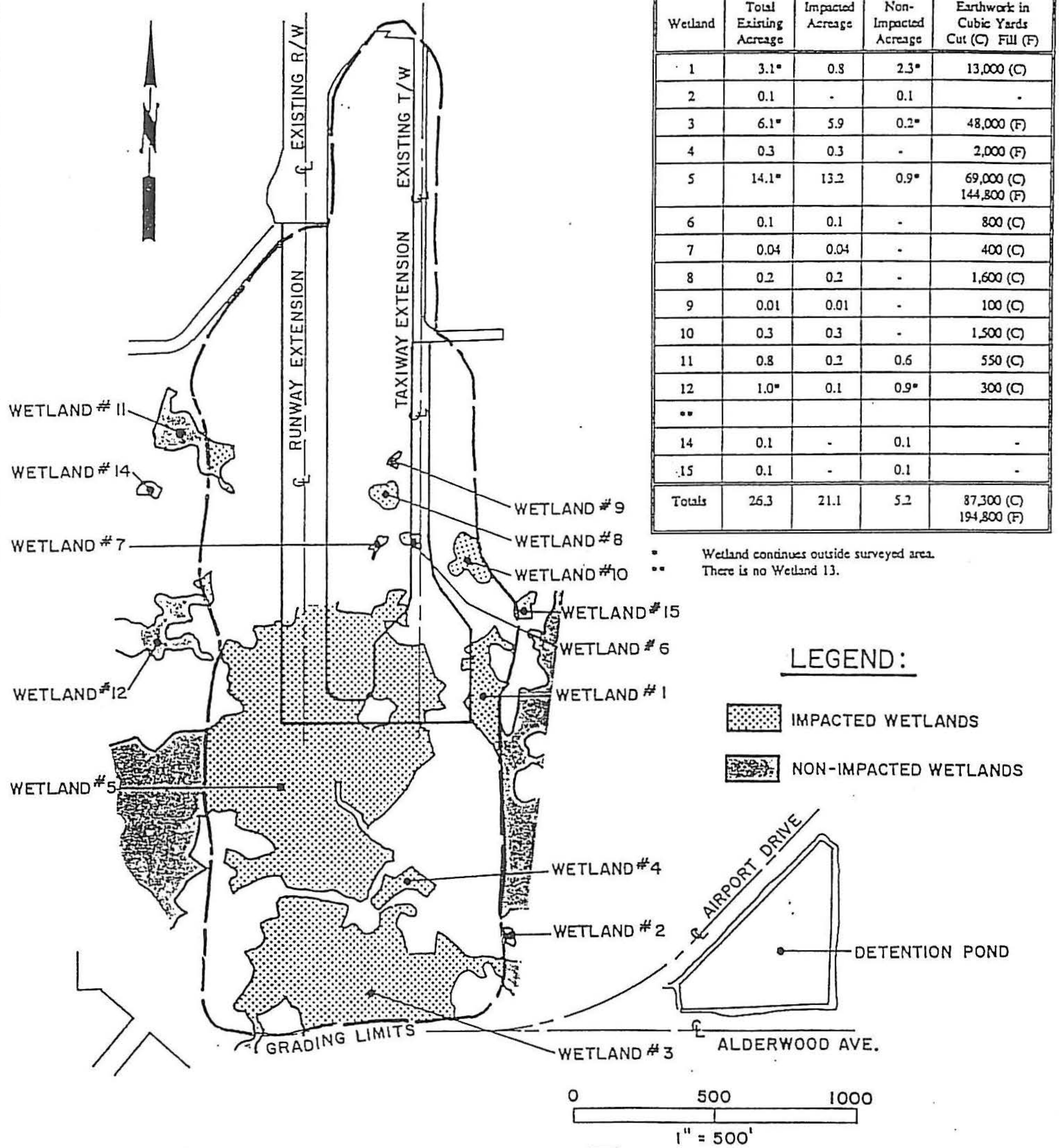
VICINITY MAP
Port of Bellingham

FIGURE 1

EXISTING WETLAND ACREAGE

Wetland	Total Existing Acreage	Impacted Acreage	Non-Impacted Acreage	* Estimated Earthwork in Cubic Yards Cut (C) Fill (F)
1	3.1*	0.8	2.3*	13,000 (C)
2	0.1	-	0.1	-
3	6.1*	5.9	0.2*	48,000 (F)
4	0.3	0.3	-	2,000 (F)
5	14.1*	13.2	0.9*	69,000 (C) 144,800 (F)
6	0.1	0.1	-	800 (C)
7	0.04	0.04	-	400 (C)
8	0.2	0.2	-	1,600 (C)
9	0.01	0.01	-	100 (C)
10	0.3	0.3	-	1,500 (C)
11	0.8	0.2	0.6	550 (C)
12	1.0*	0.1	0.9*	300 (C)
**				
14	0.1	-	0.1	-
15	0.1	-	0.1	-
Totals	26.3	21.1	5.2	87,300 (C) 194,800 (F)

* Wetland continues outside surveyed area.
** There is no Wetland 13.



OFF-SITE MITIGATION PLAN
Little Squalicum Creek

PROPOSED WETLAND IMPACTS

Port of Bellingham

FIGURE 2

communities of wetter emergent communities. The wet meadows are dominated by the presence of bent grass (Agrostis spp.), red fescue (Festuca rubra), velvet grass (Holcus lanatus), reed canarygrass (Phalaris arundinaceae), smooth rush (Juncus effusus), orchard grass (Dactylis glomerata), and thistle (Cirsium spp.). The wet meadow communities are characterized by winter sheet flow and limited standing water in isolated depressions during the wet winter months.

Soils within the impact zone are mapped as Whatcom Labounty silt loams (SCS, 1983), and within undisturbed portions of the site the soil profiles match those described within the Whatcom County soil survey. The undisturbed soils were generally 8 to 10 inches of silty loam above dense gravelly clay which was heavily mottled.

Many areas of the impact zone have been scraped and cleared historically. These activities have removed much of the silty loam from the surface horizon, leaving the dense clays as a surface layer. It was found that surface water from precipitation tended to collect and sheet flow on the upper layers of these exposed clays.

Within wetland #5 there is a distinct palustrine emergent community characterized by shallow standing water for longer period into the growing season. The longer period of saturation allows for the survival of more tolerant wetland species such as common cattail (Typha latifolia), small–fruited bulrush (Scirpus microcarpus), eleocharis (Eleocharis palustris), daggerleaf rush (Juncus ensifolius), slough sedge (Carex obnupta), and common water plantain (Alisima plantago–aquatica).

The southern portion of wetland #3 within the impact zone contains a deciduous forest which is a mosaic of upland and wetland forest. For the purposes of calculating area of wetland impacts, this entire forest zone was considered as wetland forest.

The wetland forest is characterized by a canopy of black cottonwood (Populus trichocarpa), willow (Salix lasiandra), and red alder (Alnus rubra). The understory is characterized by common snowberry (Symphoricarpos albus), Douglas' spirea (Spiraea douglasii), and rose (Rosa pisocarpa). The herbaceous layer is characterized by stands of slough sedge (Carex obnupta), wood rush (Luzula spp.), and geum (Geum spp.).

The upland forest is characterized by a canopy of black cottonwood and red alder. The understory is salal (Gaultheria shallon) and red elderberry (Sambucus racemosa). The herbaceous layer is sword fern (Polystichum munitum), and Pacific blackberry (Rubus ursinus (=vitifolius)).

Portions of wetlands #1 and 5 located off the impact site are characterized by a wetter and more mature mixed canopy forested wetland which included western red cedar (Thuja plicata) in the canopy and skunk cabbage (Lysichitum americanum) in the herbaceous layer.

The hydrology for all wetlands within the impact zone is from precipitation and surface sheet flow.

2.2.1 Functional Values

There are 11 functional values associated with wetlands in the Federal Highway Administrations Wetland Functional Assessment Method (Adamus, 1983). Of those 11, shoreline anchoring, fishery habitat, active recreation, passive recreation, historic, and education are not applicable in the wetlands of the project impact site. The remaining six functions are provided at low levels for the wetlands on site. Those six functions are summarized below.

1. Groundwater recharge: this is the ability of wetlands to store water and meter or recharge it into deep aquifers. Due to the nature of the soils within the wetlands on site, the surface water present tends to perch above an impervious clay layer and either evaporate from the surface or sheet flow to areas downhill. No groundwater recharge function is likely.

2. Groundwater discharge: this is the ability of wetlands to function as recharge sites for surface streams or to be an expression of springs coming to the surface from subsurface groundwater. Due to the clay soils present within the area, no spring systems are present on the site. In addition, the wetlands within the project impact zone do not feed to any surface stream, although they do drain to ponds located off-site to the west.

3. Flood storage: this is the ability of wetlands to attenuate flood or surface water flows. There are minor shallow basins and depressions present within several of the wetlands, therefore, minor amounts of shallow surface water attenuation is provided by those wetland systems. Most of the wetlands on site do not contain significant areas of closed depressions to provide for extensive storage, therefore the storage function of the wetlands on site is limited.

4. Sediment trapping: this is the ability of wetlands to trap suspended sediments thereby improving water quality by removing particulates, and metabolizing excess nutrients and toxics. As there is no source for sediments on the project site, this particular function is not applicable. However, it should be noted that the densely vegetated wet meadows

would provide excellent biofiltration and sediment trapping capabilities if a sediment source was present.

5. Food chain support: this is the ability of a wetland to provide high primary productivity which can then be passed down through the food chain. This function is usually highest in perennially wet emergent communities or wetlands associated with streams or tidal waters. The wetlands on site provide low to moderate food chain support. The grass dominated systems have relatively slow growth patterns so the primary productivity is limited. The wetter emergent systems present on site would have higher productivity; however, they are very limited in size and distribution. The forested communities have low productivity due to their slower growth rates.

6. Wildlife habitat: this is the ability of wetlands to provide some of the critical life needs for various wildlife species. Many species depend upon certain types of wetlands to meet critical elements of their life needs such as areas for nesting, spawning, and rearing. The open meadow communities do provide excellent production of small mammals for prey species, and the forested zones provide excellent opportunity for nesting and breeding for many mammals and bird species. Signs of large mammals such as deer were quite common outside the security fence of the airport operation zone, signs of coyote were present within the impact area.

2.3 Anticipated Impacts

The runway extension project is proposed to impact approximately 21.1 acres of existing wetland located within the impact zone. The wetlands within the impact zone were delineated using the 1989 Federal Manual. Table 1: Wetland Summary, Project Impact Site, summarizes the amount and type of wetlands anticipated to be impacted based on the surveyed wetland edges and planimetered averages. See Figure 2: Proposed Wetlands Impacts, for the mapped wetland numbers. Numbers provided are taken from the Bellingham Airport Runway Extension Draft Conceptual Wetland Mitigation Plan (FAA, 1991). That report also contains a more thorough description of the wetlands of the impact area.

Table 1: Wetland Summary Port of Bellingham Airport Project Site

Wetland #	Classification	Acreage
1	PEM	0.8
2	PEM	--
3	PEM	2.3
	PFO	3.6
4	PEM	0.3
5	PEM	12.8
	PEM	0.4
6	PEM	0.1
7	PEM	0.04
8	PEM	0.2
9	PEM	0.01
10	PEM	0.3
11	PEM	0.2
12	PEM	0.1
Total Acreage		21.1

ACREAGE BY HABITAT TYPE

PEM: Palustrine emergent wet meadows: grass dominated	17.1 acres
PEM: Palustrine emergent marsh	0.4 acres
PFO: Palustrine forested, deciduous canopy	3.6 acres
Total Impact Acreage	21.1 acres

3.0 SUMMARY OF ON–SITE MITIGATION

The three on–site compensation areas will provide 21.1 acres of compensatory wetlands. See Figure 3: On–site Mitigation Plan, for the location of the on–site wetland compensation areas. The areas include:

1. Replacing 12.7 acres of wet meadow community around the extended runway and taxiway area, post–construction. It is proposed to replace that wetland community in–place because the safety zone around the ends of the runway and taxiway will continue to exist and function the same post–construction as they do pre–construction. It is not proposed to improve the water storage capability or wildlife habitat values of these systems over existing conditions due to their proximity to the end of the runway.
2. Connect wetlands number 11, 12, and 14 located on the west side of the impact zone to create 3.4 acres of wet meadow and shrub community. These wetlands are wet meadow communities located within a short distance of one another. The three wetlands are currently fed by precipitation only, and it is proposed to simply grade down the minor elevation difference between them and allow winter rains to collect and provide for longer term saturation in the spring. The location of these wetlands near the west edge of the runway requires that they be created as shrub communities instead of emergent marsh which would likely attract waterfowl.
3. Create a wetland shrub community out of an existing stormwater detention pond located southeast of the airport operations zone. The area would provide approximately 5 acres of shrub community and upland buffer. The detention pond is currently mowed several times annually and is characterized by pasture grasses and red clover.

The retention pond drains a commercial area near the airport, the area does not contain extensive roads, parking lots, or known hazardous or toxic materials. It is proposed to create a shrub community within the basin by dropping the bottom contour slightly and raising the outlet elevation to provide more storage and shallow standing water. A shrub community is proposed to provide a vegetation community which is not used by waterfowl.

3.1 On–Site Reference Communities

Reference communities provide quantifiable goals for the mitigation design by modeling or mimicking a pre–existing wetland community. The reference community is used to determine the relative dominance of the species composition, the spatial patterns of species present, and if possible, the soils and hydroperiod. By basing the compensation design parameters such as hydrology, soil type, and vegetation composition, on an already existing wetland system, one can increase the probability of creating a successful compensation site.

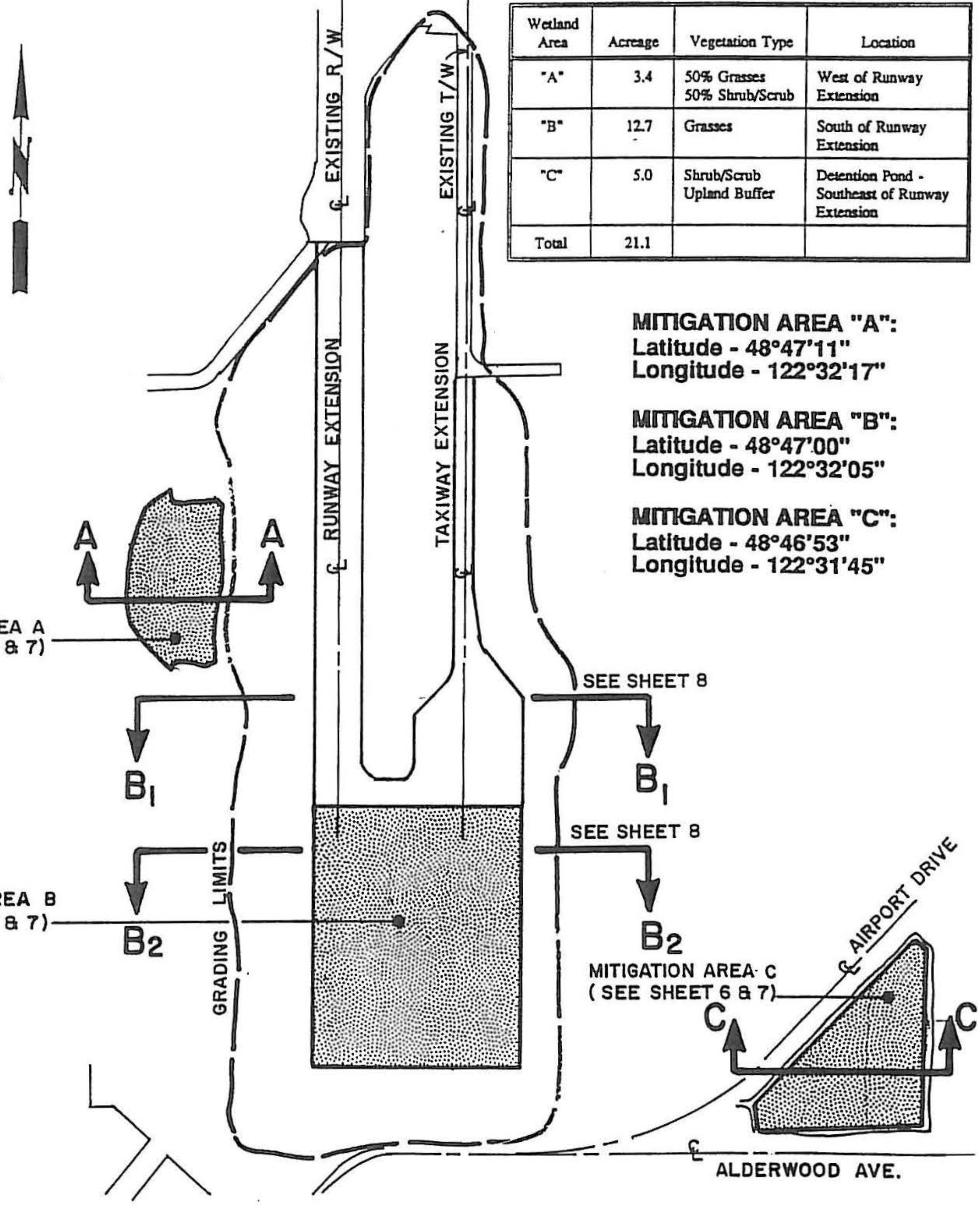
PROPOSED WETLAND MITIGATION

Wetland Area	Acreage	Vegetation Type	Location
"A"	3.4	50% Grasses 50% Shrub/Scrub	West of Runway Extension
"B"	12.7	Grasses	South of Runway Extension
"C"	5.0	Shrub/Scrub Upland Buffer	Detention Pond - Southeast of Runway Extension
Total	21.1		

MITIGATION AREA "A":
Latitude - 48°47'11"
Longitude - 122°32'17"

MITIGATION AREA "B":
Latitude - 48°47'00"
Longitude - 122°32'05"

MITIGATION AREA "C":
Latitude - 48°46'53"
Longitude - 122°31'45"



OFF-SITE MITIGATION PLAN
Little Squalicum Creek

ON-SITE MITIGATION PLAN
Port of Bellingham

FIGURE 3

For this compensation design it is proposed to use reference communities from those communities existing within the impact zone. The three reference communities include the wet meadow grasslands present as a dominant within the project zone, the wet emergent marsh located within wetland #5 of the impact zone, and the forested wetland community located in the south end of wetland #3 in the impact zone.

The rationale for using the wet meadow community as a reference community is that the area surrounding the existing runways and taxiways is in a rather "steady state", i.e. it is technically a wetland based on the soils and vegetation present and the fact that precipitation sheet flows on the surface in the winter and early spring. After the proposed runway extension is completed onsite, the exact same conditions will exist and the same wet meadow community will be established.

It is not sensible to pursue an increase of functional values in this area as the wet meadow is located surrounding the end of an active airport runway, and safety concerns must take precedence over wetland functional values for very practical reasons.

The wet meadow community present is significantly impacted by routine ongoing airport maintenance procedures. The species composition within the meadow is reflective of seeded pasture grasses. It is proposed to use a combination of the same species within the wet meadow restoration zone in order to provide in–kind replacement. It is proposed to use a combination of red fescue (Festuca rubra), bentgrass (Agrostis tenuis), orchard grass (Dactylis glomerata) reed canarygrass (Phalaris arundinaceae), and smooth rush (Juncus effusus).

Within wetland #5 in the impact community, there is a small portion of an emergent wetland community with much greater species diversity than the surrounding wet meadows. It is proposed to use that emergent community as a reference community due to the diversity of species present.

Species present within the emergent zone include common cattail (Typha latifolia) in dense stands of 100 percent cover along the deeper standing water portion of the wetland, eleocharis (Eleocharis palustris) present in large expanses of open growth throughout the shallow portions of the standing water, common water plantain (Alisima plantago–aquatica) present as scattered individuals interspersed with the eleocharis. Small–fruited bulrush (Scirpus microcarpus) is present in small pockets within the wetland. In addition, stands of slough sedge (Carex obnupta) are present on the outer, drier fringes of the wetland.

The outer fringes of the emergent community are characterized by the presence of a sparse shrub community composed of willows, common snowberry (Symphoricarpos albus), and rose (Rosa pisocarpa). The shrub community seems to have been more impacted by mowing activities than the emergent community in this area.

It appears that this emergent community is adapted to drying out every summer; the water level present in March was likely a maximum and it was less than 1 foot in deep. No source of inflow into the wetland exists except for overland flow from the surrounding small basin.

3.2 Performance Standards

The performance standards for the on–site mitigation are directly associated with the success of vegetation community establishment. The primary goal for the on–site mitigation is to create targeted wetland communities, not wildlife habitat within the critical operations zone of the airport. The measure of success of the on–site mitigation will be the successful establishment of the target vegetation communities for each of the three proposed sites.

Within the two herbaceous communities, the goal will be 85% species survival within the monitoring period, with a minimum of 3 species present, none of which represents less than 10% of the total presence.

Within the proposed shrub community within the retention pond, success will be determined by a minimum 30% coverage at the end of the monitoring period, with a minimum of 3 species present.

3.3 Monitoring Program

For the on–site mitigation, the construction will be monitored by the wetland biologist and/or the landscape designer responsible for the final mitigation design. Construction monitoring will assure that appropriate grading is completed, the plant material is healthy and installation methods are sound.

At the completion of installation, the wetlands biologist responsible for the mitigation design will conduct a field verification to assure that the mitigation was built as designed. The landscape designer will provide an "as–built" drawing for the Port and reviewing agencies at the time of completion of construction. Photo–stations for the long–term monitoring will be identified when field verfication of installation is conducted.

Field monitoring of the mitigation will follow a logical schedule somewhat dependent upon the season of completion of the installation. If it is assumed that final plantings are completed in the early spring, then the first monitoring visit will be conducted in late spring/early summer to determine the success of the nursery stock installation. The first visit is when non–viable stock can be identified and immediately replaced, depending upon the timing of the visit. A second field visit will be conducted in late summer/early fall prior to the dormant season. Shrubs which did not survive the first growing season can be identified and replaced during the winter dormant season.

A first–year monitoring report will be submitted to the Port and the reviewing agencies by December of the first year of installation.

Subsequent monitoring visits will be conducted in late spring of the second, and then fourth years, for a total of three years of monitoring data collection spread over a four year period.

The monitoring report for data collected during year two and four will be provided to the Port and the reviewing agencies within four weeks of the data collection each spring.

Data collection will include photographs from pre–identified photo points for each mitigation area, detailed species composition from pre–identified stationary data plots. The plots will be a minimum of 1 meter in radius on the herbaceous communities and 3 meters radius in the shrub community.

The monitoring report will provide an evaluation of the success/failure of the proposed vegetation communities, the survivability of the planted specimens, the presence/absence of volunteer species, the need, if any, for irrigation, the use, if any, by wildlife species. Recommendations for maintenance or contingency actions will be provided to the Port and the reviewing agencies on a timely basis.

3.4 Contingency Plan

Providing for successful wetland creation and enhancement is a very complex process with many variables which can influence the success/failure of the mitigation design and implementation.

Variables include, but are not limited to, adequate hydrology, adequate soils, healthy and vigorous planting stock, predation by herbivores, weather patterns and precipitation.

If it is determined that the proposed mitigation sites are "failing, the cause of failure will have to be established, and then the appropriate corrective action will be undertaken.

If is determined that the weather pattern is such that irrigation is required to allow the planted stock to establish, then temporary irrigation will be provided until the vegetation becomes established in place. Inappropriate hydrology is not anticipated as being a problem on the three proposed sites, as the target vegetation communities are chosen to be tolerant to winter saturation and summer drought. These are not communities which require summer saturation, the most difficult hydroperiod to provide in a created wetland.

Unhealthy nursery stock should be identified within the first growing season. Specimens which do not survive the first growing season will be replaced with new stock. It is expected that there will be a certain percentage of mortality of initially planted species. It is also expected that volunteer species will begin to appear within the compensation zones within the first two growing seasons. Desirable volunteer species will be left to colonize the compensation zones as long as they do not entirely crowd–out targeted species.

If it is determined by review by the resource agencies that the proposed mitigation is not successful due to conditions beyond the Ports' control, then the possibility of identifying another more appropriate mitigation site will have to be considered. Success of the proposed mitigation should not be determined until after the fourth year of monitoring to allow the communities to establish and stabilize after construction and installation.

4.0 LITTLE SQUALICUM CREEK: BACKGROUND AND EXISTING CONDITIONS

4.1 General Overview

The Little Squalicum Creek site is located south and east of the airport on Bellingham Bay. The site generally lies in an east–west alignment and is bounded on the south and east sides by residential areas and Bellingham Technical College (BCT) properties, on the west by Bellingham Bay, on the north by a vacated railroad line. The area surrounding the Little Squalicum Creek site includes commercial, residential and business park uses. The site was used as a gravel pit for several decades, and then as a log storage facility in the 1970s. What remains of Little Squalicum Creek flows through a portion of the site.

The site was identified as a good candidate for compensation because it is owned by Whatcom County and City of Bellingham Parks Departments and it appears to have a strong potential for successful wetland creation. The site appears to have the potential for adequate hydrology, the existing upland community is of low to moderate functional value, and it appears feasible to establish viable wetland communities on site.

4.1.1 Location

The Little Squalicum Creek site is located in Whatcom County in Section 23, Township 38N, Range 2E and lies within the Bellingham City limits. It is situated within the Little Squalicum Creek basin between the Nooksack Delta to the north and Squalicum Creek to the south.

The site encompasses the remaining lower section of Little Squalicum Creek and extends westward to Bellingham Bay. It is bounded on the south side by residential areas and the Bellingham Technical College (BTC), on the west by Bellingham Bay, on the north by an old railroad line. See Figure 4: Site Aerial Photo.

The site is approximately 12.5 acres and occupies a small ravine with a relatively level bottom and steep sides. Little Squalicum Creek is a small stream with a well developed riparian edge that is located on the extreme northern boundary of the property. The steep side slopes are vegetated with blackberry and alder and are relatively undisturbed. The vegetation in the bottom is predominantly young deciduous forest and open meadow, and generally reflects the history of disturbance the site has experienced.

SITE AERIAL PHOTO	FIGURE 4	LITTLE SQUALICUM CREEK
PORT OF BELLINGHAM	Springwood Associates	SHELDON & ASSOCIATES

4.1.2 Site History

The Little Squalicum Creek site and a nearby site currently held by Oeser Cedar were owned by Mr. Hugh Eldridge in the early 1900s. Mr. Eldridge sold the property where Oeser Cedar currently exists (east of the Little Squalicum Creek site) in 1925 to the U&I Sugar Company for sugar beet refining. At that time, Mr. Eldridge granted U&I Sugar Company easements for open channel discharge of wastewater into Little Squalicum Creek. This wastewater was discharged into Little Squalicum Creek downstream (west) of the site where Oeser Cedar effluent currently enters into the creek.

Oeser Cedar was a large wood preserving facility and was in operation from 1939 to 1988. Oeser Cedar used creosote and a pentachlorophenol/oil mixture as a wood preservative. Wastewater and stormwater runoff from the Oeser Cedar facility are channeled through a storm sewer and enters the creek upstream of the Marine Drive Bridge.

Portions of the Little Squalicum Creek site (the east and middle meadow areas) were farmed by the Tiscornia family prior to 1939. The site was mined for gravel and sand from the 1920s to the late 1960s by the Eiford Company. During this time a number of ditches were created on the site which were designed to drain the flat areas of the site. A number of these ditches remain on site today.

As part of the gravel mining operation, a number of basins were excavated for gravel washing. Each basin was used for a period of time and then filled in. Many of these basins were seasonally filled with water, and a few of them contained water year round. The site was leased from Eiford Company by Mt. Baker Plywood during the early 1970s. The site was then used as a raw log storage facility from one to two years.

The Whatcom County Parks Department purchased the land from Eiford Company following the log storage operations. The City of Bellingham Parks Department and County Park have recently entered into an agreement that the City Parks division operate and manage the site for 35 years.

The Bellingham Technical College (BTC) is located south of the site. BTC has occupied the land adjacent to the site since the early 1960s. A parking lot located directly east of the school was constructed during the 1970s. Prior to the 1960s the land occupied by BTC was farmed and grazed by the Tiscornia family.

Bellingham Bay is located west of the site. The beach was historically used by the public for swimming, however, for a period of time access to the beach was prohibited by the Eiford Company. Bellingham Bay was closed to the public for swimming because of the presence of high levels of fecal coliform caused by a direct sanitary sewer outfall into the Bay. The public is currently allowed access to the beach for a variety of activities, including fishing and swimming.

4.1.3 Surrounding Land Uses

The area surrounding the Little Squalicum Creek site includes commercial, residential and business park uses. The site is surrounded by a number of public roads, overpasses and a railroad trestle.

Oeser Cedar, a large wood preserving facility is located east of the site, upstream of Little Squalicum Creek. It is no longer in operation; see Section 4.1.2 for the history of Oeser Cedar.

Two residential neighborhoods (Cedarwood and Birchwood) are located north and east of the site. These neighborhoods are not directly adjacent to the site, however, surface water from the neighborhoods drain to the storm system on site and empty into Little Squalicum Creek.

The area south of the site includes the Eldridge residential neighborhood, composed mostly of single–family residences. In addition, the Vo Tech is located south of the site.

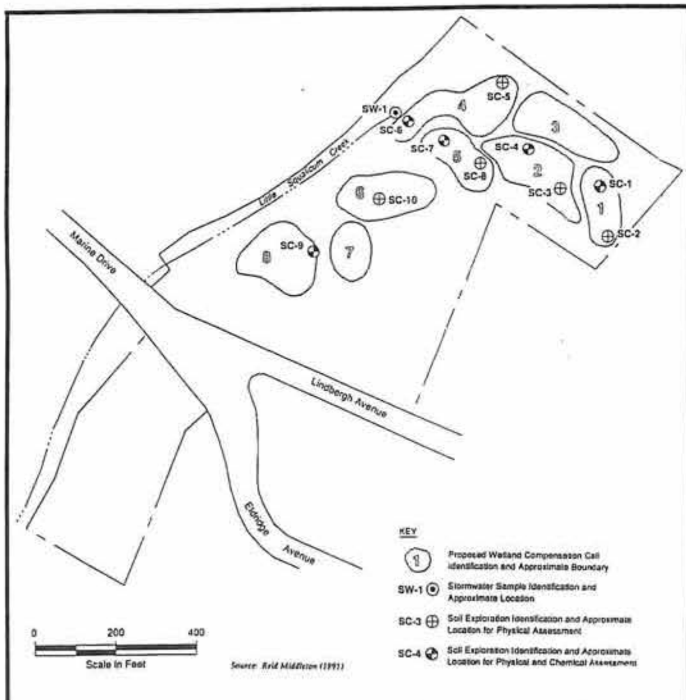
4.2 Soils

The draft Whatcom County Soil Survey (SCS, in press) maps the soil in the area as Urban Land–Whatcom–Labounty complex. There is no profile description for this mapping unit. The Urban Land–Whatcom–Labounty complex is a soil formed from radically altered native Whatcom–Labounty complex soils (Gillies, pers. comm.). Given the landscape position of the Little Squalicum Creek, it is unlikely the native soils were Whatcom–Labounty complex soils which form in Glacialmarine drift plains and exhibit a kettle and kame topography. Regardless of the native soil types, most of the site's soils have been radically altered by human activities. Many areas have extensive gravel and cobble in the surface horizons with a few areas also having bark and wood chips near the surface.

Most of the soils in the Little Squalicum Creek valley have been disturbed by human activities. Much of the site was a gravel pit which was backfilled after excavation. A portion of the site was also a log storage yard. Other than the addition of bark and wood debris, the log yard was probably also surfaced periodically with gravel and cobble to maintain a suitable working surface. Roads through the valley were also probably surfaced with gravel and cobble when deemed necessary. In addition, the stormwater pipeline which daylights at the current headwaters of Little Squalicum Creek was also backfilled, probably with finer texture materials.

Twelve pits were excavated in August, 1991, for preliminary soils investigations. See Figure 5: Existing Topography, Hydrology, and Soils and Water Sampling Locations. Backfill ranges in depth from 10 to 30 inches over the site where soil pits were dug with a backhoe. The subsoil in these pits was variable. Of the 12 pits, 6 had unconsolidated backfill over coarse textured subsoils with evidence of seasonally high water tables. Three soil pits had unconsolidated backfill over stratified clay layers with indications of perched water tables. One soil pit had 30 inches of unconsolidated fill over finely textured subsoils which were suggestive of buried intertidal mudflats. One soil pit had unconsolidated backfill over a buried histic epipedon and strata of clays and sands. Finally a compacted till layer was encountered at 6 feet. This pit had no apparent hydrology. One soil pit had no evidence of backfill, with a surface horizon of loam over a sandy clay loam horizon, and sands beginning at 24 inches in depth. This pit showed evidence of weakly perched seasonal surface water. See Appendix A: Hydrologic Assessment on Little Squalicum Creek Mitigation Site prepared by Watershed Dynamics, Inc., for illustrations of the soil pit profiles for the 12 pits.

Physical and chemical tests were conducted on soil samples gathered from hand–excavated pits in the areas identified for wetlands creation in December, 1991. See Figure 5 and Appendix B: Surface Water Quality and Soil Assessment for the Proposed Little Squalicum Creek Compensation Project prepared by Landau Associates, Inc. The soils were tested for the presence of chemical contaminants that might preclude use of the site for mitigation purposes. Except for one area, all the samples showed no signs of contamination beyond State of Washington Toxics standards. Further testing will be conducted around the one area which showed elevated levels of polynuclear aromatic hydrocarbons (PAH's) to determine is this is a case of isolated dumping, or if the problem is more widespread. Results will be available before final permit issuance.



LANDAU – Water Quality, Physical and Chemical Soil Testing

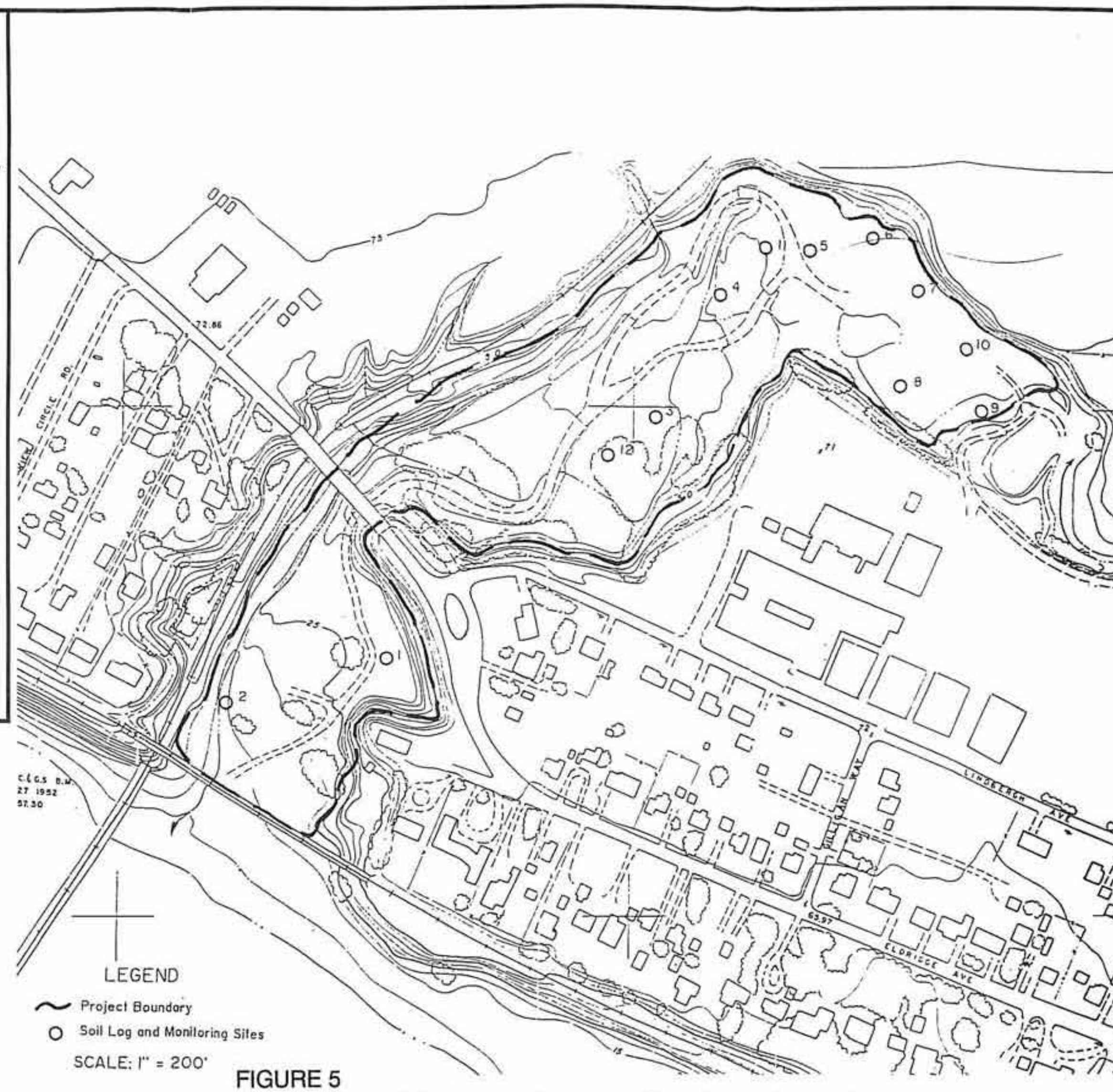


FIGURE 5

EXISTING TOPOGRAPHY, HYDROLOGY, AND SOILS AND WATER SAMPLING LOCATIONS		LITTLE SQUALICUM CREEK
PORT OF BELLINGHAM P.O. Box 1737 Bellingham, WA 98227	Springwood Associates	SHELDON & ASSOCIATES

The soils tests performed to measure physical parameters include mechanical grain size analyses to estimate the hydraulic conductivity of the existing soils. The soils are generally described as consisting primarily of slightly silty to silty sand and gravel which is suitable as structural fill. High infiltration rates and low organics reduce the suitability of the existing soils as wetland substrate. The wetland creation effort will require importation of more suitable soils to reduce water loss due to infiltration and to provide a better growing medium for plants.

4.3 Hydrology

Water enters the Little Squalicum site from three primary sources: precipitation, stormdrains, and springs. The primary surface water flows on to the site originate from two stormdrains, the Oeser box culvert and the Birchwood stormdrain. These stormdrains outlet into the extreme eastern end of Little Squalicum Creek which flows approximately 1800' west into Bellingham Bay. The box culvert collects flows from the north and east of the site, including the Oeser Cedar facility and the Cedarwood neighborhood. The Birchwood stormdrain collects flows from east and south of the site and appears to collect primarily residential and parking lot runoff. Springs contribute water into existing emergent wetlands located along the northeastern edge of the site, at the base of the slope. Shallow groundwater is perched in the northern portion of the site as well. From past land uses on site, the soils are commonly compacted and winter ponding often occurs in closed depressions.

According to stormwater plans provided by the City of Bellingham Public Works, additional smaller storm drains enter the site along the eastern edge from the residential zone. The outfalls of these stormdrains were not visible from onsite, though evidence of soil saturation along the eastern foot of the steep slope could likely be from such a source. See Figure 5 for the locations of the storm drains entering the site.

In addition to the stormwater flows, there are springs located along the northern edge of the site, at the base of the steep slopes within the blocked channel of the historic creeks. These springs appear to have a relatively constant surface water elevation throughout the year. This assumption is based on observation of the water levels through late summer.

4.3.1 Water Quality.

Typical sources of contamination of a residential stormwater drainage basin include: vehicle traffic on roadways, motor oils, agricultural and landscape fertilizers, pesticides and herbicides, as well as biological oxygen demand, carbon oxygen demand and fecal coliform.

Water samples from the Little Squalicum Creek collected by Ecology in 1977 and 1978 showed elevated concentrations of phenols. Creek sediment samples taken in 1987, showed elevated levels of Pentachlorophenol (PCP) and polynuclear aromatic hydrocarbons (PAH's).

Soils, sediments and groundwater within Little Squalicum Creek were tested by Parametrix during July 1991 (Parametrix, 1991). Soils, sediments and groundwater tested within the stream channel were found to be contaminated with a number of semivolatile and phenolic compounds. Identified compounds of concern included: PCP, Benzo(a)anthracene, Benzo(b)fluroanthene, Benzo(a)pyrene, 4–nitrophenol, Indeno(1,2,3–CD)pyrene, and Dimethylphthalate.

PCP was found at high levels both in the sediment and in the groundwater at the outfall of the Oeser Cedar storm drain and in the sediment of the stream bed between the railroad bridge and Marine Drive bridge on the south side of the creek. Other compounds were located throughout the creek sediment, soils and groundwater.

Several spills of creosote and PCP occurred at the Oeser Cedar facility in the 1970s. In 1971 a PCP spill of 50 or more gallons entered Little Squalicum Creek and another spill in 1975 of approximately 30 gallons of PCP was discharged to the creek. Storm drain outfalls below the Oeser Cedar facility showed detectable levels of these compounds (Parametrix, 1991). Due to the degraded water quality within Squalicum Creek, no portion of the waters from the creek are proposed to be used for onsite compensation.

4.3.2 Groundwater

Twelve pits were excavated on site to identify soil profiles and hydrologic conditions in August, 1991. See Appendix A. Two pits were located on the western portion of the site, the remainder of the pits were located in the upper (eastern) portion. See Figure 5 for the pit locations.

The pits were dug to characterize the soils located on site and to determine the relative location of groundwater if it was present late in the season. Groundwater levels were assessed in 12 pits.

Initial data collected identified four hydrologic patterns. These include areas of intertidal influence, perched surface water, seasonally high groundwater and areas with no apparent hydrology.

One pit (#2) is located on the western portion of the site near the creek. The area showed evident of historic intertidal influence. No groundwater was present. It is assumed that for mitigation purposes that water from the nearby creek could be used.

Three pits (#3, 9 and 11) were in areas with seasonally perched surface water over a clay layer. Pit 3, located adjacent to wetland #2 in the middle of the site showed perched surface water at 22 to 32 inches. Pit 9, located at the far southeastern end of the site showed perched surface water between 16 to 34 inches. Pit 11, located at the far eastern side of the site, just upstream of the point at which Oeser Cedar enters into the creek showed perched surface water at 34 to 40 inches. Below these areas of perched surface water lies a relatively impermeable layer. Excavation of existing backfill to the impermeable clay layer and importation of top soil should provide a medium which would hold seasonally perched surface waters and allow root growth.

Seven pits (#1, 5, 6, 7, 8, 10 and 11) were in areas with seasonally high groundwater levels. Pit #1, located near the entrance of the storm drains from the Eldridge community has a fluctuating groundwater level between 24 and 34 inches and permanent groundwater at 33 inches. Other pits have fluctuating groundwater between 16 and 54 inches.

Two pits (#5 and 11) were in areas with high groundwater table. Both pits are located just south of the Oeser Cedar outfall. High groundwater table in pit 5 is present at 10 inches and in pit 11 at 72 inches during the winter and spring months.

Excavation of existing backfill to the level of gleying (42 inches in general) and importation of top soil on areas with seasonally high groundwater and high groundwater would provide sufficient hydrology for establishment of deep rooted species.

Two pits (#4 and 12) were in areas with no apparent hydrology. Pits 4 and 12 both were located in the middle section of the site. These areas are not suited for wetland creation.

4.4 Upland Vegetation

Approximately 40 percent of the total site is highly disturbed meadow, much of it upland. Much of the upland meadow is dominated by several upland grasses and common tansy (Tanacetum vulgare), with a wide variety of other weedy upland herbs present. Throughout the upland meadow community there are also many scattered weedy shrubs, vines and trees such as ornamental hawthorn (Crataegus monogyna), Himalayan blackberry (Rubus discolor), red alder (Alnus rubra) and black cottonwood (Populus trichocarpa). General vegetation communities present on site are shown on Figure 6: Existing Vegetation.

Approximatley 50 percent of the total site is disturbed forest, much of it upland. The upland portions of the forest were dominated by red alder, black cottonwood, ornamental hawthorn, and in some areas by big–leaf maple (Acer macrophyllum). Common understory shrubs and vines included Himalayan blackberry, and common snowberry, Pacific blackberry. The herbaceous layer was generally depauperate. Field horsetail (Equisetum arvense) was the most common species on the herbaceous layer.

The remaining approximate 10 percent of the upland was scrub/shrub habitat, most of it dominated by Himalayan blackberry and ornamental hawthorn. Figure 7: Existing Vegetation Photos, shows the character of the Little Squalicum Creek site.

4.5 Existing Conditions: Wetlands

The site was checked for the presence of wetlands as defined by the Corps of Engineers (COE), "those areas inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions." (40 CFR Section 230.3(t)).

The wetlands on site were assessed using the three parameter approach as provided within the Federal Manual for Identifying and Delineating Jurisdictional Wetlands (FICWD, 1989). In order for an area to be identified as wetland it must have positive indicators of hydric (wetland) soils, hydrology, and hydrophytic (wetland) vegetation. Each parameter, including field sampling techniques, is discussed in this report.

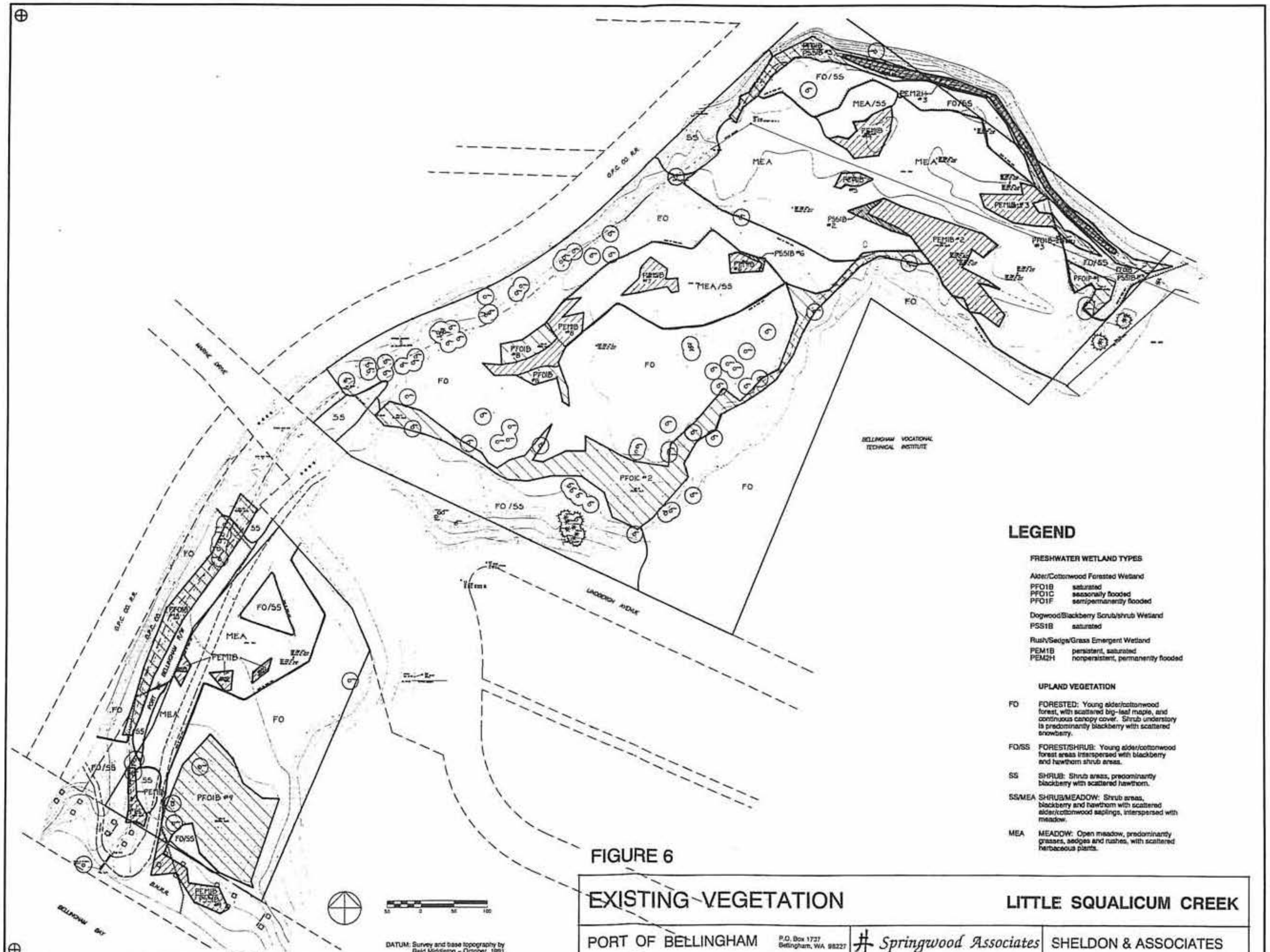


FIGURE 6

EXISTING VEGETATION

LITTLE SQUALICUM CREEK

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Young deciduous forest with blackberry understory (future conversion to forested wetland)

Meadow with shrubs (future Wetland Cell 6)

Area west of Marine Drive overpass (future stream channel)

EXISTING VEGETATION PHOTOS
Port of Bellingham

Figure 7

Hydric soils are defined as soils that are saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper part (U.S.D.A. Soil Conservation Service, 1987).

Soils on site were examined by digging soil pits and re–checked with a handheld auger. The draft Whatcom County Soil Survey (SCS, in press) was checked for the presence of mapped hydric soils.

Hydrophytic vegetation is defined as macrophytic plant life growing in water, soil, or on a substrate that is at least periodically deficient in oxygen as a result of excessive water content (FICWD, 1989).

Vegetation on site was identified after Hitchcock and Cronquist (1973). Wetland plant species indicator status was determined using Reed (1988).

An area has wetland hydrology when saturated to the surface or inundated at some point in time during an average rainfall year. It is generally required for an area to be saturated to the surface for at least one week or ponded at least two weeks during the growing season (FICWD, 1989). Wetland hydrology was determined by examining field evidence.

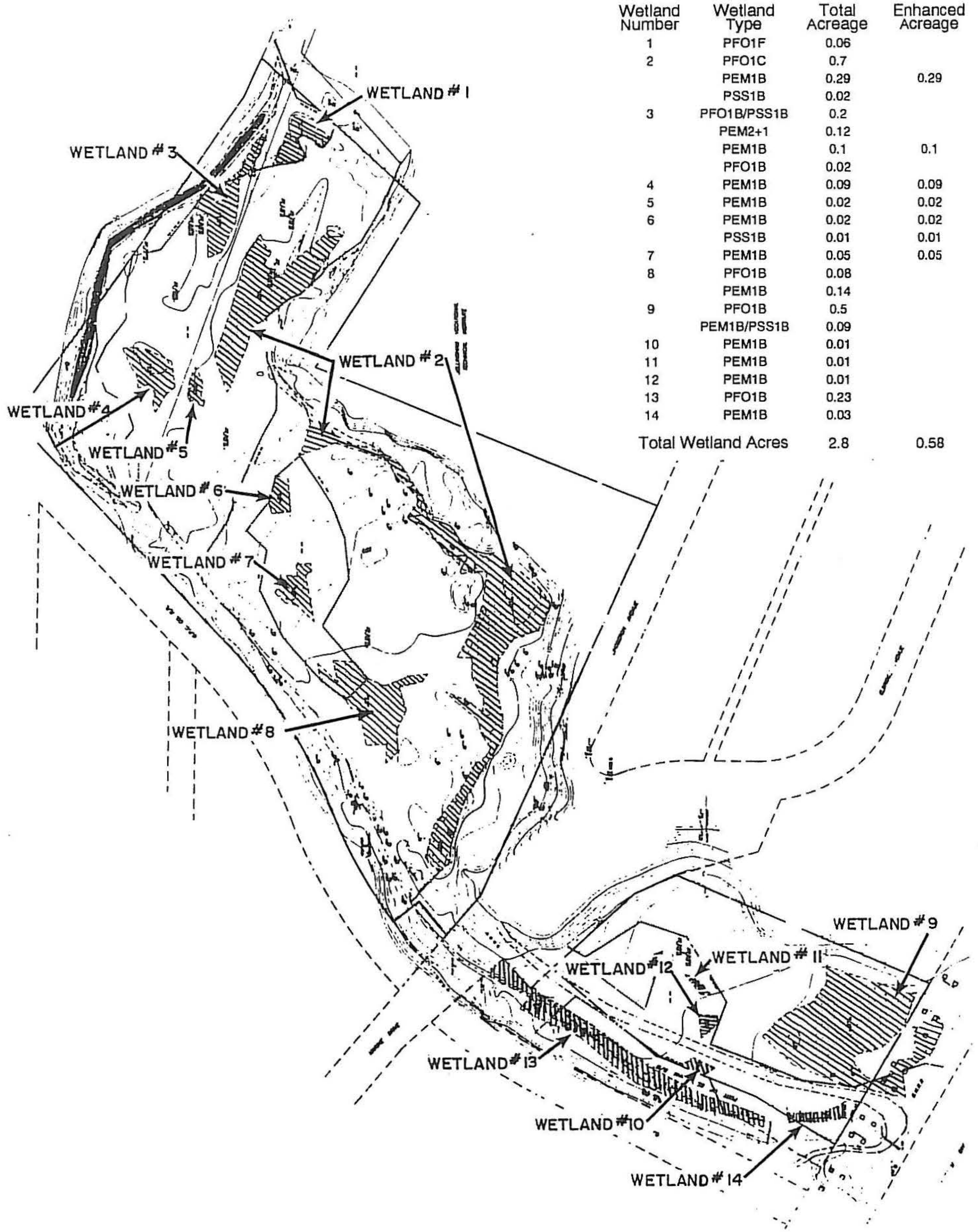
The site inspection was conducted four days during the dry season, between August 9 and August 26, 1991, by James Hartley and Deborah Dole of Sheldon & Associates. See Figure 8: Existing Wetlands, for the surveyed wetland boundaries.

Small areas of the disturbed meadows were wetlands. In those wetlands common tansy was absent or not dominant. A variety of rushes (Juncus spp.) and sedges (Carex, Eleocharis, Scirpus spp.) were present, and the grass species were mostly hydrophytic. Although some scattered ornamental hawthorn and Himalayan blackberry were present in the meadow wetlands, these species were often found with or replaced by various willows (Salix spp.).

The largest and most diverse wetlands were within or at the edge of forests on the site. Though these wetlands were within the forest canopy, most of the wetlands were only partly forested themselves. In the wetlands, the most prevalent tree species included red alder, black cottonwood, and Pacific willow (Salix lasiandra). Big–leaf maple was prevalent in one wetland.

EXISTING WETLAND ACREAGES

Wetland Number	Wetland Type	Total Acreage	Enhanced Acreage
1	PFO1F	0.06	
2	PFO1C	0.7	
	PEM1B	0.29	0.29
	PSS1B	0.02	
3	PFO1B/PSS1B	0.2	
	PEM2+1	0.12	
	PEM1B	0.1	0.1
	PFO1B	0.02	
4	PEM1B	0.09	0.09
5	PEM1B	0.02	0.02
6	PEM1B	0.02	0.02
	PSS1B	0.01	0.01
7	PEM1B	0.05	0.05
8	PFO1B	0.08	
	PEM1B	0.14	
9	PFO1B	0.5	
	PEM1B/PSS1B	0.09	
10	PEM1B	0.01	
11	PEM1B	0.01	
12	PEM1B	0.01	
13	PFO1B	0.23	
14	PEM1B	0.03	
Total Wetland Acres		2.8	0.58



OFF-SITE MITIGATION PLAN
Little Squalicum Creek

EXISTING WETLANDS
Port of Bellingham

FIGURE 8

Common shrubs include Sitka willow (Salix sitchensis), coast black gooseberry (Ribes divaricatum), and in more disturbed areas, Himalayan blackberry. Common herbaceous layer species include Watson's willow–herb (Epilobium watsonii), smooth rush, field horsetail, and giant horsetail (Equisetum telmateia).

Fourteen separate wetlands were identified on site, only four of which are greater than 1 acre in size. Five of the six largest wetlands on site are located at the toe of slopes leading into Little Squalicum Creek Valley. The detailed discussion of each individual wetland delineated on the Little Squalicum site is provided within Appendix C: Wetlands Analysis Report for Little Squalicum Creek, of this report. Table 2: Little Squalicum Creek Existing Wetland Acreages, below, summarizes the wetland community types and acreages of the existing wetlands located on the site. Wetland classifications provided are based on the U.S. Fish & Wildlife Service classification, Classification of Wetland and Deepwater Habitats (Cowardin, 1979).

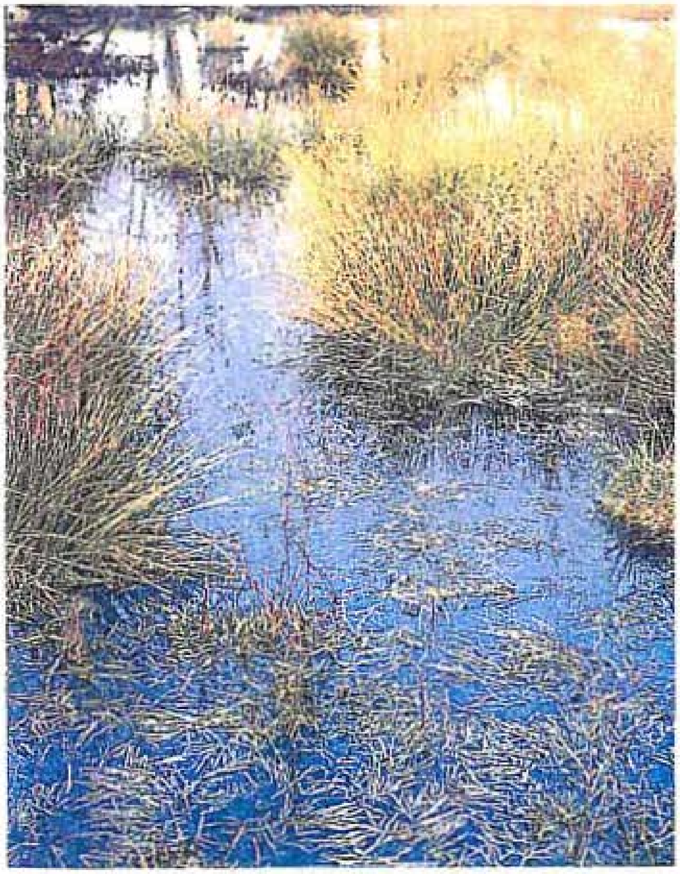
Table 2: Little Squalicum Creek Existing Wetland Acreages

Wetland Number	Wetland Type	Total Acreage
1	PFO1F	0.06
2	PFO1C	0.7
	PEM1B	0.29
	PSS1B	0.02
3	PFO1B/PSS1B	0.2
	PEM2+1	0.12
	PEM1B	0.1
	PFO1B	0.02
4	PEM1B	0.09
5	PEM1B	0.02
6	PEM1B	0.02
	PSS1B	0.01
7	PEM1B	0.05
8	PFO1B	0.08
	PEM1B	0.14
9	PFO1B	0.5
	PEM1B/PSS1B	0.09
10	PEM1B	0.01
11	PEM1B	0.01
12	PEM1B	0.01
13	PFO1B	0.23
14	PEM1B	0.03
Total Wetland Acres		**2.8**

4.6 Reference Wetland Communities

Reference plant communities were selected from 8 sites around Whatcom County to provide information about local plant associations and wetland conditions that will be useful in designing new wetlands systems. The three plant communities types proposed in this mitigation (wet meadow, emergent, scrub–shrub) will be based on these local reference communities. See Figure 9: Reference Community Photos.

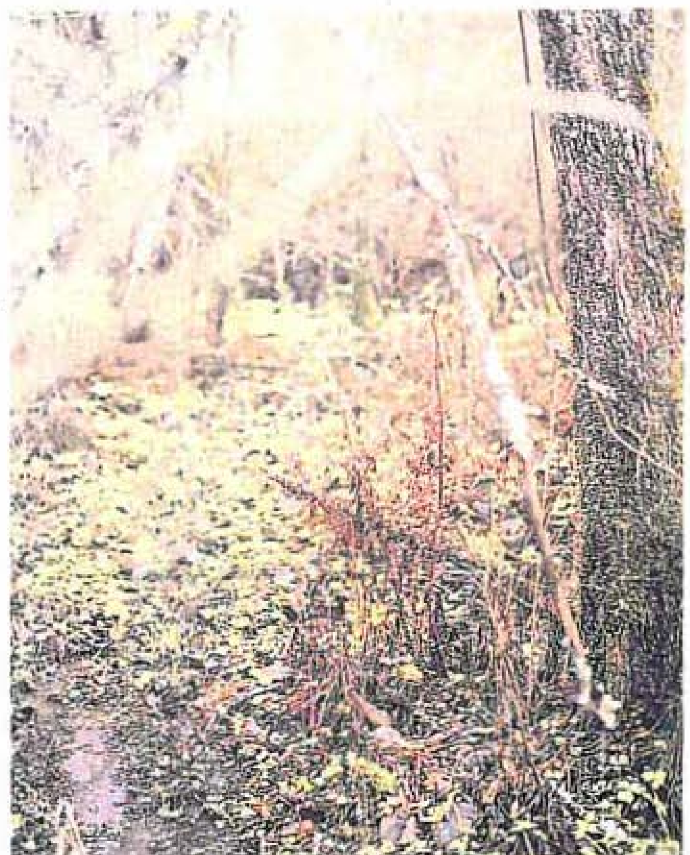
In selecting the different reference sites, several different hydrologic regimes were looked for, and soils information was gathered in addition to species composition and distribution. A minimum of two sample plots were taken at each community, using a 1 meter radius circle for wet meadow and emergent communities, and a 5 meter radius circle for scrub–shrub communities. Table 3, below, indicates the different sites used for each plant community type, with some information about the dominant plants and soils conditions.



A. Shallow emergent wetland

B. Wet meadow with rose

C. Forested wetland with scrub-shrub/emergent



D. Scrub-shrub wetland with emergent understory

REFERENCE COMMUNITIES
Port of Bellingham

FIGURE 9

Table 3: Plant Community Reference Sites

Site Name	Classification	Water Depth	Soils
#1 Sunset	PEMC wet mead/mixed grass	W:3–8" S:saturated	Whatcom Silt Loam deep, well drnd
#2 Winn	PEM	permanent	Hallenton Silt Loam
#3 Ferndale Industr Pk	PEM disturb meadow	saturated 3–6" swales	La Bounty: fine roots loamy, organic
#4 Church	PEM wet pasture	flooded 12" until May	Whatcom–La Bounty clay pan
#5 Birch Bay	PEM wet meadow red fescue	12" ditch sat. swale drier meadow	Whitehorn silt/sandy Loam 8–20"
#6 Central	PEM wet pasture grass/sedges	16" ditch sat. swales flooded 3"	Everson silt loam clay over sand Shalkar muck: acid
#7 Lindsey Trapline	PEM PSS	stand. H2O to 18" edges drawdown	Bellingham silty clay Skipopa silt loam
#8 Agate Bay	PEM	drawdown June–July	Squalicum gravelly loam
	pond edge wet meadow	" drawdown April	
#9 James St	PSS	saturate to 6"	Whatcom or La Bounty

The plant species lists for the emergent wet meadow communities are based on four sites; #1 – Sunset; #3 – Ferndale Industrial Park; #4 – Church; and #5 – Birch Bay. The reference sites used for the emergent marsh communities were #2 – Winn Rd; #4 – Church; #6 Central; and #8 – Agate Bay. The scrub–shrub wetland communities are based on reference sites #7 – Lindsey/Trapline and #9 – James St. The majority of the individual reference sites were located in Whatcom County by Binda Colebrook. See Appendix D: Off–Site Reference Community Field Notes and Map, for species lists and observed percentages.

Reference community data was also collected from the forested wetland (#3) at the Bellingham Airport. A forested community will not be planted at Little Squalicum Creek however, the information about the understory shrubs is useful in developing a species list for understory plantings in the forested wetland conversion area. The description of this reference community is include in Appendix D.

5.0 MITIGATION PROPOSAL

The wetland mitigation plan proposed for Little Squalicum Creek is directed at achieving a range of goals and objectives which include the following;

1) The provision of approximately 4.6 acres of wetland creation and enhancement using stormwater flows from the Birchwood stormdrain to create a diversity of wetland habitats (30% forested, 20% scrub–shrub and 50% emergent).

2) The creation of approximately 1100' of new stream channel to Bellingham Bay with associated wetlands and fisheries enhancement for salmon.

3) Opportunities for passive recreation and environmental education in response to the site management goals of the City of Bellingham Parks Department.

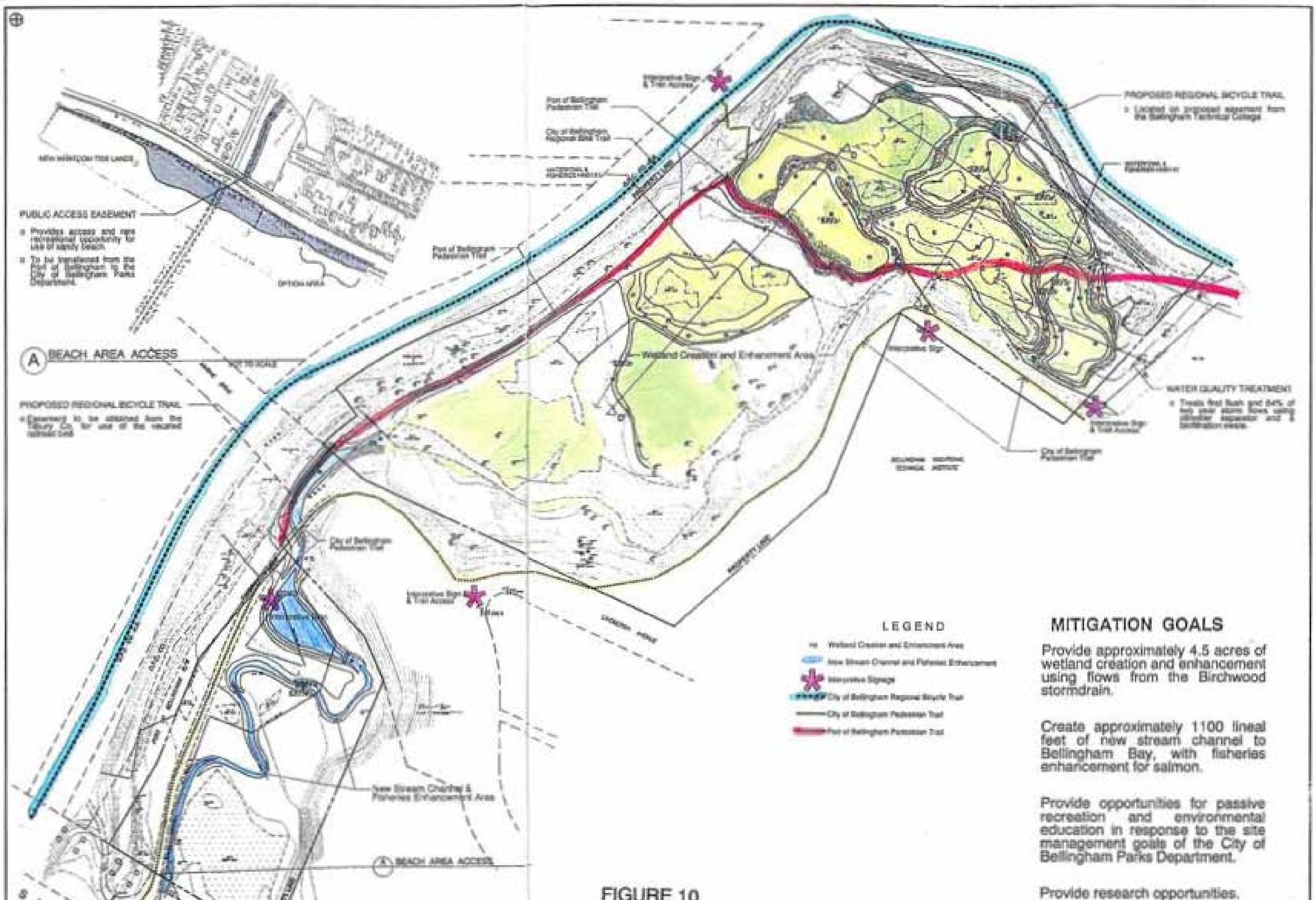
4) Opportunities to achieve a number of research objectives through the careful implementation of a site monitoring plan.

The wetland types proposed for creation are intended to be similar to selected reference sites at the airport and locally in the area. The new stream channel will be designed to accommodate salmon spawning and provide juvenile fish access to upstream overwintering habitat in the created wetlands. A trail system will be carefully integrated into the site design to provide shoreline access to Bellingham Bay while minimizing disturbance to wildlife habitat and avoiding conflicts with on–going research and site monitoring. Interpretive signage will also be included which describes elements of the natural environment such as wildlife, plant community ecology, and wetland functions as well as provide information about the site history, the wetlands creation effort, fisheries enhancement, and the importance of the research areas. See Figure 10: Conceptual Mitigation Plan.

The following sections will discuss each of the goals of this mitigation plan. Proposed changes to the site will be described, including conceptual design information about the proposed site topography, hydrology, and plant community types. The expected impacts to the site will be discussed along with the expected increase in beneficial functions and values the site will provide. A section addressing project implementation will also consider the relationship of the mitigation plan to the expected clean–up of the contaminated areas of the site.

5.1. Wetland Creation and Enhancement

The majority of the existing wetlands at the Little Squalicum Creek Mitigation Site occur in minor depressions in the gravelly soil, or where a perched water table occurs near the surface.



MITIGATION GOALS

Provide approximately 4.5 acres of wetland creation and enhancement using flows from the Birchwood stormdrain.

Create approximately 1100 lineal feet of new stream channel to Bellingham Bay, with fisheries enhancement for salmon.

Provide opportunities for passive recreation and environmental education in response to the site management goals of the City of Bellingham Parks Department.

Provide research opportunities.

FIGURE 10

CONCEPTUAL MITIGATION PLAN		LITTLE SQUALICUM CREEK
PORT OF BELLINGHAM	Springwood Associates	SHELDON & ASSOCIATES

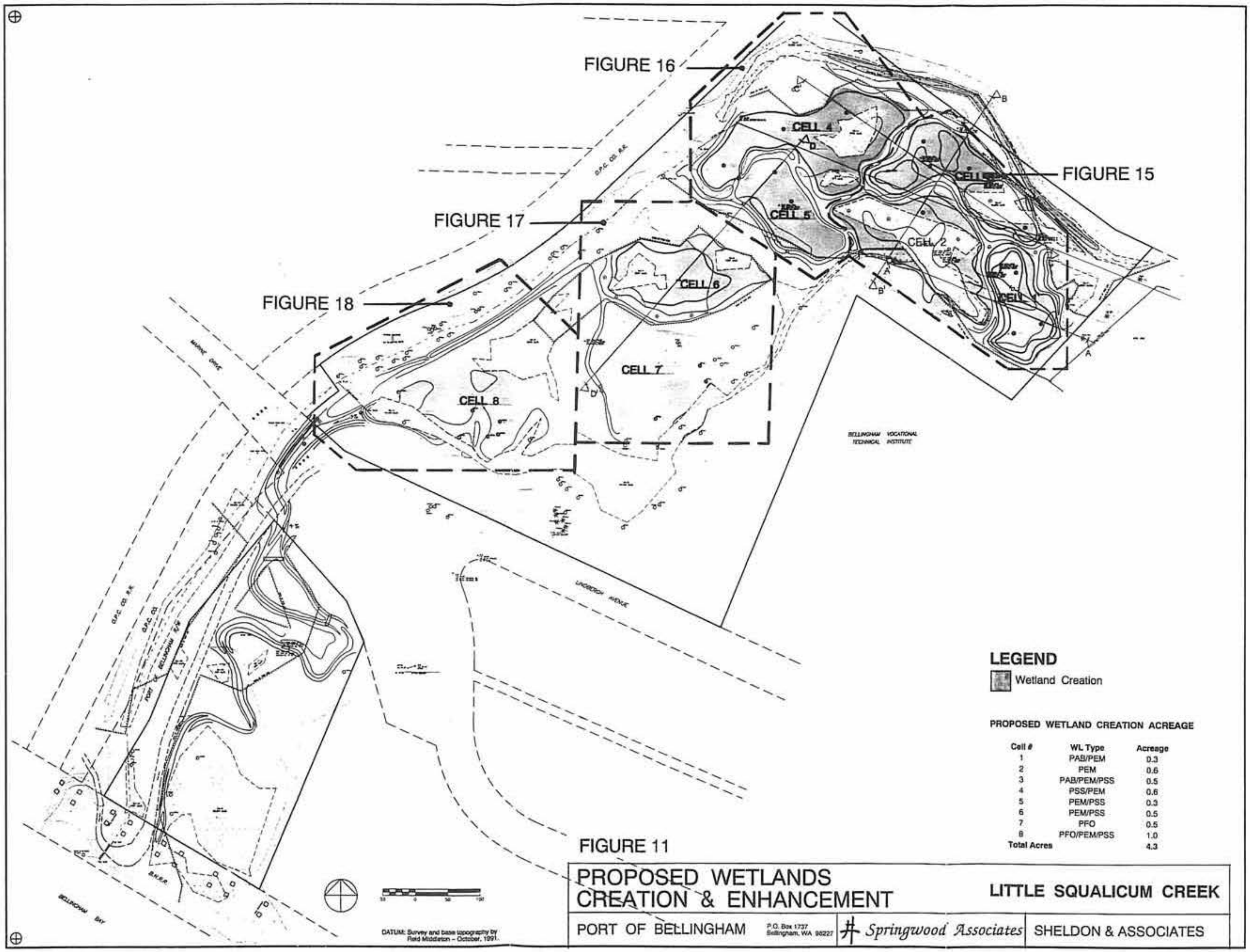
These wetlands generally have low plant diversity and little structure. The wetlands creation proposed in this plan intends to augment and in some instances replace the low functions and values of the existing wetlands. The majority of the wetland creation and enhancment will occur in the area east of the Marine Drive overpass. See Figure 11: Proposed Wetlands.

Some of the goals of the wetland creation are to create a diversity of wetland community types that will provide better wildlife habitat and visual amenity in the proposed park. In response to the constraints of the hydrology and soils, the deeper open water areas occur at the head of the system in the area closest to the boundary with BTC. These deep emergent systems form a mosaic with shallow emergent marsh and scrub–shrub wetlands. In order to preserve existing visual corridors along the proposed regional bicycle trail, trees will be planted only around the edges of the site. This allows relatively unobstructed views down into the new wetlands and beyond to Mount Baker.

5.1.1 Grading

The new wetlands will be created by containing surface water flows in a series of eight wetlands cells. See Figure 12: Grading & Hydrology. Low berms will be constructed to contain and backup surface water flows in the first seven wetland cells. The elevation of the outlet for the entire eastern portion of the site will be raised to increase seasonal flooding in the area adjacent to the existing channel (Cell 8). Site work associated with the wetlands creation primarily involves excavation to create ponds with both deep and shallow marsh components (Cells 1 to 6). Cell 7 and Cell 8 will not undergo extensive site work beyond construction of a low berm, and raising the outlet elevation.

Graded slopes in the wetlands will generally not exceed 5%. The constructed berms will not exceed 3:1 sideslopes, and like the wetlands, will be varied to increase the diversity of conditions for plant establishment. Plant communities are adapted to specific water regimes (both depth and hydroperiod). Low gradient slopes will allow for broad transitions between plant communitity types, and contribute to plant diversity. The spring–fed wetlands at the toe of the slope east of Cells 3 & 4, will be protected from disturbance during construction by leaving a dike between these wetlands and the area proposed for excavation.



LEGEND

Wetland Creation

PROPOSED WETLAND CREATION ACREAGE

Cell #	WL Type	Acreage
1	PAB/PEM	0.3
2	PEM	0.6
3	PAB/PEM/PSS	0.5
4	PSS/PEM	0.6
5	PEM/PSS	0.3
6	PEM/PSS	0.5
7	PFO	0.5
8	PFO/PEM/PSS	1.0
Total Acres		4.3

FIGURE 11

PROPOSED WETLANDS CREATION & ENHANCEMENT

LITTLE SQUALICUM CREEK

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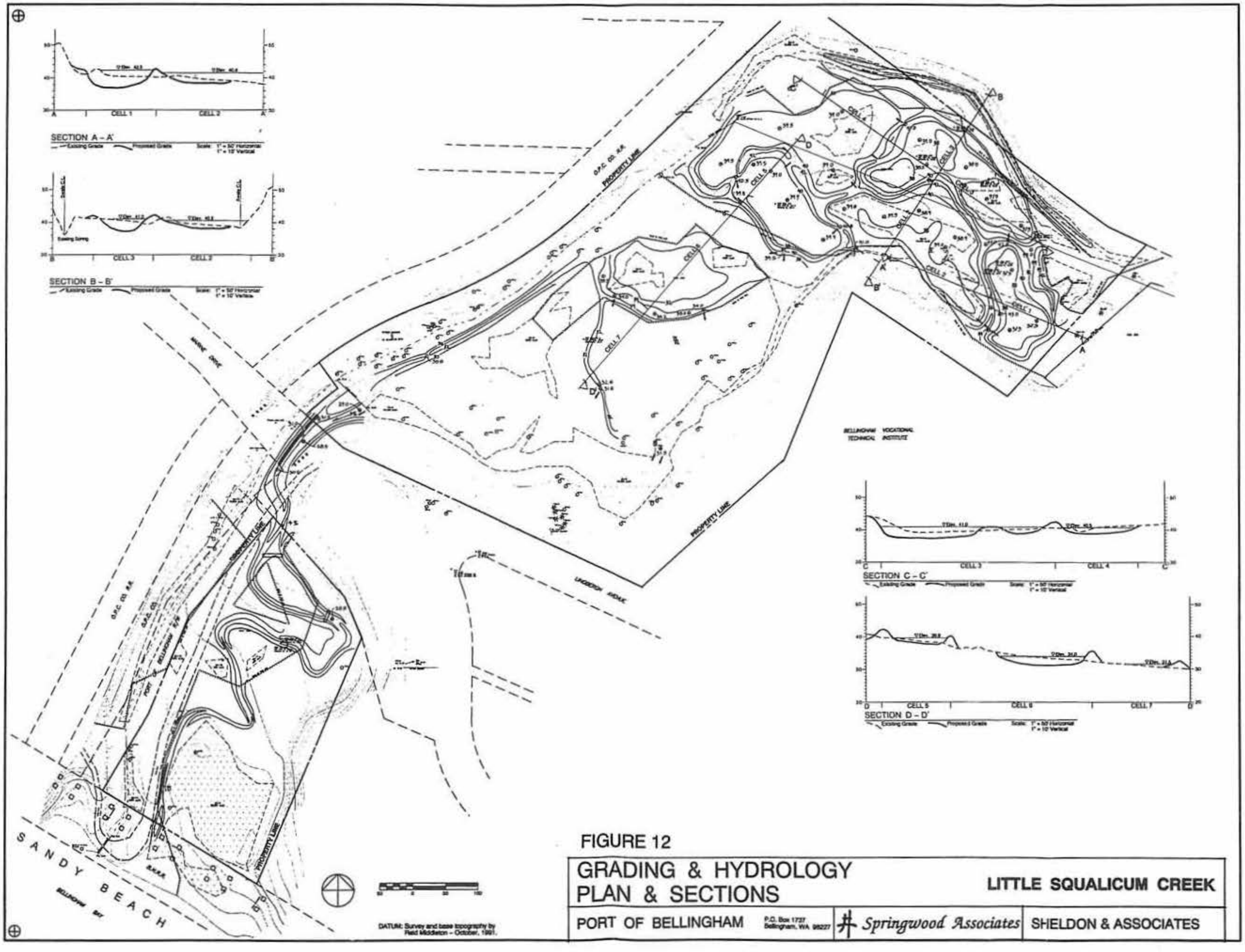
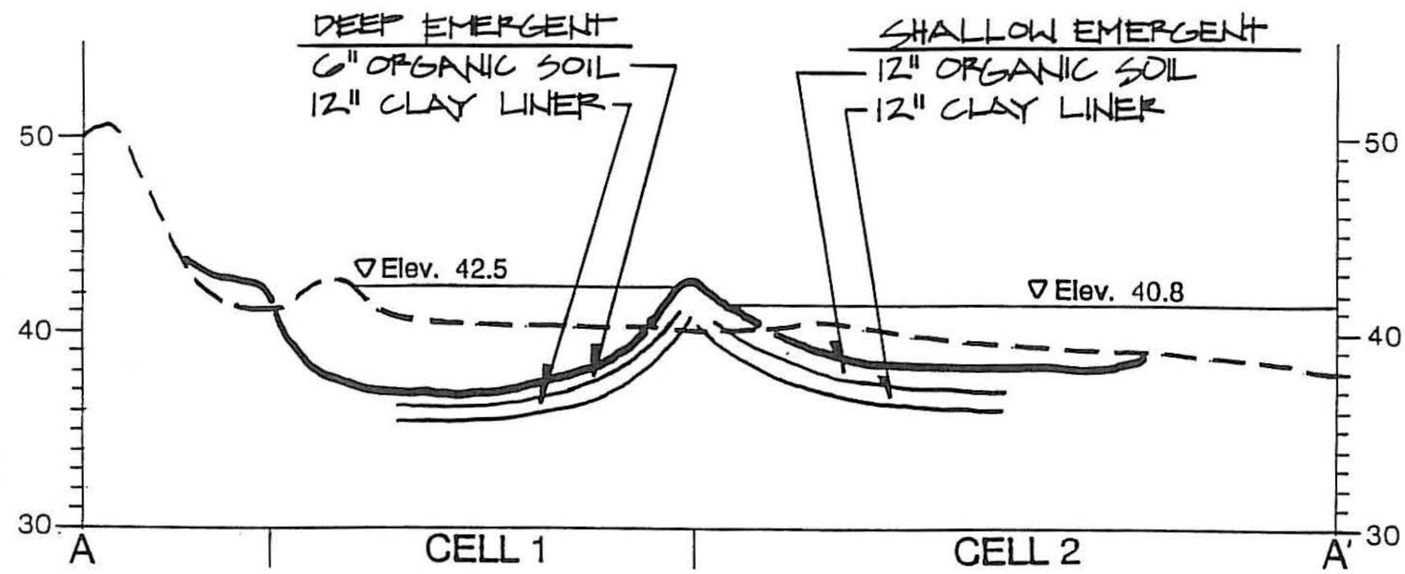
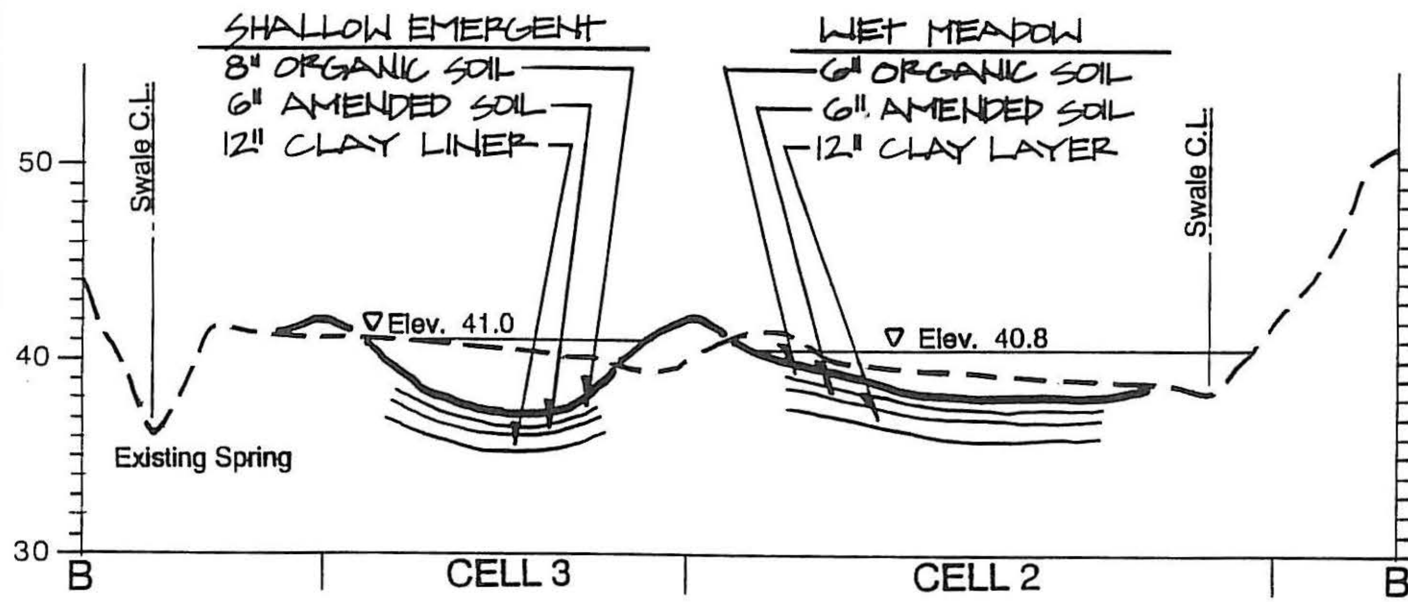

SECTION A - A'
CELL 1
CELL 2
SECTION B - B'
CELL 3
CELL 2
SECTION C - C'
CELL 3
CELL 4
SECTION D - D'
CELL 5
CELL 6
CELL 7
PROPERTY LINE
PROPERTY LINE
PROPERTY LINE
PROPERTY LINE
BELLINGHAM VOCATIONAL TECHNICAL INSTITUTE
SANDY BEACH
DATUM: Survey and base topography by Reid Middleton - October, 1991.
FIGURE 12
GRADING & HYDROLOGY PLAN & SECTIONS
LITTLE SQUALICUM CREEK
PORT OF BELLINGHAM
Springwood Associates
SHELDON & ASSOCIATES



SECTION A – A'

Existing Grade Proposed Grade Scale: 1" = 50' Horizontal
1" = 10' Vertical



SECTION B – B'

Existing Grade Proposed Grade Scale: 1" = 50' Horizontal
1" = 10' Vertical

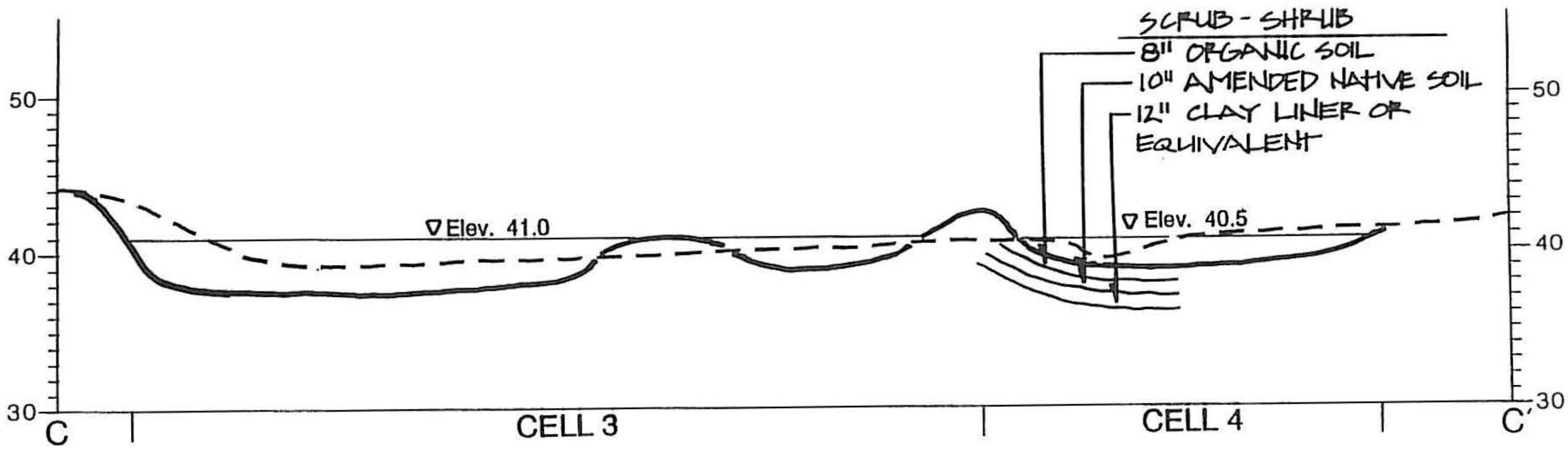
GRADING SECTIONS
Port of Bellingham

FIGURE 13

OFF-SITE MITIGATION PLAN
Little Squalicum Creek

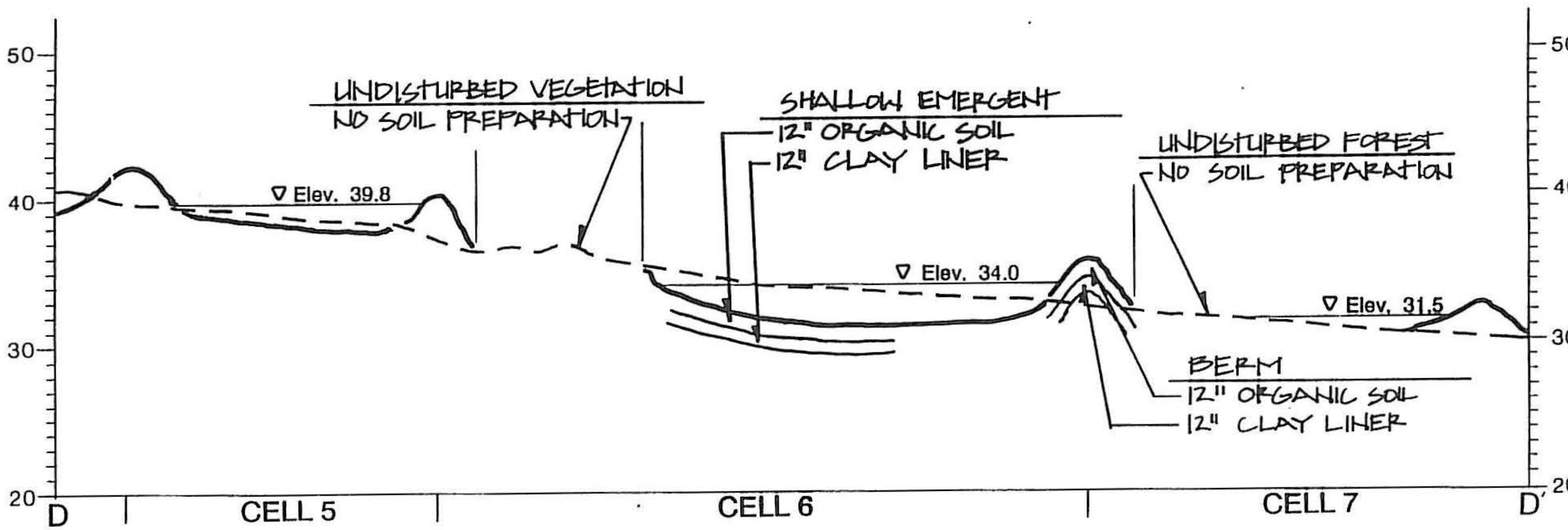
GRADING SECTIONS
Port of Bellingham

FIGURE 14



SECTION C – C′

Existing Grade Proposed Grade Scale: 1" = 50' Horizontal
1" = 10' Vertical



SECTION D – D′

Existing Grade Proposed Grade Scale: 1" = 50' Horizontal
1" = 10' Vertical

5.1.1.1 Clay Lining and Soil Preparation

All areas to be planted will be over–excavated and backfilled with approximately two feet of a sandy clay loam soil with an infiltration of not more than 0.16 inches per hour, or a 12 inch lift of clay will be put down to hold water and slow the rate of infiltration. If a clay liner is used, an organic soil amendment will be incorporated into the native soil and placed over the clay liner. Imported topsoil will then be placed over the amended native soils to provide a suitable medium for plant growth and establishment. Wetlands soil salvaged from the proposed project site and other donor sites can be used to provide a seed bank of wetland species. See Figures 13 & 14: Grading Sections.

5.1.1.2 Wetland Dimensions and Acreage Estimates

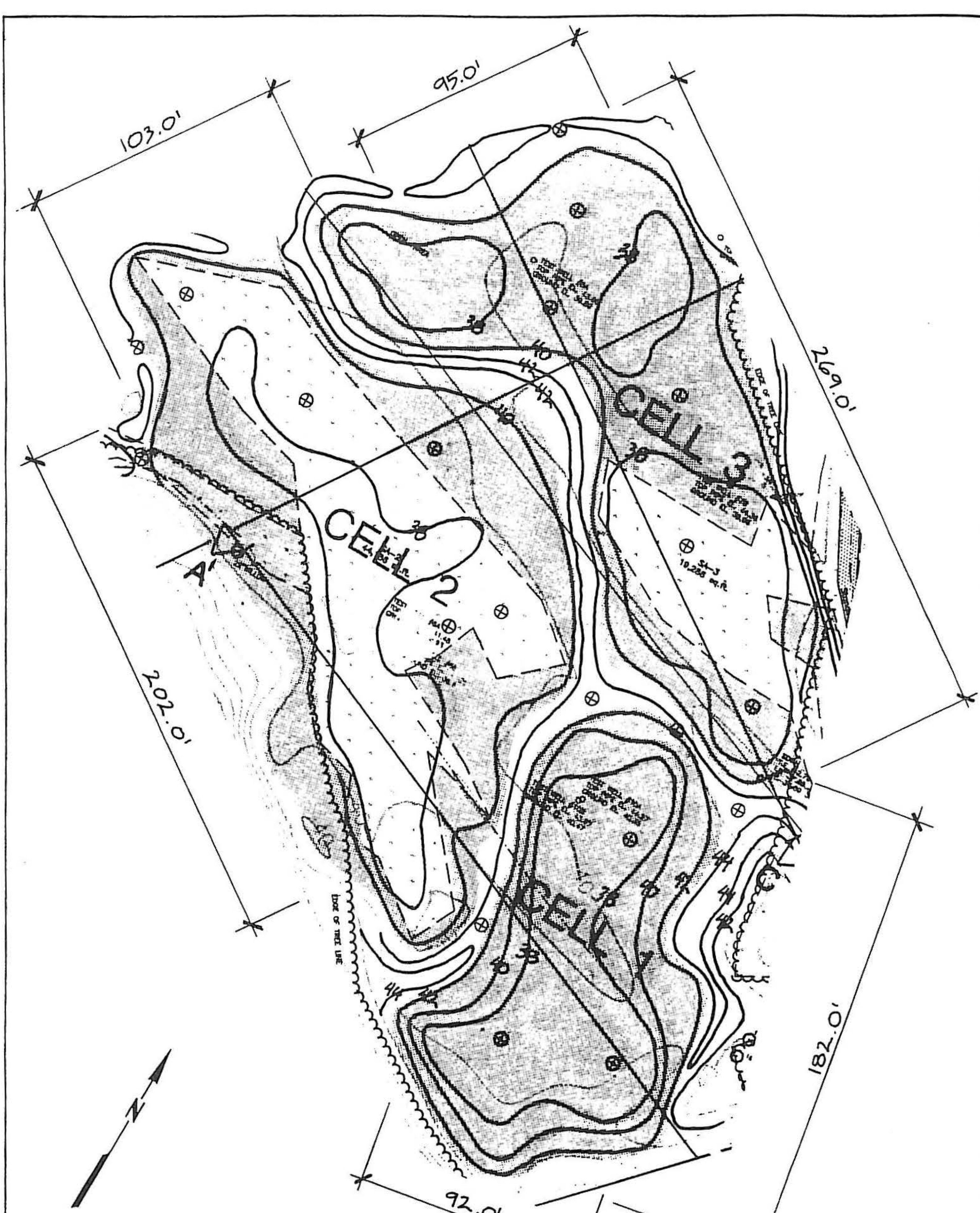
Figure 11 and Figures 15 – 18, provide information about the size and configuration of the proposed wetland areas. Approximately 4.0 acres of new wetland will be created in the upper portion of the site. No acreage estimates are given for overflow wetlands that might be associated with the new stream channel. Table 4, below, presents the estimated acreage of each of the proposed wetland cells.

Table 4: Estimated Wetland Areas (in acres)

Cell #	WL Type	Acreage
1	PAB/PEM	0.3
2	PEM	0.6
3	PAB/PEM/PSS	0.5
4	PSS/PEM	0.6
5	PEM/PSS	0.3
6	PEM/PSS	0.5
7	PFO	0.5
8	PFO/PEM/PSS	0.7
Creation		**4.0**
Enhancement		**0.6**
Total Acres		**4.6**

5.1.2 Hydrology

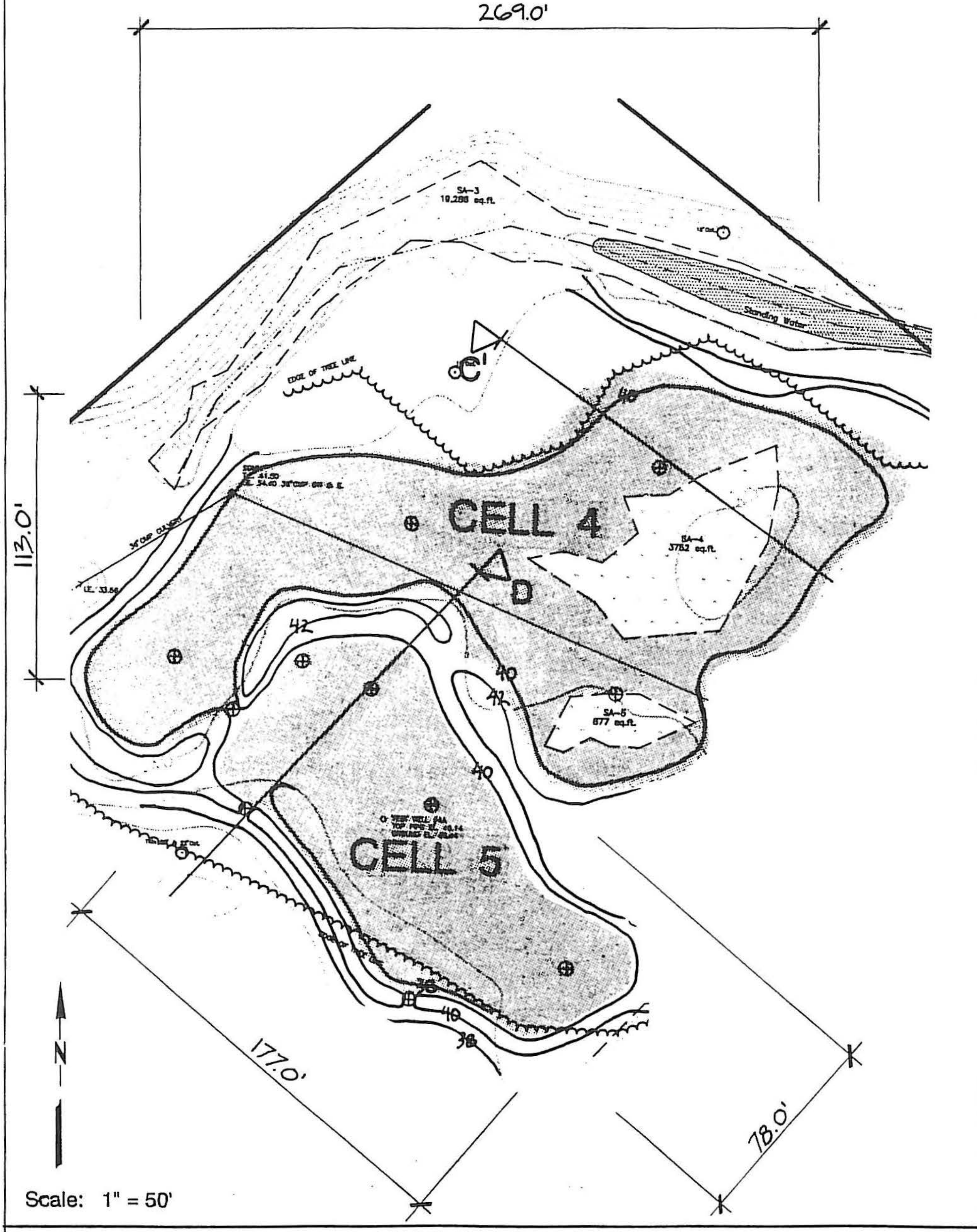
Flows from the existing Birchwood stormdrain will be daylighted to provide a source of water for the new wetland system. The maximum flows entering the wetlands from the Birchwood stormdrain are estimated to range from 87 ac. ft. for the month of November, to 89 ac. ft. in December and 71 ac.ft. in January. See Appendix E: Technical Memorandum #1, prepared by Kramer, Chin, and Mayo, Inc. According to Dave Carlton, this amount of water should be adequate to meet the hydrologic requirements of the wetlands creation and fisheries enhancement



OFF-SITE MITIGATION PLAN
Little Squalicum Creek

WETLAND CELLS 1, 2, & 3
Port of Bellingham

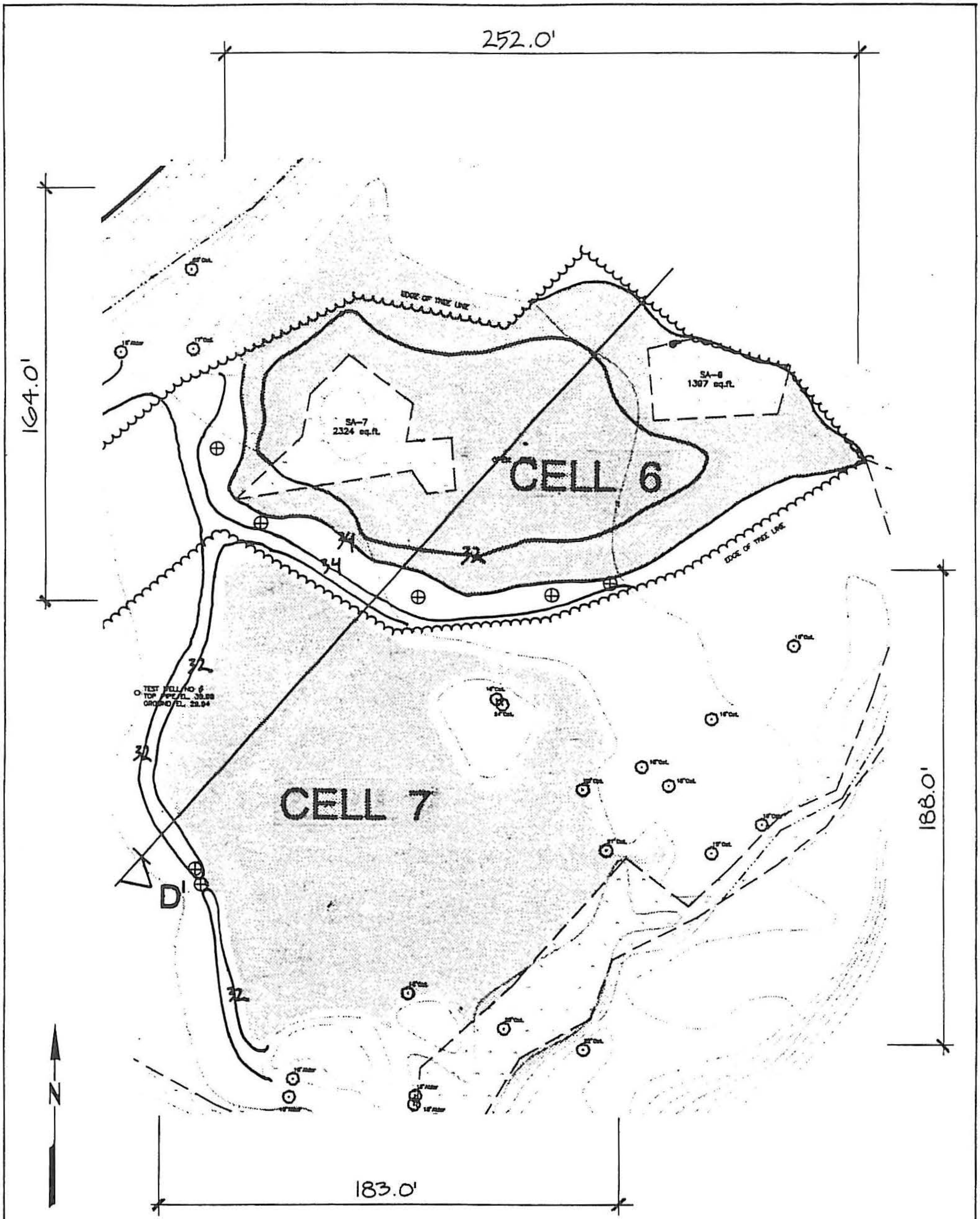
FIGURE 15



OFF-SITE MITIGATION PLAN
Little Squalicum Creek

WETLAND CELLS 4 & 5
Port of Bellingham

FIGURE 16

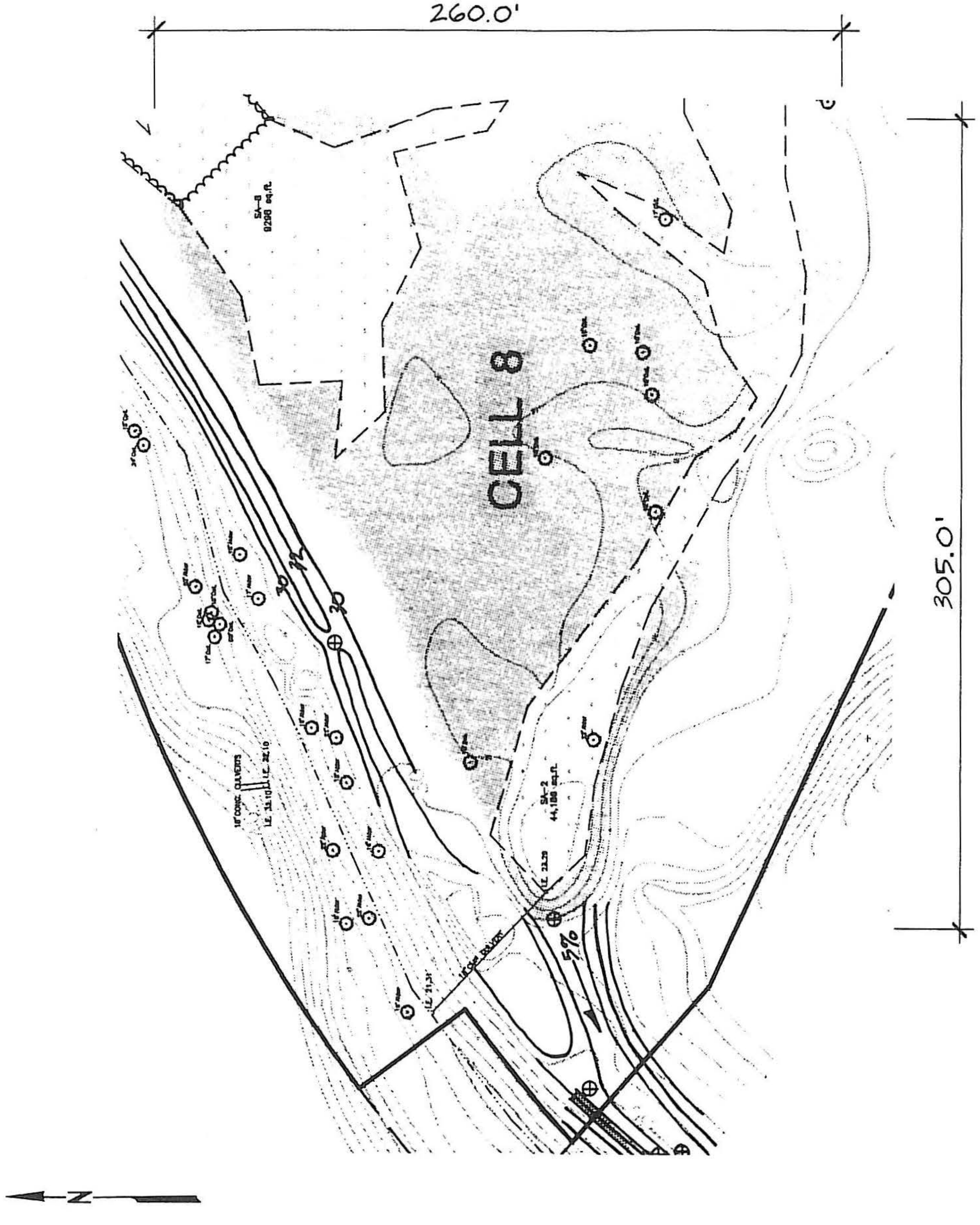


Scale: 1" = 50'

OFF-SITE MITIGATION PLAN
Little Squalicum Creek

WETLAND CELLS 6 & 7
Port of Bellingham

FIGURE 17



Scale: 1" = 50'

OFF–SITE MITIGATION PLAN Little Squalicum Creek	WETLAND CELL 8 Port of Bellingham	FIGURE 18

efforts if the infiltration rate of the imported wetland soils is not greater than 0.5 feet/hour (Carlton, pers. comm., 1991). Peak flows in November and December would result in approximately 1 cfs (cubic feet per second) of water flowing through the new stream channel. This is the minimum flow necessary for salmon spawning. If soils with a lower hydraulic conductivity are used to line the wetland cells, then there would be an increase of approximately 0.3 cfs in the stream channel.

In order to meet the standards of the State of Washington 401 water quality certification, flows entering the created wetlands will be treated according to the requirements of the State of Washington Draft Stormwater Management Manual for the Puget Sound Basin (Dept. of Ecology, 1990). According to the manual, most of the contaminants are carried in the first flush of a rain event following a dry period, and in up to 64% of the two year storm which is equivalent to the 6 month, 24 hour storm. Therefore, based on input from Kramer, Chin, and Mayo, the recommended hydrologic design proposes to divide the flows from the Birchwood drain so that the first flush and the 6 month, 24 hour storm flows pass through water quality treatment, and all flows greater than the 6 month, 24 hour storm can pass directly into the created wetlands. The following sections will describe the water quality treatment system and the routing of the two flows through the proposed wetlands system.

5.1.2.1 First flush and flows up to the 6 month, 24 hour storm (Cells 1 & 2)
The first flush and flows up to the 6 month, 24 hour storm event will be separated from the existing pipes, upstream of the Bellingham Technical College parking lot. These flows will be diverted to an oil/water separator and will then pass through biofiltration in a vegetated swale. The biofiltration swale will be located along the northern edge of the Bellingham Technical College and will be designed according to the standards defined in the Draft Stormwater Management Manual for the Puget Sound Basin (Ecology, 1991) for the 6 month, 24 hour storm. Water exiting the biofiltration swale will enter Cell 1. Cell 1 will fill until the water level is approximately 39.5 feet of depth, at which time, water will be delivered to Cell 3 through a one–way pipe with a flap valve. When the water elevation in Cell 3 reaches 39.5 feet of depth, the flap valve will close, and no further water will be received from Cell 1. Cell 1 will continue to fill, and at elevation 40.0, water will begin to flow into Cell 2 via a small orifice stand pipe also with a flap valve to prevent backflows. Cell 1 can continue to fill up to elevation 42.0 when it will overflow into Cell 3 via a surface overflow channel. Water below elevation 42.0 in Cell 1 will continue to slowly feed into Cell 2 until the water drops below the standpipe elevation. In

this way Cell 1 acts as a holding pond to extend flows into Cell 2. Water from Cell 2 will overflow into Cell 4 and Cell 5 at elevation 40.8, and into the existing channel wetland along the south slope of the ravine at elevation 41.0. It is expected that Cells 1 and 2 will carry the majority of the runoff from a 2–year storm event.

5.1.2.2 Flows greater than the 6 month, 24 hour storm (Cells 3 & 4)
Flows greater than the 6 month, 24 hour storm event will be routed through the existing drain pipes directly into Cell 3. In general, Cell 3 should already contain water received from Cell 1. This water will help disperse the energy of incoming high flows. Water from Cell 3 will overflow into Cell 4, a heavily planted scrub/shrub wetland, at elevation 41.0. The vegetation in Cell 4 is intended to further disperse the energy of peak flows. Water in Cell 4 overflows into Cell 5 at elevation 40.5 feet. This system is designed to carry the overflow of large storm events which do not occur with any regularity, therefore, it is necessary to divert some water from the <6 month, 24 hour flows to ensure the development of wetlands in the overflow system.

5.1.2.3 Combined flows (Cells 5, 6, 7, and 8)
All the waters combine in Cell 5. When the water elevation reaches 39.8, Cell 5 overflows into Cell 6, a shallow excavation designed to provide overwintering habitat for juvenile salmonids. At elevation 34.0, water in Cell 6 flows into Cell 7, a young deciduous forest where no site work is proposed except the construction of a low berm which will shallowly confine incoming waters. At water elevation 31.5, Cell 7 will overflow into Cell 8, which contains the outlet for the entire system. In order to broaden the extent of seasonally flooded areas, the culvert which is the existing outlet to Cell 8 will be capped, and the new outlet elevation will be raised to approximately 29.0 feet.

5.1.3 Plant Community Concepts
The concepts proposed for wetland creation and enhancement are based on the use of selected reference sites. The references areas chosen as models for the design of the new wetlands are located at the airport, at Little Squalicum Creek, and are found in the local area, as described in Section 4.6 above. The plant communities represented by these sites include forested wetland, scrub–shrub wetland, emergent wet meadow, shallow emergent marsh, and deep emergent marsh. As shown in Figure 19: Conceptual Planting Plan, the different wetland types occupy different parts of the site depending on the available hydrology, the existing plant communities on the site, and the particular mosaic of wetland habitats that is desired.

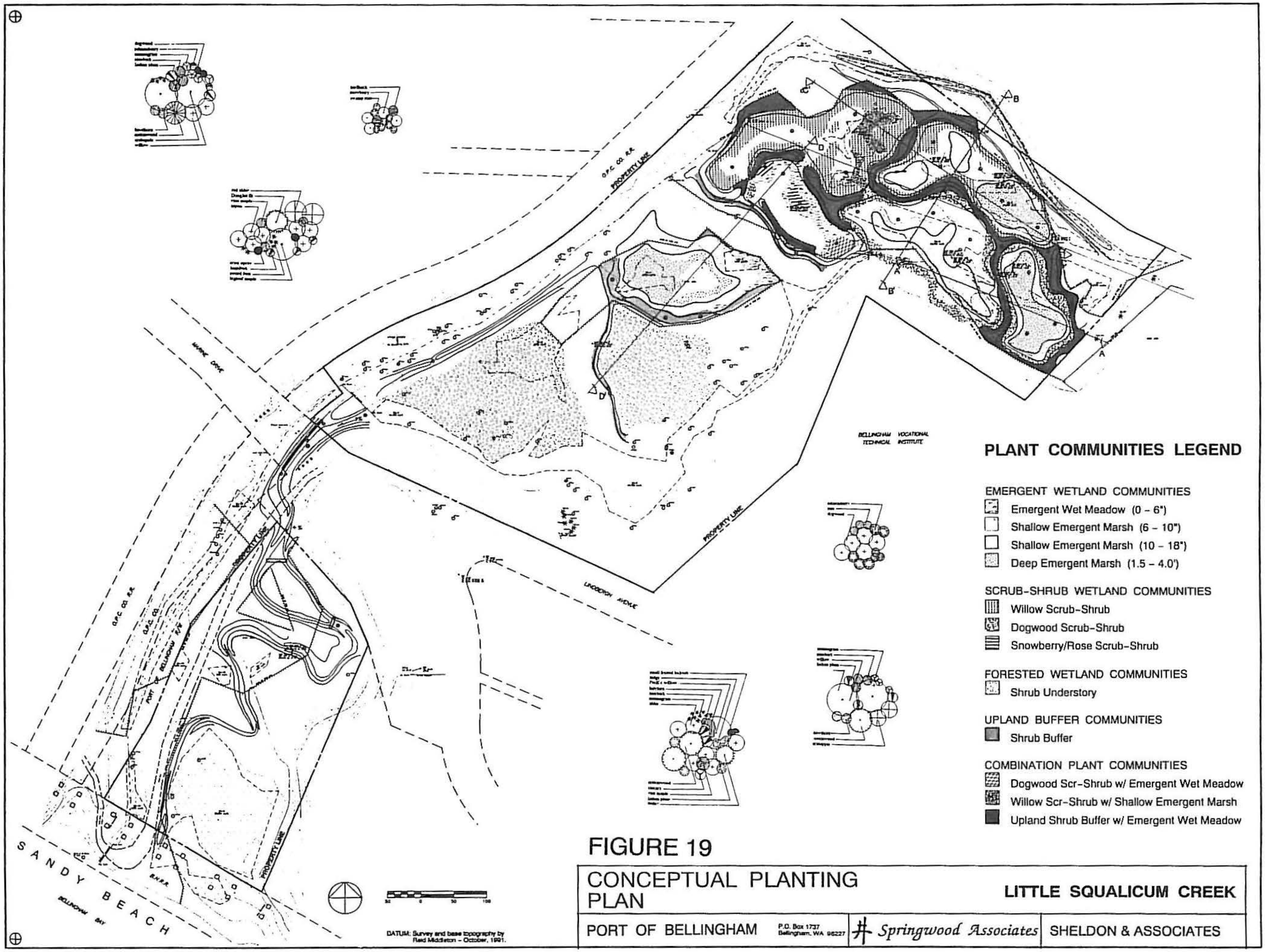


FIGURE 19

CONCEPTUAL PLANTING PLAN

The following section provides descriptions of the individual plant communities proposed at Little Squalicum Creek. See Figures 20 & 21: Planting Details. A list of the different species and their distribution for each plant community is presented in Figure 22: and Figure 23: .

5.1.4.1 Wet Meadow and Vegetated Biofiltration Swale

The wet meadow communities are characterized by seasonal inundation in shallow depressions and topographic lows. Design water depths are 0–3" in the "drier" wet meadows and 3–6" in the "wetter" meadows. Biofiltration swales are designed to allow water to move through at a rate not to exceed 0.5 feet/second and generally not deeper than 4–6". The vegetation in a bioswale is similar to that of a wet meadow. Wet meadows are generally grass, sedge, and/or rush dominated with varying amounts of herbaceous constituents. A common species mix is foxtail (*Alopecurus spp.*) or bentgrass (*Agrostis spp.*) and sedges (predominantly *Carex obnupta*) in the wetter areas and redtop (*Agrostis alba*) in the drier fringes. Tufted hair grass (*Deschampsia caespitosa*) is dominant in many of the wet meadow communities in Whatcom County.

5.1.4.2 Shallow Emergent Marsh

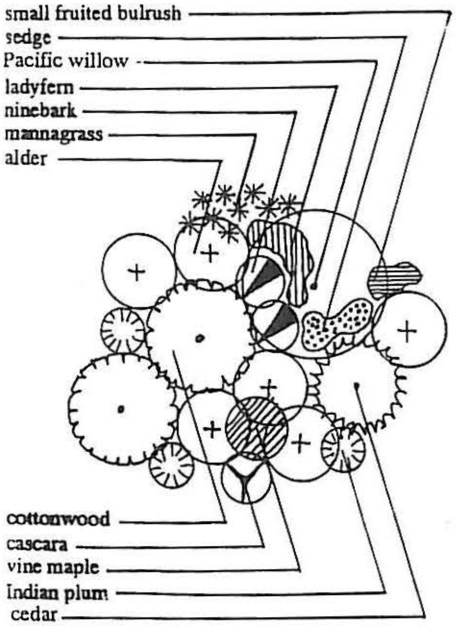
Shallow emergent wetland communities are characterized by relatively deep inundation in the wet season and can tolerate dry conditions only in late summer. Design depths for these communities are broken into a 6–10" range, and a 10–18" range. Some of the reference wetlands for this plant community type are dominated by mannagrass, spikerush and water plantain.

5.1.4.3 Deep Emergent Marsh

Water depths for this community type range from approximately 1.5–4.0' feet in depth. Plants communities that serve as models for this type of wetland often include a large component of bulrush (*Scirpus acutus*, *S. validus*) and water pondweed (*Potomageton natans*), and may or may not have yellow water lily (*Nuphar polysepalum*).

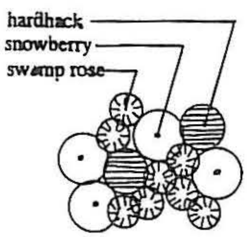
5.1.4.4 Scrub–Shrub Wetlands

Scrub shrub wetlands occur under a wide range of hydrologic conditions and may exhibit high diversity or be monotypic plant communities. The conditions expected at the Little Squalicum Creek site will range from wet meadow with scattered shrubs to shallow emergent marsh interspersed with patches of scrub–shrub vegetation. Three different plant communities have been identified for the proposed scrub–shrub wetlands. See Figure __: Plant Community Lists.



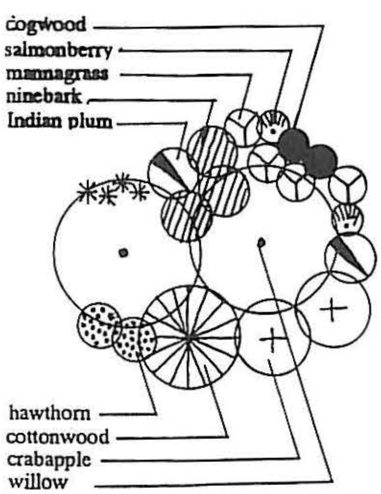
FORESTED WETLAND

Scientific Name	Common Name	Percent
Existing Trees		
Alnus rubra	red alder	40%
Populus trichocarpa	black cottonwood	15%
Thuja plicata	western red cedar	5%
Salix lasiandra	Pacific willow	15%
Proposed Understory Plantings		
Acer circinatum	vine maple	5%
Oemleria cerasiformis	Indian plum	15%
Physocarpus capitatus	Pacific ninebark	40%
Rhamnus purshiana	cascara	5%
Athyrium felix-femina	ladyfern	10%
Carex obnupta	slough sedge	10%
Glyceria grandis, elata	giant & tall mannagrass	10%
Scirpus microcarpus	small fruited bulrush	5%



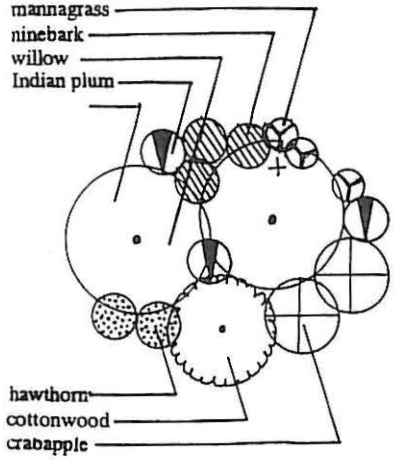
SNOWBERRY/ROSE SCRUB-SHRUB

Scientific Name	Common Name	
Rosa pisocarpa	swamp rose	40%
Spiraea douglasii	hardhack	20%
Symphoricarpos albus	snowberry	40%



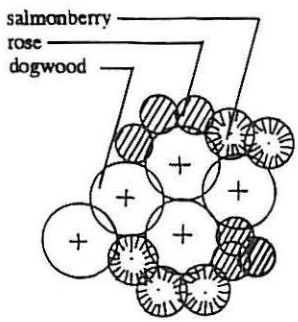
WILLOW/DOGWOOD SCRUB-SHRUB

Scientific Name	Common Name	Percent
Cornus stolonifera	red osier dogwood	20%
Crataegus douglasii	black hawthorn	5%
Glyceria grandis, elata	giant & tall mannagrass	15%
Oemleria cerasiformis	Indian plum	10%
Physocarpus capitatus	Pacific ninebark	10%
Populus trichocarpa	black cottonwood	10%
Pyrus fusca	western crabapple	10%
Rosa pisocarpa	swamp rose	25%
Rubus spectabilis	salmonberry	5%
Salix lasiandra, sitchensis	Pacific & Sitka willow	30%



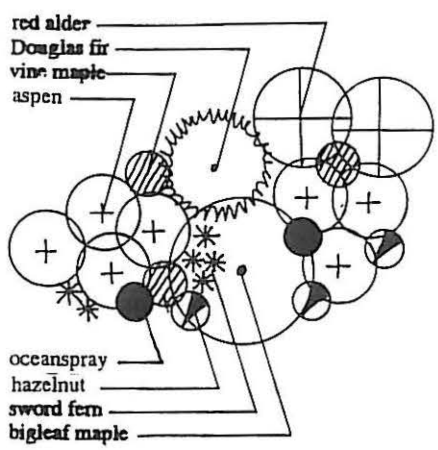
WILLOW SCRUB-SHRUB

Scientific Name	Common Name	Percent
Crataegus douglasii	black hawthorn	5%
Glyceria grandis, elata	giant & tall mannagrass	15%
Oemleria cerasiformis	Indian plum	10%
Physocarpus capitatus	Pacific ninebark	10%
Populus trichocarpa	black cottonwood	10%
Pyrus fusca	western crabapple	10%
Salix lasiandra, sitchensis	Pacific & Sitka willow	50%



RED OSIER DOGWOOD SCRUB-SHRUB

Scientific Name	Common Name	Percent
Cornus stolonifera	red osier dogwood	50%
Rosa pisocarpa	swamp rose	25%
Rubus spectabilis	salmonberry	25%



UPLAND BUFFER

Scientific Name	Common Name
Alnus rubra	red alder
Populus tremuloides	quaking aspen
Pseudotsuga menziesii	Douglas fir
Tsuga heterophylla	western hemlock
Acer circinatum	vine maple
Acer macrophyllum	bigleaf maple
Amelanchier sinifolia	serviceberry
Corylus cornuta	hazelnut
Holodiscus discolor	oceanspray
Symphoricarpos albus	snowberry
Polystichum munitum	sword fern

Emergent Wetland Community Composition

SPECIES	COMMON NAME	PERCENT COVER
WET MEADOW: (drier fringe)		
Agrostis alba, tenuis	redtop, colonial bentgrass	30%
Carex limnophila, obnupta	pond & slough sedge	10%
Deschampsia caespitosa	tufted hair grass	30%
Festuca rubra	red fescue	20%
	forbs	10%
WET MEADOW: (wetter pockets: 3–6")		
Alopecurus aquatilis	water foxtail	10%
Carex leporina	sedge	15%
Carex obnupta	slough sedge	combine w/above
Deschampsia caespitosa	tufted hair grass	15%
Eleocharis ovata	spikerush	5%
Lolium perenne		15%
Juncus bolanderi	Bolander's rush	15%
Juncus effusus var. Pacificus	smooth rush	combine w/above
Juncus ensifolius	daggerleaf rush	combine w/above
Veronica americana	American speedwell	5%
Veronica scutellata	marsh speedwell	combine w/above
SHALLOW MARSH: (6–10")		
Alisma plantago–aquatica	water plaintain	5%
Carex leporina, obnupta	hare & slough sedge	20%
Eleocharis ovata	spikerush	15%
Eleocharis palustris	common spikerush	combine w/above
Glyceria borealis	mannagrass	30%
Glyceria elata	tall mannagrass	combine w/above
Glyceria grandis	giant mannagrass	combine w/above
Juncus bolanderi	Bolander's rush	15%
Juncus effusus var. Pacificus	soft rush	combine w/above
Scirpus mircocarpus	small–fruited bulrush	10%
Sparganium emersum	narrowleaf burreed	5%
SHALLOW MARSH: (10–18")		
Alisma plantago–aquatica	water plaintain	5%
Carex obnupta	slough sedge	15%
Eleocharis palustris	common spikerush	15%
Glyceria borealis	mannagrass	40%
Glyceria grandis	giant mannagrass	combine w/above
Juncus bolanderi	Bolander's rush	10%
Juncus effusus var. Pacificus	soft rush	combine w/above
Potomageton natans	floatingleaf pondweed	10%
Sparganium emersum	narrowleaf burreed	5%
DEEP MARSH: (1.5' – 3.5')		
Lemna minor	pondweed	5%
Potomogeton natans	floatingleaf pondweed	20%
Scirpus acutus	hardstem bulrush	40%
Scirpus validus	softstem bulrush	combine w/above
Sparganium emersum	narrowleaf burreed	5%

Scrub-shrub Wetland Community Composition

SPECIES	COMMON NAME	PERCENT COVER
WILLOW SCRUB SHRUB:		
Crataegus douglasii	black hawthorn	5%
Glyceria grandis, elata	giant and tall mannagrass	15%
Oemleria cerasiformis	Indian plum	10%
Physocarpus capitatus	Pacific ninebark	10%
Populus trichocarpa	black cottonwood	10%
Pyrus fusca	western crabapple	10%
Salix lasiandra, sitchensis	Pacific & Sitka willow	50%
RED OSIER DOGWOOD SCRUB SHRUB:		
Cornus stolonifera	red osier dogwood	50%
Rosa pisocarpa	swamp rose	25%
Rubus spectabilis	salmonberry	25%
SNOWBERRY SCRUB SHRUB:		
Rosa pisocarpa	swamp rose	40%
Spiraea douglasii	hardhack	20%
Symphoricarpos albus	snowberry	40%

Forested Wetland Community Composition

SPECIES	COMMON NAME	PERCENT COVER
MIXED DECIDUOUS		
Alnus rubra	red alder	40%
Populus trichocarpa	black cottonwood	15%
Thuja plicata	western red cedar	5%
Salix lasiandra	Pacific willow	15%
Acer circinatum	vine maple	5%
Oemleria cerasiformis	Indian plum	15%
Physocarpus capitatus	Pacific ninebark	40%
Rhamnus purshiana	cascara	5%
Athyrium felix-femina	ladyfern	10%
Carex obnupta	slough sedge	10%
Glyceria grandis, elata	giant and tall mannagrass	10%
Scirpus microcarpus	small fruited bulrush	5%

Upland Buffer Plant Community Composition

SPECIES	COMMON NAME	PERCENT COVER
BUFFERS: (to include any of the following in various percentages)		
Alnus rubra	red alder	
Populus tremuloides	quaking aspen	
Pseudotsuga menziesii	Douglas fir	
Tsuga heterophylla	western hemlock	
Acer circinatum, macrophyllum	vine & bigleaf maple	
Amelanchier sinifolia	serviceberry	
Corylus cornuta	hazelnut	
Holodiscus discolor	oceanspray	
Symphoricarpos albus	snowberry	
Polystichum munitum	sword fern	

5.1.4.4.1 Willow Scrub–shrub

Sitka willow (*Salix sitchensis*) and Pacific willow (*Salix lasiandra*) are the dominant species of this plant community with Pacific ninebark (*Physocarpus capitatus*) and western crabapple (*Pyrus fusca*) occurring as subdominants. Black hawthorn is found in the drier portions of this community. This wetland type tolerates quite saturated conditions late into the growing season and is often interspersed with shallow emergent marsh vegetation.

5.1.4.4.2 Red Osier Dogwood Scrub–shrub

The red osier dogwood dominated communities have salmonberry and swamp rose as subdominants species. These communities tolerate inundation early in the growing season and often survive in quite dry conditions by summer. Other species that could be included based on availability are the native currants (*Ribes lacustre, R. divaricatum*).

5.1.4.4.3 Snowberry/Rose Scrub–shrub

This plant community often occurs in wet meadow situations where snowberry (*Symphoricarpos albus*) and swamp rose (*Rosa pisocarpa*) grow in mixed patches. Hardhack is included as a small component in this plant community though it sometimes forms monotypic stands.

5.1.5 Forested wetland

The existing mixed deciduous forested wetlands at Little Squalicum Creek, generally range in age from 15 to 40 years. They are mostly dominated by black cottonwood and red alder with scattered Pacific willow and western red cedar. The proposal for this wetland type is to add understory plantings to increase the diversity of this community. Pacific ninebark, vinemaple, Indian plum, and cascara are a few of the recommended species. Wet pockets in the forested community would contain sedge, mannagrass and small–fruited bulrush.

5.1.6 Upland Buffer Communities

No specific reference sites were selected for this plant community, rather, species have been selected based on the collective experience of the consultants and using the literature (Franklin and Dyrness, 1976). See Figure 23: Plant Community Lists for a summary plant list of the species that form the many upland plant associations.

5.1.7 Wetland Cells

In each of the proposed wetlands (Cell 1 to Cell 8), the plant communities to be established require distinct hydrologic regimes. The following sections describe the proposed hydrologic regime and associated plant communities for each wetland cell. See Figures 15 – 18.

Cell 1

Cell 1 is designed to be a pond ranging in water depth from approximately 2 feet to a maximum of 4 feet. The majority of the wetland will be deep emergent marsh with a narrow fringe of shallow emergent marsh and some scrub–shrub vegetation. This wetland cell is expected to hold water into the summer, and may stay permanently saturated, depending on the permeability of the subsoil. In conjunction with Cells 2 & 3, this cell should provide desirable waterfowl habitat. This wetland is approximately 0.3 acres in size, with the average dimensions approximately 182' long and approximately 92' wide.

Cell 2

Cell 2 is intended as a shallow emergent marsh approximately 0.6 acres in size. Water levels range from 6 inches near the margins to 30 inches in the deeper pockets. The dominant wetland type is shallow emergent marsh with a small deep marsh component. A scrub–shrub wetland fringe is proposed to be a dogwood community because inundation is not expected to be much deeper than 3–4 inches early in the growing season. The deeper parts of this wetland are expected to remain saturated until early summer and may dry out completely by July or August. The average dimensions of this wetland are approximately 202' long by 103' wide.

Cell 3

Cell 3 is designed as an energy dispersion pond for peak flows. It contains a number of plant community types including deep emergent marsh, shallow emergent marsh, and a more developed scrub–shrub fringe around the edges. Water in this cell is expected to range from 0 – 2 feet most of the time with irregular influxes of water up to 3.5 feet deep in the deepest parts. A Willow Scrub–Shrub community is proposed for this wetland because of the flashy nature of the hydrology. This wetland is approximately 0.5 acres with the average length and width dimensions approximately 269' and 95' respectively.

Cell 4

Cell 4 is designed as part of the peak flow system. It is a mixed emergent and scrub–shrub wetland with water levels ranging from 6 inches to 1.5 feet deep. This wetland receives overflow from Cell 2, and is expected to be slightly wetter than Cell 3 in an average year. Soils are expected to remain saturated until early to mid–May. A willow scrub–shrub community is proposed for this wetland. This wetland is approximately 0.6 acres in size. The average length is approximately 269' and the width is approximately 113'.

Cell 5

Cell 5 is designed as a wet meadow with interspersed scrub–shrub wetlands. Water levels are generally less than 6 inches in much of the cell. This cell is expected to dry out in mid– to late spring except for small areas of shallow marsh that are slightly deeper. A snowberry/rose scrub–shrub community recommended for this wetland. On average, this wetland is approximately 177' long by 78' wide.

Cell 6

Cell 6 will be excavated to provide a shallow to deep emergent marsh, and is intended to provide overwintering habitat for juvenile salmonids. It is expected to remain saturated in the deeper parts until late May or early June. This cell is approximately 0.5 acres in size. The average length is approximately 252' long and the width is approximately 164'.

Cell 7

Cell 7 is intended to be shallowly flooded only 2–4". This should be enough water to convert the existing forest to forested wetland. Alder and cottonwood are the dominant species present in this young forest and are both well adapted to varying amounts of inundation (Walters, et al., 1980; Oliver and Hinckley, 1987; Teskey and Hinckley, 1977). Therefore, only a minor amount of mortality in the existing trees and saplings is expected from extending the depth and duration of flooding. Standing water is expected only intermittently, but such that soils and vegetation should begin to reflect wetland conditions. Proposed plantings consist of understory plantings to increase structural diversity. Increasing the water to this cell should eliminate the existing blackberry in the understory. This wetland occupies approximately 0.5 acres. It is approximately 188' long by 183' wide.

Cell 8

Cell 8 will be inundated by raising the outlet elevation to the entire east end of the site. This will result in the conversion of existing upland forest to forested wetland as with Cell 7. Proposed plantings consist of understory plantings to increase structural diversity. Increasing the water to this cell should eliminate the existing blackberry in the understory. This triangular shaped wetland is approximately 0.7 acres in size with the longest dimension approximately 305' and the width approximately 260' long.

5.2 Stream Channel and Fisheries Enhancement

A new stream channel will be created in the meadow area west of the Marine Drive overpass. The new channel will be designed to accommodate salmon spawning and provide juvenile fish access to upstream overwintering habitat in the created wetlands. Seasonally flooded, overflow wetlands will be created in conjunction with the new stream channel. See Figure 10: Conceptual Mitigation Plan.

5.2.1 Grading and Hydrology

The new channel will be cut along the 29.0' contour, following the existing trail. Bioengineered crib walls will be used to contain the stream in the narrow reach below the footings of the Marine Drive overpass, to allow enough room for both the channel and a footpath. If this area cannot reasonably accommodate the stream and the trail, the trail can be moved to the south side of the overpass footings, higher up the slope. In general, slope gradients within the channel do not exceed 0.5% to provide suitable conditions for salmon spawning. There is one drop with an approximately 4% gradient, through a log weir, into a small pool which is included for resting. A second weir is located at the downstream outlet of the pool. In general, the channel is between 4 to 6 feet wide to accommodate the 1 to 1.5 cfs expected at peak flows and still provide the minimum water depth necessary for salmon spawning of 8 inches. Final design of the stream channel will be coordinated with the Washington State Department of Fisheries as part of a Hydraulic Project Approval application.

As designed, the stream will carry the minimum flows and water depths necessary for Coho salmon to spawn. There is a possibility of diverting additional water from the Marine Drive stormdrain north of the ravine if the water can receive water quality treatment before entering the new stream. The Washington Department of Fisheries representative is working with Whatcom

County Public Works Department to coordinate revisions to the County storm drainage system along Marine Drive to be constructed in 1992. The Parberry property north of the Tilbury railgrade and east of Marine Drive has been identified for acquisition by the City of Bellingham Greenways Program. Tim Wahl, City of Bellingham Park planner, has indicated that should the city acquire the Parberry property, there would be no problem in allowing the County space for water quality treatment of flows designated for the new stream.

5.3 Recreation and Environmental Interpretation

The City of Bellingham Parks Department will be signing a 35 year lease agreement with the Whatcom County Parks Department to manage the Little Squalicum Creek Site as a City park.

A trail system will be carefully integrated into the mitigation site design to provide shoreline access to Bellingham Bay while minimizing disturbance to wildlife habitat and avoiding conflicts with on–going research and site monitoring. The constructed berms between wetland Cell 5 & Cell 6, and between Cell 8 and the existing stream channel will be built to a 5 feet wide pedestrian trail standard per the specifications of the City of Bellingham Parks Department. Six interpretive signs will be installed which describe elements of the natural environment such as wildlife, plant community ecology, and wetland functions as well as provide information about the site history, the wetlands creation effort, fisheries enhancement, and the importance of the research areas. The design and installation of the signs will be coordinated with the City of Bellingham Park Department. See Figure 10: Conceptual Mitigation Plan.

5.4 Research Opportunities

The water quality treatment program implemented as part of the mitigation design provides an opportunity for systematic assessment of the surface water quality, best management practices recommended by Washington State Department of Ecology (DOE). The data collected as part of the water quality component of the monitoring program will be made available to the water quality section at DOE and EPA. The University of Washington Center for Water Resources has reviewed the proposed hydrologic design and monitoring plan and is also interested in including the site as part of their research program (Horner, pers. comm., 1992).

Other research opportunities exist relative to the rates of establishment of native emergent plant species that are common to Whatcom County. This information will be gathered as part of vegetation monitoring and will also be made available to the scientific community at large.

5.5 Functional Values

The functional value of the existing wetlands at the Little Squalicum Creek site are low to medium. Table 5, below, provides a comparison of the functional values in the existing and proposed wetlands.

Table 5: Little Squalicum Creek Wetland Functional Values

Functions	Existing Wetlands	Created Wetlands
Groundwater Recharge	Low	Low
Groundwater Discharge	Low	Low
Flood Attenuation	Low	Medium
Shoreline Anchoring	N/A	N/A
Sediment Trapping	Medium	Medium
Food Chain Support	Low/Medium	Medium
Wildlife Habitat	Low/Medium	Medium/High
Passive Recreation	Low	Medium
Environmental Education	None	Medium/High
Fisheries Habitat	None	Low/Medium

6.0 PERFORMANCE STANDARDS

Performance standards provide a clear means of evaluating the success of a mitigation effort. The performance standards for any mitigation project should reflect the goals of the mitigation effort. For goals such as avoidance or minimization of impacts, the performance standard may be a punch list of actions to be completed, or documents to be produced. Other goals such as wetlands enhancement or wetlands creation require quantifiable performance standards that allow the progress and success of the mitigation effort to be measured. The following sections discuss performance standards for each of the goals identified in the beginning of this report. See Appendix F: Performance Standards Summary.

6.1 Enhancement and Creation

Success in wetlands creation efforts is generally measured by vegetative establishment and hydrologic stability. Hydric soils characteristics will most likely not develop within the monitoring period. Performance standards for compliance with mitigation goals will be based on evidence of a stable hydrologic regime and establishment of stable plant communities that are similar to existing replacement and reference plant communities. The following sections will discuss the standards that will be used to assess the success of achieving the desired hydrology, and will also present the minimum standards for success for each of the vegetative communities.

6.2.1 Hydrologic Predictability

The issues of concern regarding hydrology are whether the design hydrologic flows are achieved in the correct locations at the desired time of year. This involves information about depth, frequency and duration of flooding. This information can be obtained by installing simple gaging stakes to measure surface and groundwater elevations in different locations at different times of year. If water levels are within prescribed ranges for the different times of year, then the hydrology would be considered to meet the performance standards. If flows are too deep or not deep enough, volumes are too high or too low, or flooding is too late in the season, the plant material will indicate signs of water stress. Special attention will paid to the forested wetland conversion areas in Cell 7 and Cell 8.

Water quality is another parameter that, though a performance standard is not easily applied, will be monitored for changes from the pre–development, values of incoming waters.

6.2.2 Vegetation Establishment

Standards for success of vegetation establishment on this project will be addressed according to the type of vegetative cover (i.e. trees, shrubs, and groundcover) in both wetlands and upland plantings. The performance standards for Cell 7 and Cell 8 will be developed separately from the rest because they represents a special case with respect to wetland establishment. Standards for success for each wetland type will be discussed separately below.

6.2.2.1 Shrub and Tree Cover

The tree and shrub communities in both the wetlands and the upland, will be monitored according to several different performance standards. The first is percent survivability of planted stock. The standard for success is 75% survival in the first two years. The second is maintenance of species diversity such that: 1) a minimum of 2 tree species will be present and no individual species will represent less than 10% of the total; and 2) a minimum of 3 shrub species will be represented and no individual species will be less than 10% of the total. The last measure of success that will be applied as a performance standard is percent cover. Among tree species a minimum of 10% percent cover of what was planted would be expected at the end of the monitoring period. The minimum cover that would be expected of shrub species within the monitoring period is 10% of what was planted.

6.2.2.2 Groundlayer

Performance standards for the groundlayer in both the upland and wetland is 85% cover in each plant community within the monitoring period. Plant community composition will consist of a minimum of three different species distributed such that no individual species represents less than 10% of the total.

6.2.2.3 Cell 7 and Cell 8

Performance standards for the forested wetland conversion area will be based largely on evidence of hydrology and mortality of existing trees. Water depth or amount of soil saturation at a particular time of year will be used as a measure of successful wetland establishment. Initially a maximum water depth of 3 inches over the ground surface until April 1 of the year will be considered adequate hydrology to develop hydric soils characteristics over time, and to effect the conversion of upland forest to forested wetland. A maximum of 30% mortality of existing trees will be considered acceptable since these forests are quite young and some mortality would be expected as a natural part of succession. The survival rate for planted understory shrubs should be 75% at the end of the monitoring period.

7.0 MONITORING

Monitoring programs serve as a means of achieving a systematic post–construction evaluation of wetlands creation and upland restoration efforts. They provide a framework for assessing whether a mitigation project is meeting a set of established performance standards, and they can provide basic information about the development of new wetlands systems. Post–construction evaluation also provides a means of identifying problems in the design and implementation of the project as well as providing diagnostic information about problems for which remedial actions can be taken. Finally, monitoring provides the opportunity for a thoughtful critique of the mitigation effort.

7.1 Goals

The monitoring program for the Port of Bellingham Little Squalicum Creek Wetlands Mitigation Plan attempts to provide many of the purposes described above. Monitoring is proposed to occur over an 8 year period, with sampling to occur in years 1, 2, 4, 6, and 8. The goals of this monitoring program are:

1) to evaluate the mitigation effort relative to the performance standards by measuring the success of vegetative establishment and the stability of the hydrologic regime.
2) to monitor water quality as a condition of water quality certification
3) to evaluate the need for vegetative maintenance or adjustments to the hydrologic regime.
4) to note wildlife and fisheries use of the new wetlands and stream channel.

Each of these goals will be discussed in greater detail in the sections below.

7.2 Evaluation of Performance Standards

The performance standards described in Section 8.0 above, are generally based on the successful establishment of vegetation, in both the wetlands and in the upland, and on a stable hydrologic regime. The protocols for measuring each of these parameters will be discussed below.

7.2.1 Vegetation

Successful vegetation establishment is measured by three parameters; survivability, percent cover, and species composition. Survivability is important in assessing the initial success of planting and provides more useful information than percent cover when the planting stock is young and of a small size. Percent cover is a way of measuring the rate of establishment of a new ecosystem, and in combination with information about species occurrence provides a way of comparing the composition of the new communities to selected reference communities. A more qualitative method of monitoring the development of the plant communities is to use photographic documentation to provide a visual record of the evolution of the community.

In undertaking vegetation monitoring, it is important to have an as–built drawing of the plant installation. Plots should be located along permanent transects and everything labeled and mapped so that data can be collected quickly and consistently from year to year. Data should be collected when the plants are at their maximum growth, generally from July to August. Each measurement parameter and the protocol for conducting photo documentation will be briefly discussed below.

7.2.1.1 Survivability

Survivability is used as a measure of early success in the transplanting of trees and shrubs. It is useful in determining, within the first and second years, whether there is a need to replant, adjust the hydrology, provide maintenance against invasive plant species, or in some other way, "fine tune" the design and implementation of the mitigation plan. Survivability is also the only way to assess performance by the contractor, and to determine if the contract to install the plant material has been adequately carried out.

Survivability is generally measured as a percentage based on the total number surviving divided by the total number planted multiplied by 100. It is not practical to conduct counts of all the trees and shrubs. Using a stratified random sample is the best way of obtaining information about each of the plant communities. The strata should be based on plant community composition and the uniformity of growing conditions. Initially a minimum of 40 data points should be taken for each strata, and the plot size should be large enough to obtain counts of between 6 and 10 specimens per plot (Henderson, pers. comm., 1991).

7.2.1.2 Percent cover and species composition

Percent cover measurements of the different vegetative zones provide information about the rates and complexity of plant community establishment. It is a relatively easy parameter to measure and, in combination with species occurrence, provides information about shifts in community composition. It is especially useful for early assessment of the planting effort in the groundlayer and emergent zone. If the rate of cover establishment of desired species is too slow, remedial actions such as replanting, reseeding, or removal of competition may be necessary. Following early assessments of tree and shrub survival, percent cover measurements provide a means of evaluating community development and comparing species composition with selected reference communities. Percent cover is measured by estimating the areal extent of canopy coverage of a vegetation zone (e.g. overstory, understory, groundlayer) or of individual species in a sample plot.

7.2.1.3 Photographic Documentation

Permanent photo points will be established for each wetland as it is constructed. The photographic record will begin with pre–development existing conditions, and will include photographs for each sampling year of the monitoring period. Sample points will be located such that every plant community type will be photographed. In order to assure the same points will be used from year to year, painted posts will be installed for the duration of the monitoring period. A compass bearing will be established so that the camera uses the same alignment each time. Photo points and compass bearings will be recorded on a map. Photographs will be taken at roughly the same time each year, in June or July. A measuring stick will be include in each photograph to serve as a reference for vegetation height. Two photographs will be taken at each point, with the date, time, data point, compass bearing, and frame number recorded on a field data form. (Horner and Raedeke, 1989).

7.2.2 Hydrology

Initial hydrologic monitoring was conducted by Landau, Inc. and KCM, Inc. as part of the mitigation planning phase to evaluate the design constraints of the existing water regime. See Section 3.4 Existing Conditions, this report. When the new wetlands have been constructed, post–construction evaluation will be necessary to confirm the adequacy of the hydroperiod, both to support wetland plant community establishment and stay within identified depth ranges to maintain a design hydroperiod.

7.2.2.1 Groundwater

No groundwater influence is expected in the areas underlain by thick deposits of glacial till due to the low rate of permeability in these subsurface layers. A groundwater well will be used to measure the elevation of the water table in Cell 5 of Mitigation Site 2, as the soils in this area are over alluvium and the water table is expected to fluctuate a fair amount. This well will provide information about groundwater inputs and outflows that might be expected at different seasons. This information is important in establishing the hydrologic regime in what is proposed to be a created forested wetland that will not maintain surface water at all times. The type of groundwater to be installed is a perforated tube that can be read by inserting a chalk marked measuring tape. A plastic cap will cover the tube to prevent debris and rainwater from entering. (Horner & Raedeke, 1989).

7.2.2.2 Surface Water

Surface water gaging stakes measure water depth and are useful in characterizing the hydroperiod of the created wetlands. Information about the depth, frequency and duration of inundation is useful in evaluating plant community development. A staff gage for reading water elevations can be assembled from anything that can be permanently held vertically in the water and that can be marked with water elevation lines. The staff gage should be placed in an area of deep water or where it will register the lowest annual water level. Each gage will be referenced to a permanent benchmark elevation using surveying equipment to establish the level of the staff gage relative to the benchmark. (Horner & Raedeke, 1989).

Water elevation readings should be collected daily, weekly, then biweekly in the first year following construction. When the water levels are stable over long periods of time, the frequency of readings can be reduced.

7.3 Water Quality

Water quality in wetlands is influenced by many factors including the different hydrologic sources (i.e. precipitation, groundwater, and surface water) and annual, seasonal, and diurnal variations in water quantity, velocity, and chemistry. Factors such as the size of the wetland and both its topographic and geographic location in the landscape influence the water chemistry of individual wetlands. For the purposes of compliance with the 401 Water Quality Certification, one full year of water quality samples will be taken from appropriate sampling locations to establish pre–development baseline values for comparison with post–development samples.

7.3.1 Sampling Design

Establishing a baseline for an individual wetland requires a minimum of one full year of sampling to establish a water quality "signature" for that particular wetland. The recommended sampling regime consists of 8 samples distributed throughout the year (Horner, 1989; Stevens, 1990). This is shown below in Table 6.

Table 6: Recommended Water Quality Sampling Regime

Season	Sampling Period	# Samples
Early Growing Season	March 1 – May 15	2
Dry Season	May 15 – September 30	3
Wet Season	October 1 – February 28	3

Sampling analysis, detection limits, and quality assurance/quality control should be based on Recommended Protocols for Measuring Conventional Water Quality Variables and Metals in Fresh Water of the Puget Sound Region, (Puget Sound Estuary Program,). See Appendix G: Determination of Threshold Water Quality Values for a discussion of significant changes from the baseline values.

7.3.2 Water Quality Parameters

Water quality monitoring in wetlands involves measuring both the soluble and insoluble elements present in the water column. Depending on the area of concern, many different parameters can be used to characterize water quality. The Puget Sound Wetlands and Stormwater Management Research Program provided data for pH, Total Suspended Solids (TSS), Nitrogen (NH3–N, NO3–N, TKN), Phosphorus (SRP and Total P), and Fecal Coliform (FC) (Reinelt and Horner, 1990). The Washington State Transportation Center publication Guide for Wetland Mitigation Project Monitoring (Horner and Raedeke, 1989) presents a thorough discussion of the significance of measuring temperature, pH, DO, specific conductivity, and pollutant removal and retention along with guidance for when and how samples should be collected and analyzed. KCM, will recommend water sampling locations, parameters to tested, and a sampling regime for water quality monitoring.

7.4 Evaluate the need for vegetative maintenance or hydrologic adjustments.

Wetland systems subject to disturbance often have zones where invasive species, if introduced, can spread rapidly through the community. Invasive species that occur on the site include cattail (*Typha latifolia*), reed canarygrass (*Phalaris arundinacea*), soft rush (*Juncus effusus*), creeping buttercup (*Ranunculus repens*), and small thistle (*Cirsium arvense*). It will be important to monitor the growth of these species to prevent their invasion of the created wetlands on site.

Monitoring will include observations of the presence of such species. None will be planted, but seedlings can be expected at any time after the initial planting of the wetlands. Control of these species is expected to include both the physical removal of the plants, and the careful maintenance of a hydrologic regime that is counter to their growth. It is also expected that successful establishment of the planned vegetation communities will help curtail the invasion of weedy species.

7.5 Note Wildlife and Fisheries Use

Wildlife are integral to wetland ecosystem dynamics and an important component of open space values that contribute so significantly to our quality of life. Macroinvertebrates such as insects are primary consumers in the complex wetland food web. They provide an important source of food for fish, amphibians, birds and small mammals. Amphibians also provide food for birds and mammals. The rich food source that wetlands provide in addition to resting, feeding and breeding habitat, results in disproportionate use by birds and mammals making wetlands the single most productive habitat for wildlife.

Monitoring wildlife presence in different wetland types requires more intensive surveys than can be provide as part of the wetlands monitoring plan. However, wildlife observations will be made during sampling for other parameters.

8.0 PROPOSED CONSTRUCTION SCHEDULE

The final design and working drawings for the wetlands creation and new stream channel will be completed in spring, 1992, in order that site work can begin during the summer low water period. The revisions to the Birchwood stormdrain and the system of shallow berms will be in place by October, in time for the winter rains to begin. If the site work is completed before the planting season, a cover crop of sterile wheat will be used to stabilize the site and prevent invasion by weedy species. Existing patches of reed canary grass will be mechanically removed early in the year and treated with glyphosate (Roundup) a minimum of two times throughout the summer.

Sources for plant material and "clean" soil, free from undesirable seed, will be located throughout the spring and summer. Arrangements will be made with contract growers to produce local plant material that will not be available this year. Seed colletion for the *Festuca* and *Deschampsia* will take place in late summer for seeding in September. If there is insufficient rain to support new transplants, temporary irrigation will be installed. Temporary fencing may be necessary to protect newly seeded and planted areas from disturbance by humans and animals.

Deciduous trees and shrubs can occur in late winter, just at bud break, which should give the new plantings an opportunity to stabilize before the stress of the dry season.

9.0 CONTINGENCY PLAN

The creation of wetlands systems is a complex undertaking that requires the coordinated efforts of people from many disciplines, thoughtful attention to detail, a willingness to put forth the extra effort, and above all, perseverance and patience.

The Port of Bellingham proposes to take remedial actions necessary to ensure the success of the mitigation effort. This may involve replanting, maintenance, and/or additional wetland mitigation to meet the conditions of compliance.

10.0 ON–SITE AND OFF–SITE MITIGATION SUMMARY

The On–site and Off–site Wetlands Mitigation Plans are intended to provide compensation for anticipated wetland losses associated with the extension of the runway and taxiway at Bellingham International Airport, Bellingham, Washington.

The analysis of anticipated wetlands impacts at the proposed project site utilized the 1989 Federal Delineation Methodology. The number of acres of anticipated impacts to wetlands is based on a surveyed field delineation which identified 17.5 acres of palustrine emergent wetland and 3.6 acres of a mosaic of forested upland and wetland communities, for a total of 21.1 acres of wetland that will be impacted.

The goals for the on–site and off–site mitigaiton were established based on the existing condition of the wetlands within the project impact zone, the practical considerations of providing wetland compensation within an airport operational zone, and the existing conditions within the identified compensation areas.

The on–site mitigation plan proposes to create 8.4 acres of palustrine scrub/shrub and replace in the same location, 12.7 acres of in–kind palustrine wet meadow, for a total of 21.1 acres of wetland compensation. The goal is to replace wetlands of similar functional value within the proposed project zone, where feasible and practical from both a functional wetland perspective and a functional airport facility perspective.

The off–site mitigation plan proposes an additional 4.6 acres of palustrine wetland creation and enhancement. In addition, approximately 1100 linear feet of relocated stream channel will be created at the Little Squalicum Creek site along with increased fisheries, wildlife habitat, and water quality improvement values. Passive recreation, environmental education, public shoreline access and research opportunities are additional benefits provided by this plan.

The off–site mitigation is designed to provide wetlands of similar to higher functional values than those existing in the impact zone, to locate the compensation areas outside of the airport operations zone where they would be constantly impacted by maintenance and safety requirements, and to allow for an increase in wildlife usage which will not pose hazard to aircrafts using the airport. Other goals are to create a mosaic of forested, scrub/shrub, and emergent wetland communities outside of the airport zone that will increase the overall functional value of the habitat currently present within the Little Squalicum Creek site.

10.1 Selection Criteria for Wetland Mitigation Sites

The mitigation sites were selected based on the following criteria:

1. Sites where creation of the target wetland communities appears to have a high potential for success based on analysis of existing site conditions. Critical factors considered included existing hydrology and soils conditions;
2. Sites where the upland habitat present within the proposed creation zone is of a low functional value so that upland habitat of moderate to high value is not being sacrificed for wetland compensation;
3. Sites which were outside of the airport zone, in order to eliminate the conflict of providing wildlife habitat within safety and maintenance zones of the airport operations. This precluded several sites located close to the airport;
4. To provide replacement for the wetland types identified within the impact zone with an emphasis of providing compensation of community types of the same or higher functional value than those present within the impact zone, where feasible; and
5. Sites owned by the Port of Bellingham or other public agencies to assure long–term protection of the compensation resource.

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APPENDIX A

HYDROLOGIC ASSESSMENT
ON PROPOSED
LITTLE SQUALICUM CREEK MITIGATION SITE

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INTRODUCTION

Watershed Dynamics has been contracted to provide a hydrologic assessment on the proposed Little Squalicum Creek Mitigation Site in Bellingham, Washington (T38N,R2E,S21,WM). The approximate 18.8-acre project site is located along Marine Drive near the site of the Bellingham Technical School (Figure 1). This report documents the hydrology assessment methodology, describes existing conditions, and makes recommendations pertinent to mitigation development opportunities.

Project Site Description

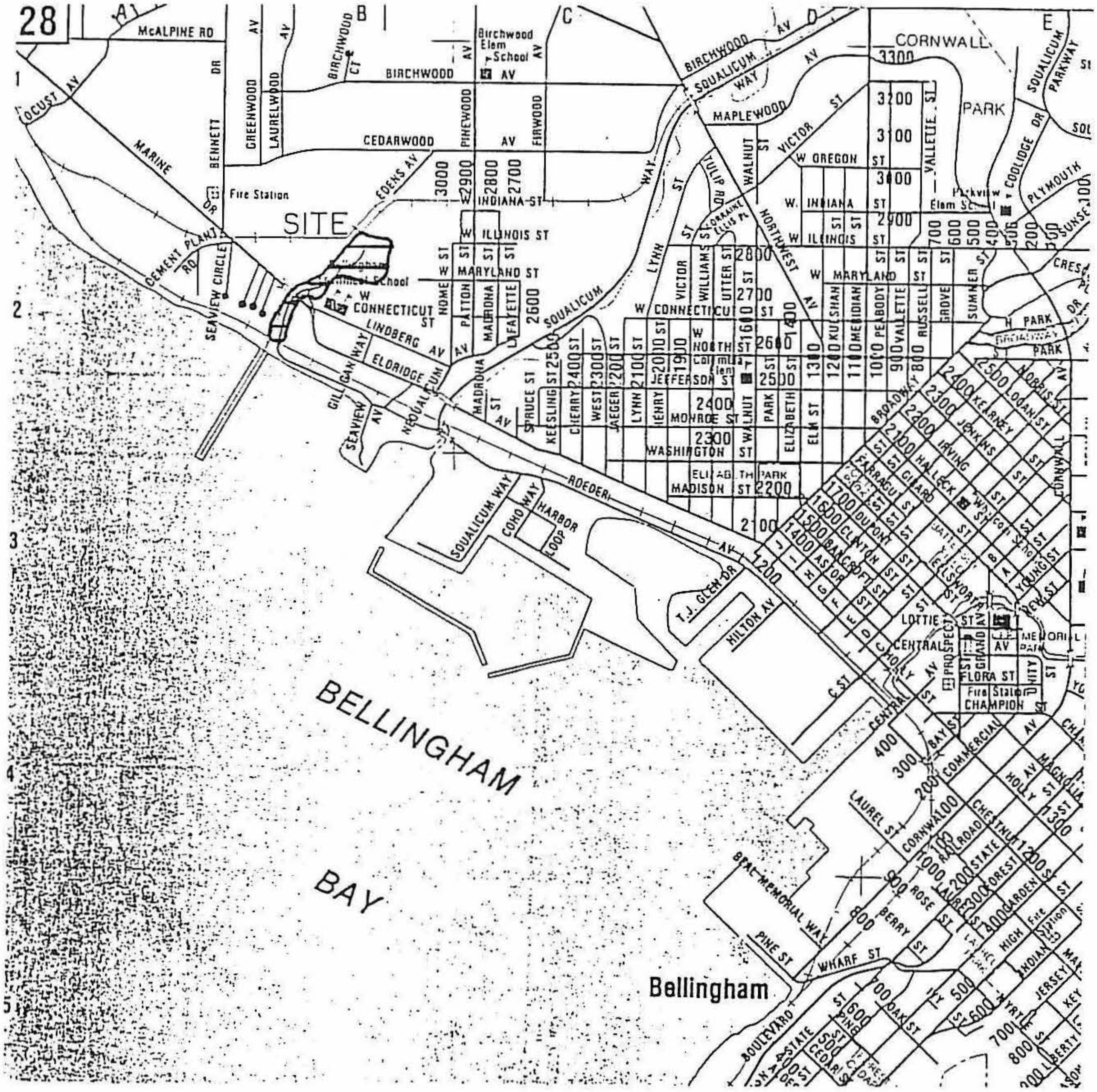
Much of the proposed project site is a former gravel excavation area that has been inactive and was backfilled several years ago. The site is a generally level basin, with elevations from 14 to 50 feet, surrounded by steep sideslopes. Vegetation in the basin is predominately open grass/forb fields and deciduous forest. Little Squalicum Creek flows along the north edge of the site. Prior to upstream activities that captured flow and prior to gravel mining, Little Squalicum Creek may have taken a more sinuous route through much of the site as depicted on the USGS Ferndale 7.5 minute quadrangle, dated 1952. At present, numerous perennial springs in toe-of-slope positions within the study area contribute to the flow of Little Squalicum Creek. Immediately west of the site, the creek flows into Bellingham Bay at elevation 10 feet.

Purpose of Investigation

The purpose of this investigation is three-fold, including;

- collection of onsite hydrology data,
- hydrology data interpretation, and
- mitigation development recommendations.

The Investigation Findings section provides a discussion of site investigations with emphasis on interpretation of soil profile descriptions as they relate to groundwater conditions. Mitigation feasibility and concepts are discussed in the Mitigation Concepts section. Field notes of onsite groundwater monitoring are appended and observed soil profiles are graphically displayed with interpretations of water table zones.



Prepared from; TOTEM ATLAS

Figure 1. Project Site Vicinity.

METHODOLOGY

Site-specific hydrologic conditions were assessed from soil indicators of high groundwater and fluctuating groundwater levels, from direct observation of groundwater, and from measurement of groundwater levels in numerous groundwater wells. A backhoe was used to advance 12 test pits in specific areas of the site (Figure 2). Test pit depths ranged from 45 to 80 inches. Depth to groundwater was recorded in each pit when encountered. In addition, soil profiles were described at test pits. Soil profile descriptions involved distinguishing soil horizons through observations of changes in texture, rooting zone, color, moisture content, presence of mottles, and presence of organic materials.

Apparent Hydrologic Indicators

Since the occurrence of mottles, low chroma soil matrix colors, and gleyed conditions are indicative of varying degrees of soil saturation and reducing conditions, these soil attributes were used as apparent indicators of seasonally present surface water and groundwater. Soil chromas were determined by the comparison of a soil ped with a *Munsell Soil Color Chart* (Soil Conservation Service, 1988). Mottles usually characterize zones of fluctuating water tables. With soil saturation, manganese, iron, sulphur, carbon, and trace elements enter their reduced states and become solubilized. When saturation ends with a lowering of the water table, these elements again become oxidized. This reduction/oxidation process causes accretion of manganese and iron, forming high to low chroma mottles. In general the lower the chroma, the longer the period of saturation and reducing conditions.

While mottling represents fluctuating short-term saturation, low soil matrix chromas and gleying indicate relatively stable, long-term saturation. These color characteristics indicate that saturation has been sufficiently long-term to not only solublize minerals, but also to leach them out of the soil profile.

For the purposes of this report, prominent mottling is used to indicate a zone of short-term fluctuations in soil saturation. In this case, short-term saturation is generally a 7 to 20 day period. Gleying and low soil matrix chromas reflect a zone of long-term saturation. In this case, long-term saturation is generally 20 to 120 days.

Groundwater Monitoring

Following soil profile descriptions, all pits were backfilled. At that time, shallow groundwater wells were installed at eight pits to assess groundwater levels for a 6 to 8 week period. Wells were installed by backfilling around 2-inch diameter, perforated pipe that was placed at depths of 4 to 7 feet. Depths to groundwater were measured twice weekly by the Port of Bellingham to assess possible changes in water levels and to observe any piezometric head.

A large source of error is possible with the installation technique used. Backfilling around 2" pipe with a backhoe may leave pockets that can trap either ground or surface water, creating inaccurate readings. The soil surface-pipe interface is difficult to seal and ponded surface water from precipitation may accumulate and leak down the pipe, creating inaccurate readings.

INVESTIGATION FINDINGS

Hydrologic Patterns

Twelve soil pits, advanced on August 9, 1991, have identified four apparent hydrologic patterns on the subject property, including;

- **areas of historic intertidal influence,**
- **areas of perched surface water,**
- **areas of seasonally high groundwater, and**
- **areas lacking apparent wetland hydrology.**

Historic Intertidal Influence: Soil Log 2 identifies an area of probable historic intertidal influence. This soil log occurs in close proximity to both Little Squalicum Creek and Bellingham Bay. The soil profile showed approximately 30" of unconsolidated backfill overlying **a 22" layer of dark, fine textured material with partially decomposed organic material.** This strata is very suggestive of buried, intertidal mud flats.

Perched Surface Water: Three soil logs, numbers 3, 9, and 11, identify areas with evidence of seasonally perched surface waters. These logs have approximately 24" of unconsolidated backfill overlying stratified clay layers. All clay layers were dry at this time of year and showed no evidence of seasonally high groundwater. However, the clay layer does perch surface waters at 16 to 30 inches.

Low chroma and gleyed conditions in the upper clay layer of these three pits suggests long-term presence of seasonal surface water. Soil Log 11 also showed evidence of high groundwater in a sand layer beneath the clay.

Seasonally High Groundwater: Seven soil logs, numbers 1, 5 through 8, 10, and 11, are in areas that have seasonally high groundwater levels. These profiles show 16 to 34 inches of unconsolidated backfill overlying coarse textured substrate.

In Soil Logs 1, 6, 7, 8, and 10, the substrate is primarily gravelly and cobbly sandy loam. The substrate is mottled at 24 to 42 inches, suggesting a zone of fluctuating seasonal groundwater. **In most of these profiles, low chroma and gleying is present at approximately 42 inches, suggesting a zone of seasonally high groundwater that is continually present during the winter and spring months.** Most of these soil logs were saturated at 45 inches during this investigation, suggesting a year round water table at this depth.

In Soil Logs 5 and 11, the substrate is primarily sand and was saturated during field investigations, at 16 inches in Log 5 and at 72 inches in Log 11. **This suggests a high water table, continually present during the winter and spring months at these depths.**

No Apparent Hydrology: Two soil logs indicate no apparent hydrology. Soil Log 4 represents an area of low permeability soil that lacks apparent indicators of hydrology. This log had 22 inches of unconsolidated backfill overlying strata of clay, **No water, low chromas, gleying, or mottling were observed.** Soil Log 12 represents an area of well drained soils that show no apparent indicators of seasonal wetland hydrology. The subsurface horizon was weakly mottled above a thin compacted sand layer at 14 to 24 inches. **These indicators are too weak to make any assumptions that surface water or groundwater would be seasonally available.**

Groundwater Monitoring

Twelve groundwater wells were installed on August 9 in eight of the twelve soil logs to observe groundwater levels over time. Paired wells were nested at four locations to observe potential piezometric head. Monitoring started on August 21 and has continued to present on a twice-weekly basis. Monitoring has been correlated to precipitation levels during that period. Monitoring data and precipitation records are appended.

During the monitoring period, 1.82 inches of precipitation occurred from August 26 through August 31. All groundwater wells responded within 48 hours, with groundwater levels rising from 4 to 15 inches. Within 72 hours after the storm event, monitoring showed a return toward pre-storm levels. This precipitation response is indicative that hydrologic support in the study area is at least partially dependent upon collected surface waters from the surrounding urban areas.

The use of nested wells at different depths was utilized to measure potential piezometric head. Piezometric head would be present whenever a deep well showed higher groundwater than an adjacent shallow well. This occurred in wells 1 and 7 to a very minor degree, with no more than 2 inches of head recorded. This amount is insignificant relative to the monitored groundwater levels and does not affect interpretation of results.

Table 1, which follows, summarizes groundwater monitoring data and correlates it to initial field observations.

Table 1
Groundwater Summary Chart

SOIL LOG#	WELL#	DEPTH TO LOW CHROMA	OPEN PIT LEVEL	MONITORED LEVEL MINIMUM	MONITORED LEVEL MAXIMUM	WELL DEPTH
1	1a	16"	34"	28"	38"	55"
	1b			28"	>38"	38"
4	4a	*N/O	60"	39"	54"	77"
5	5a	10"	16"	31"	36"	51"
6	6a	*N/O	43"	35"	39"	57"
7	7a	43"	48"	23"	36"	48"
	7b			24"	29"	41"
8	8a	35"	43"	30"	40"	51"
	8b			29"	37"	39"
10	10a	40"	43"	39"	48"	48"
	10b			39"	49"	61"
12	12a	*N/O	70"	43"	56"	68"

*N/O, not observed

Monitoring to date has shown groundwater levels that correlate closely with observed open pit levels and with apparent indicators. **Soil logs (1,5 through 8,and 10) having apparent indicators of seasonally high groundwater all had actual groundwater levels in the Zone of Long-term Saturation (see soil profiles) at this time of year.** This supports the validity of the apparent indicators, and winter and spring groundwater levels are expected to be within the low chroma and gleyed strata for 20 to 120 days in the average year.

Soil Logs 4 and 12, which showed no apparent groundwater indicators, did have monitored groundwater levels in the 39″ to 56″ range. These monitored levels may be influenced by surface water leakage associated with concurrent precipitation. Without supportive, subsurface apparent indicators, the monitoring levels are not reliable.

Summary

Long-term shallow groundwater exists at 30″ to 48″ in those areas with low chromas and gravelly to cobbly, sandy loam soils. Long-term shallow groundwater does not exist in those areas where immpermeable clay is present or in areas of well drained soils. Monitoring during this time of year has substantiated the reliability of the apparent indicators of shallow groundwater found in most subsurface strata. **Following recharge, long-term winter and spring groundwater levels are expected to be at levels indicated by low chroma conditions.** Short-term, fluctuating groundwater is expected in strata where mottling is prominent. Perched surface waters are found where immpermeable clay layers exist near the soil surface. Gleyed conditions in the upper clay layer and overlying strata suggest the presence of long-term seasonal surface water.

These findings suggest general areas of perched surface water and long-term shallow groundwater based on locations of soil logs. To more precisely define and map the location and extent of the observed hydrologic patterns, a more intensive, systematis sampling is required, due primarily to the varied stratigraphy created by historic excavation operations.

MITIGATION CONCEPTS

Mitigation design and construction considerations differ for each separate hydrologic pattern. In order to maximize the site acreage as a wetland mitigation area, designs should focus on the use of both groundwater and perched surface water to provide the necessary hydrology for mitigation success. This appears feasible from the above site assessment. Design considerations vary with each of the hydrologic patterns, as follows.

<u>Historic Intertidal Influence</u>: Mitigation recommendations include the excavation of existing backfill in these areas. Removal of downstream structures may restore the apparent intertidal influence and allow creation of a small, brackish estuarine wetland. If downstream features cannot be altered, excavation of backfill to approximately 32 inches would allow wetland creation utilizing seasonally perched surface water.

Perched Surface Water: Mitigation recommendations for these areas include excavation of existing backfill to the impermeable clay layer (16" to 30") Top soil should be imported to provide a medium that would allow root penetration and hold seasonally perched surface waters. This recommendation would provide sufficient hydrology for a shallow-rooted emergent community with selected species capable of withstanding long, summer dry periods.

Seasonally High Groundwater: Mitigation recommendations for these areas include excavation of existing backfill to the level of low chromas and gleying, approximately 42 inches for most areas. Top soil should be imported to provide a rooting medium and prolong surface saturation by "wicking". This should provide sufficient hydrology for a species diverse wetland with year around moisture. The sandy, cobbly, and gravelly nature of these areas should allow establishment of some deep-rooted species. The possibility exists that year around inundation or open water could be created with over-excavation and utilization of near-by toe-of-slope springs.

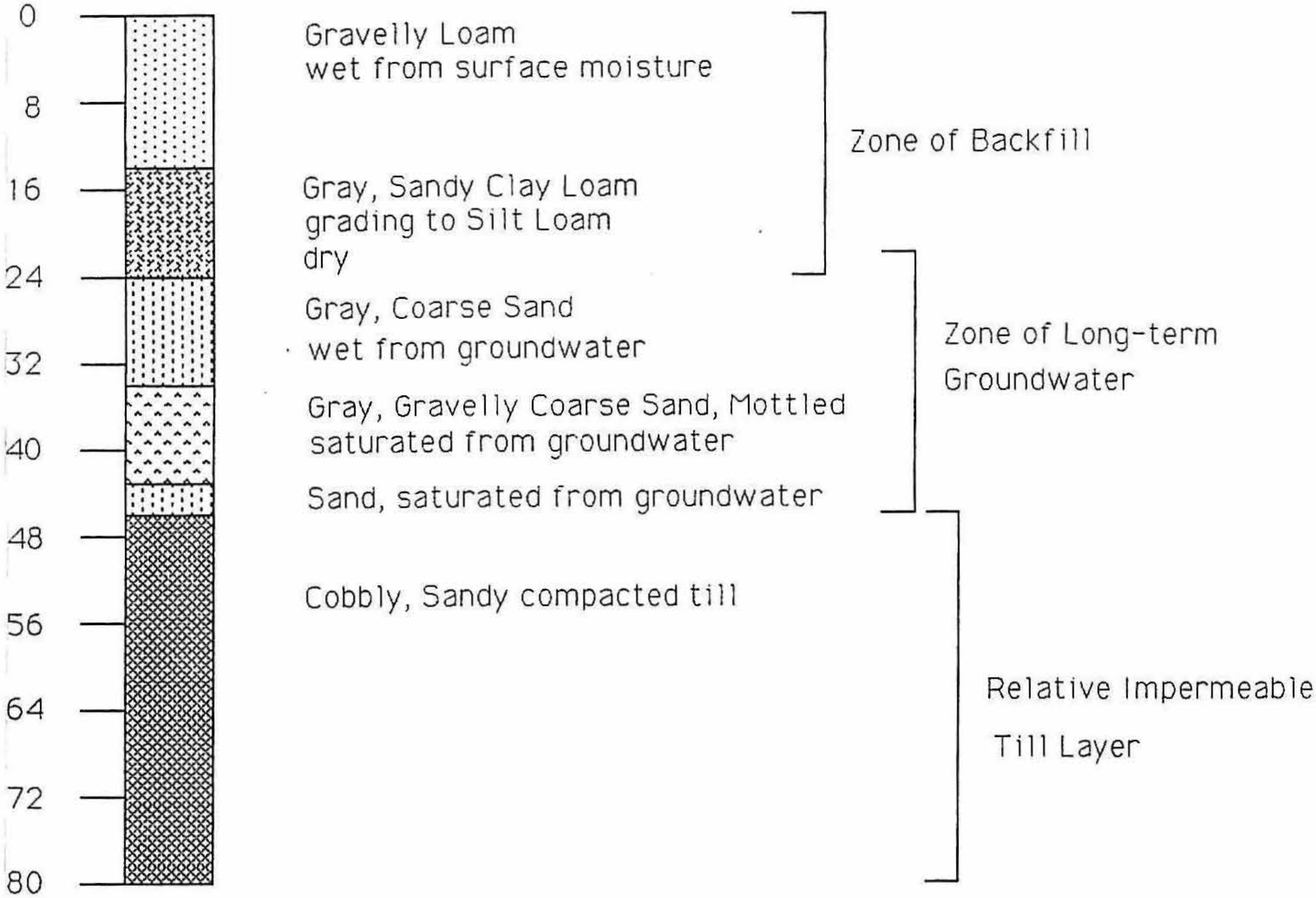
No Apparent Hydrology: These areas are not suited to direct wetland creation. With hydrology and apparent indicators lacking, it is unlikely that adequate wetland hydrology could be created through excavation. Soil Log 4 has an impermeable clay layer at 22 inches and would perch surface waters, if artificailly directed to these areas. However, with time and with surrounding wetland creation, the area of Soil Log 12 may eventually become wetland. The additional moisure from adjacent created wetlands would most likely affect this area, altering plant succession and eventually developing a more hydrophytic community.

Watershed Dynamics feels that there is adequate hydrology to support wetland creation over portions of the property currently perching seasonal surface water and currently having apparent indicators of long-term shallow groundwater. Although intertidal wetland creation is desirable, we cannot recommend such creation without a more extensive downstream assessment. Those areas lacking hydrologic indicators are not recommended as areas for wetland creation.

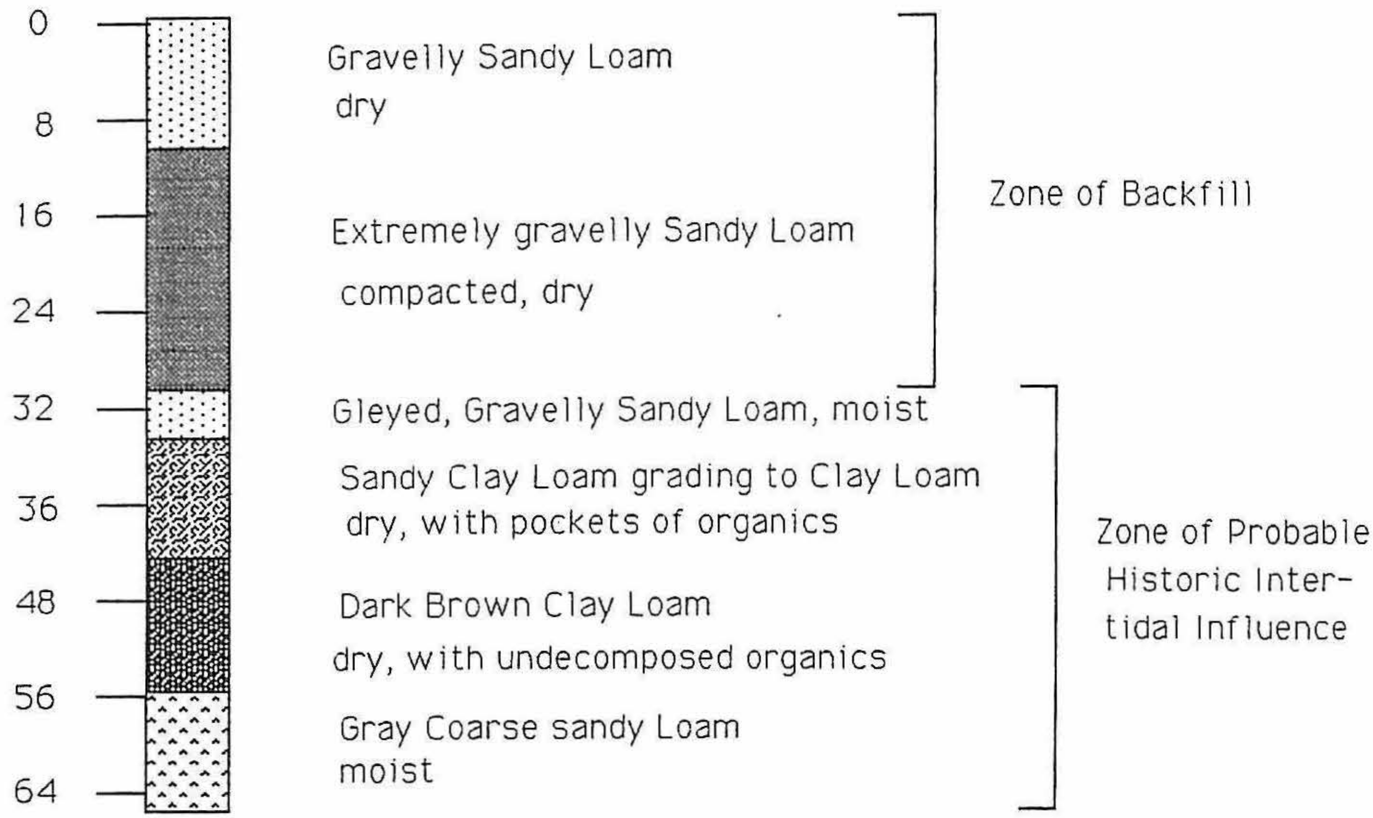
APPENDIX A

Soil Profiles

SOIL PROFILE # 1



SOIL PROFILE # 2



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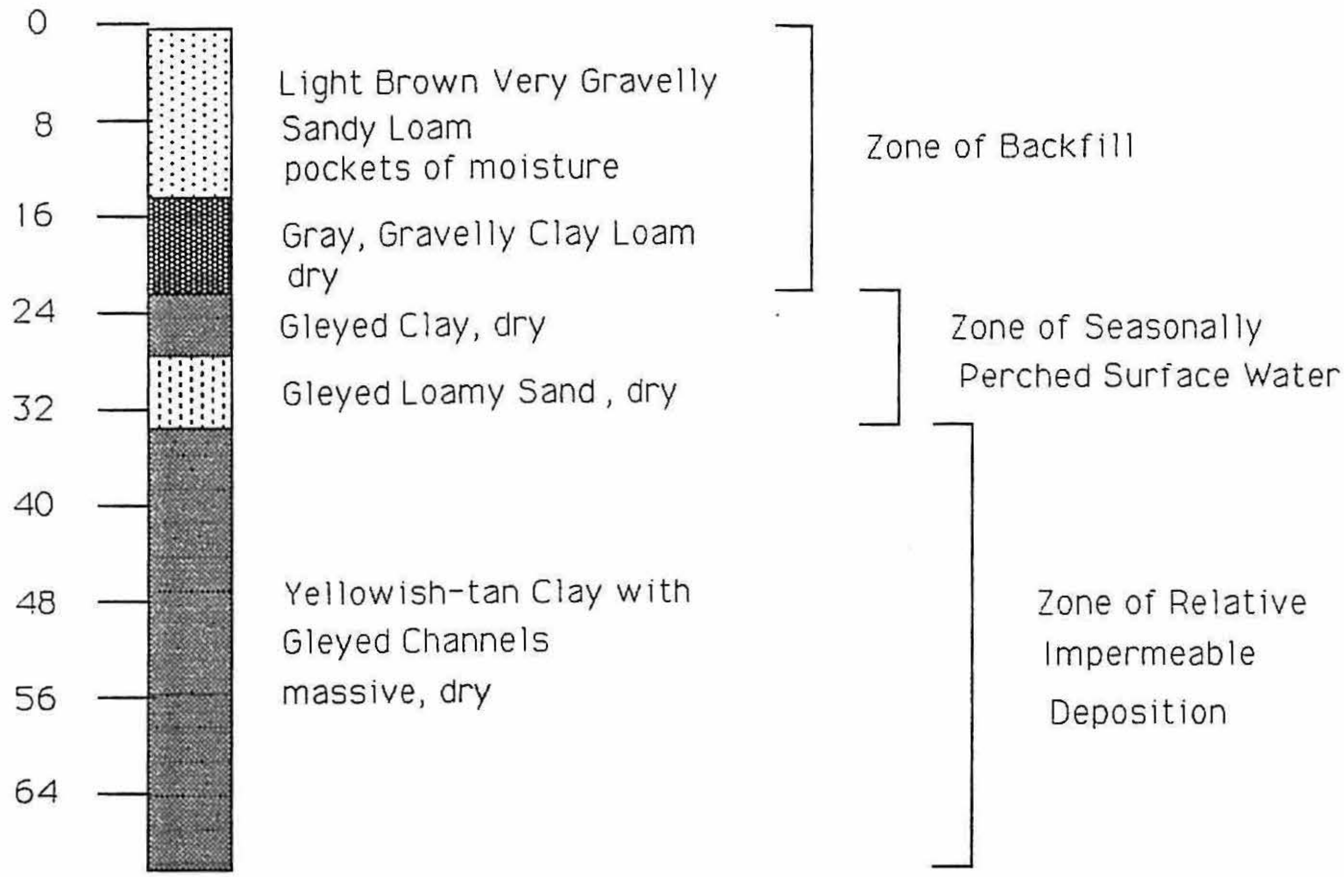
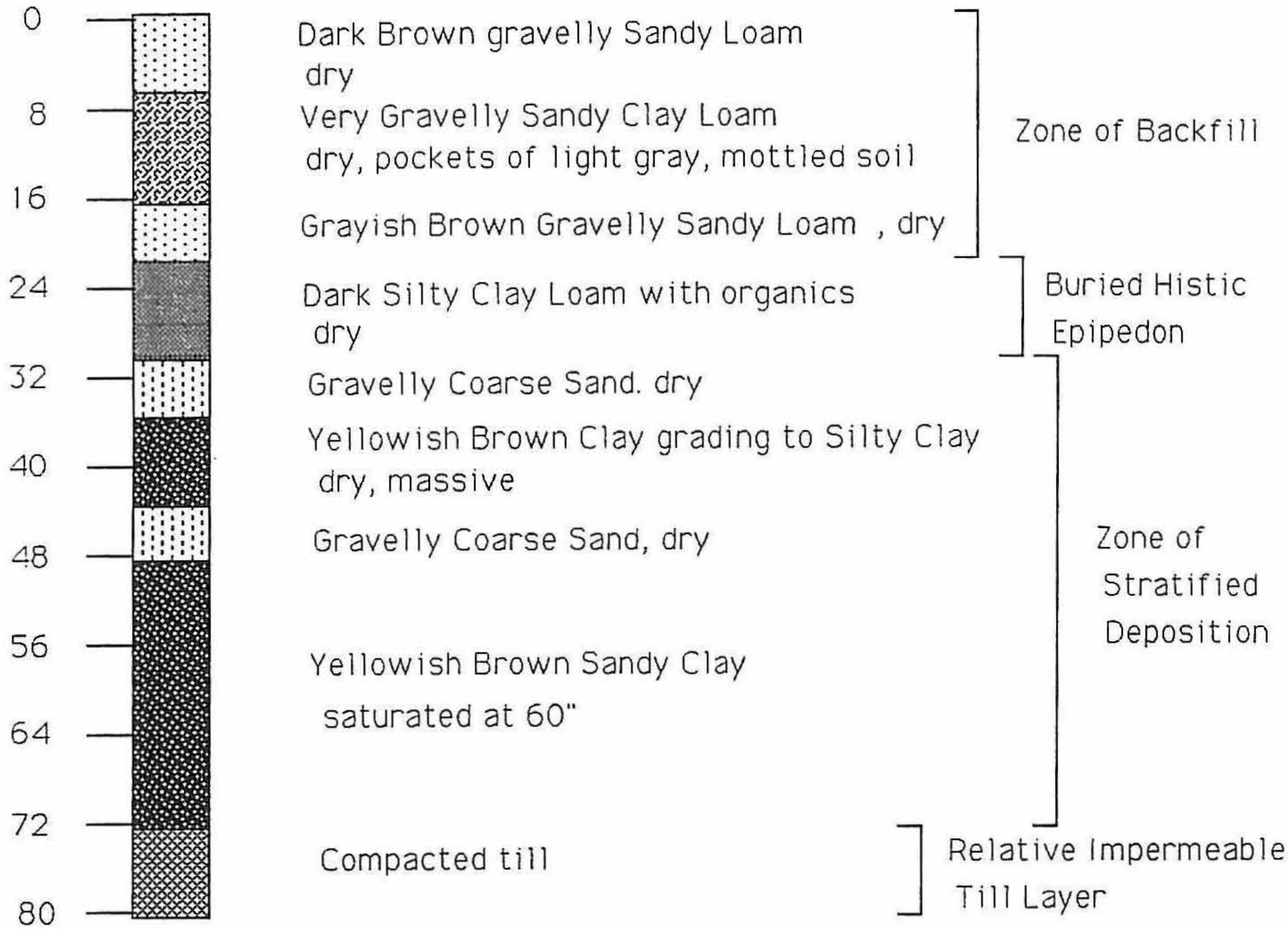
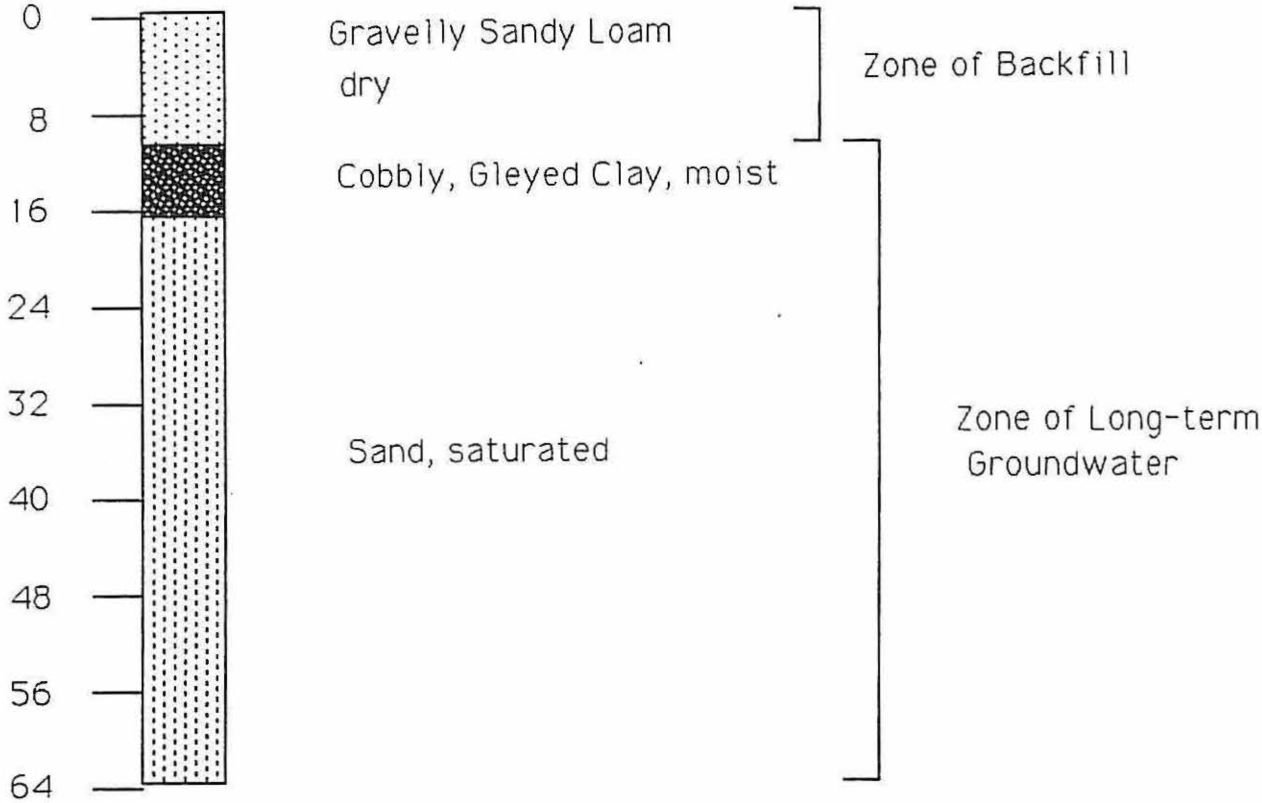


SOIL PROFILE # 4

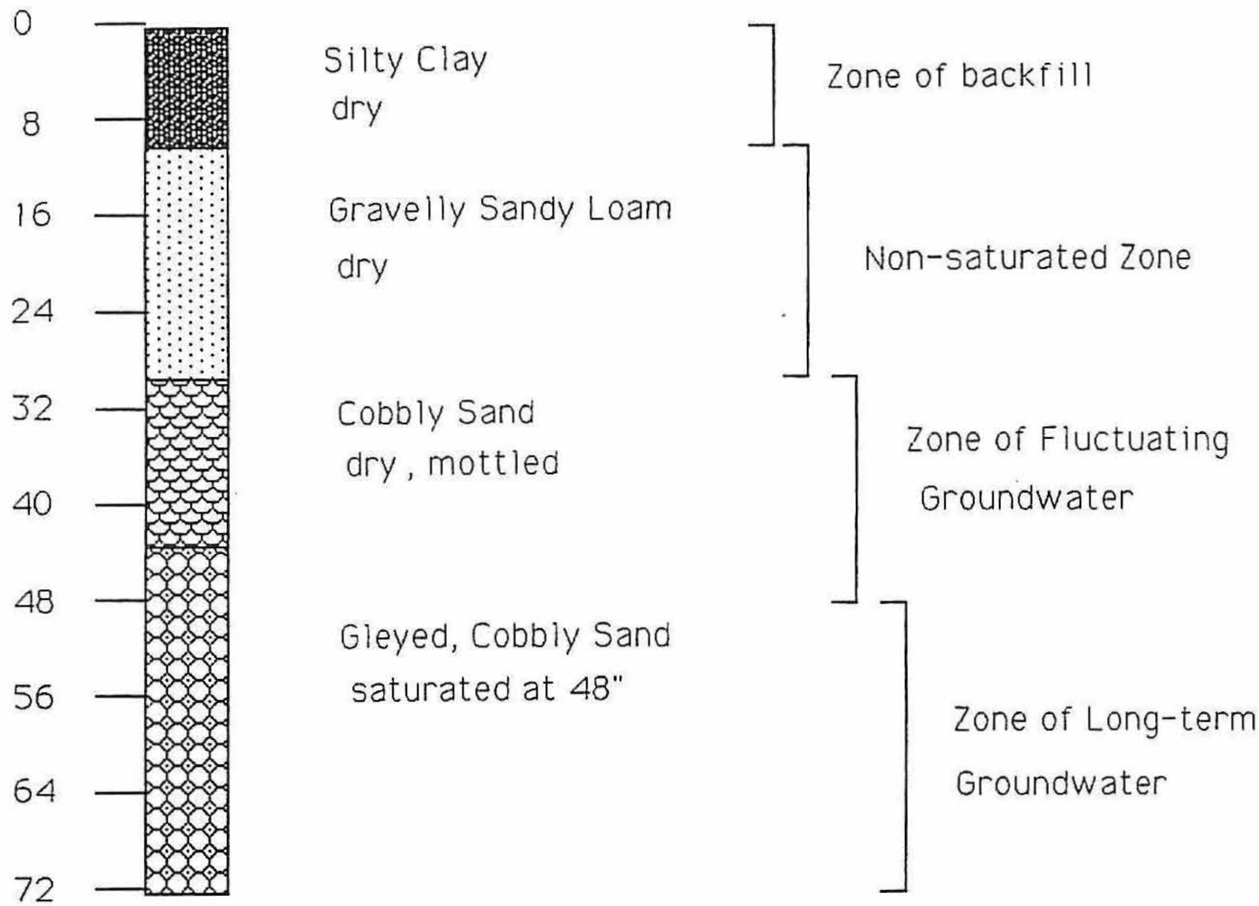


SOIL PROFILE # 5

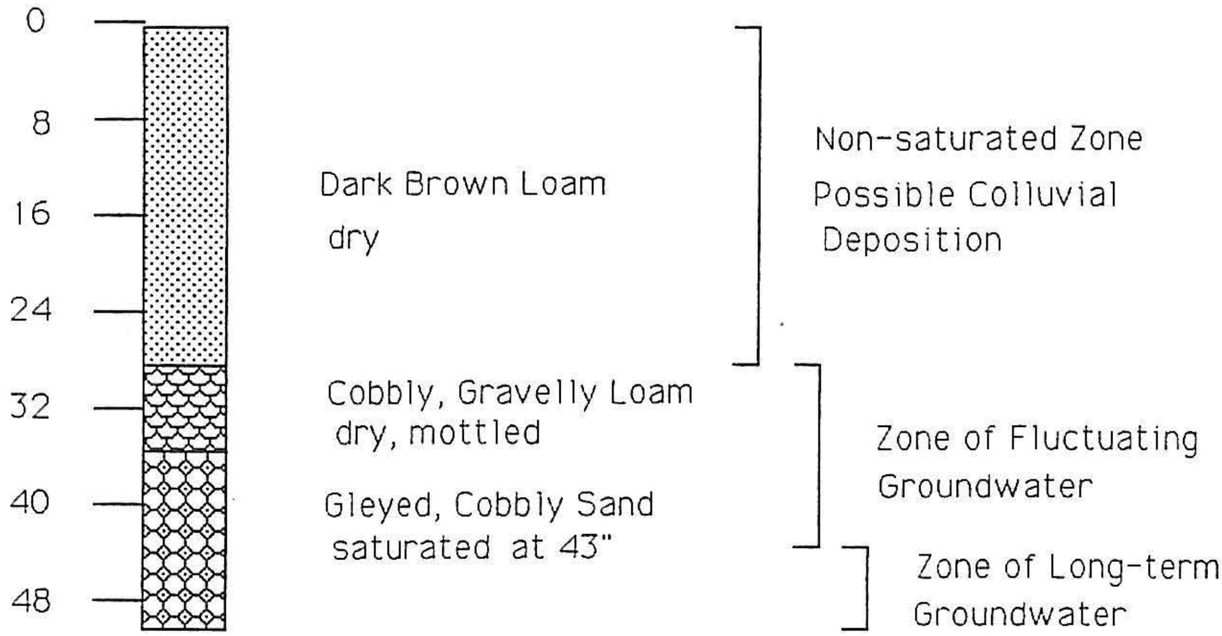


NOTE: Soil Log 6 not described

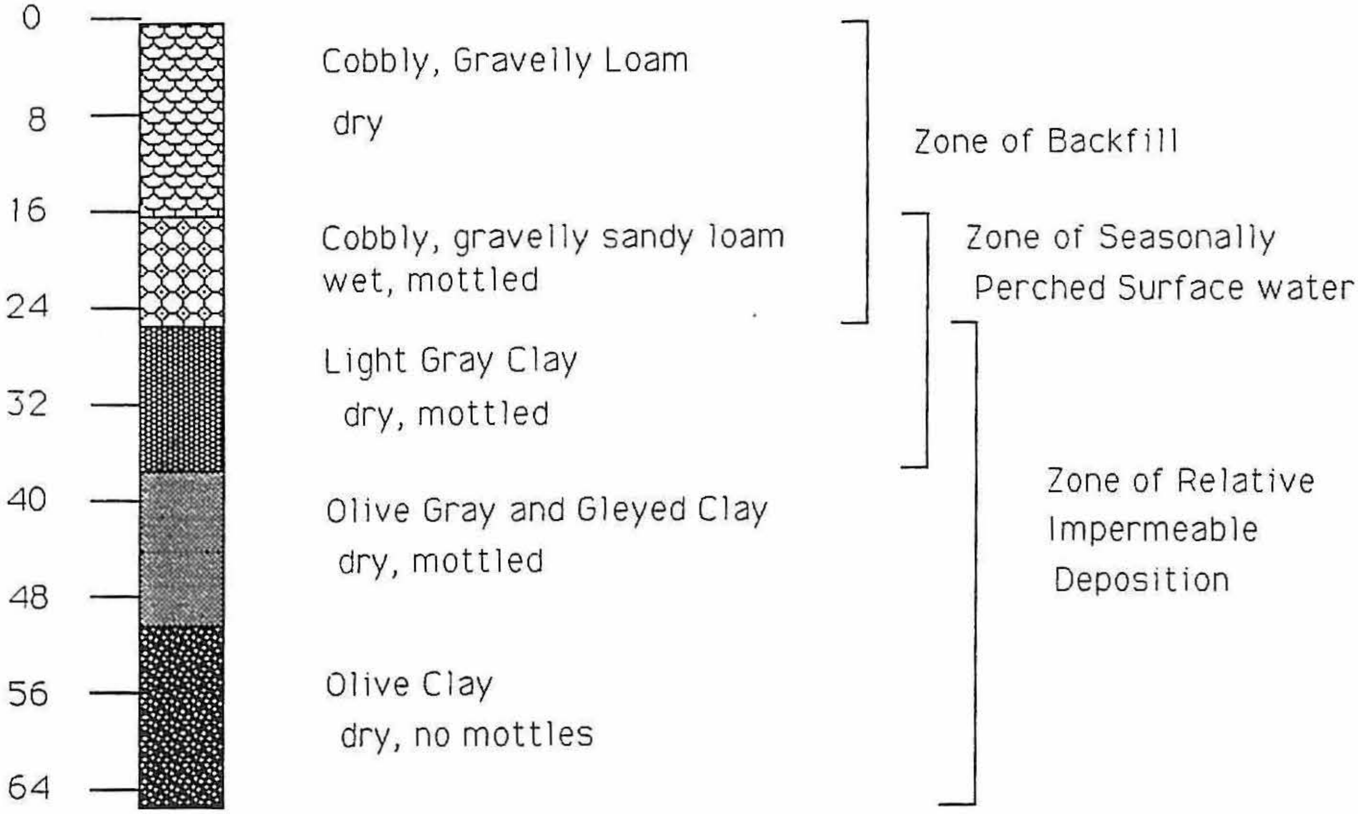
SOIL PROFILE # 7



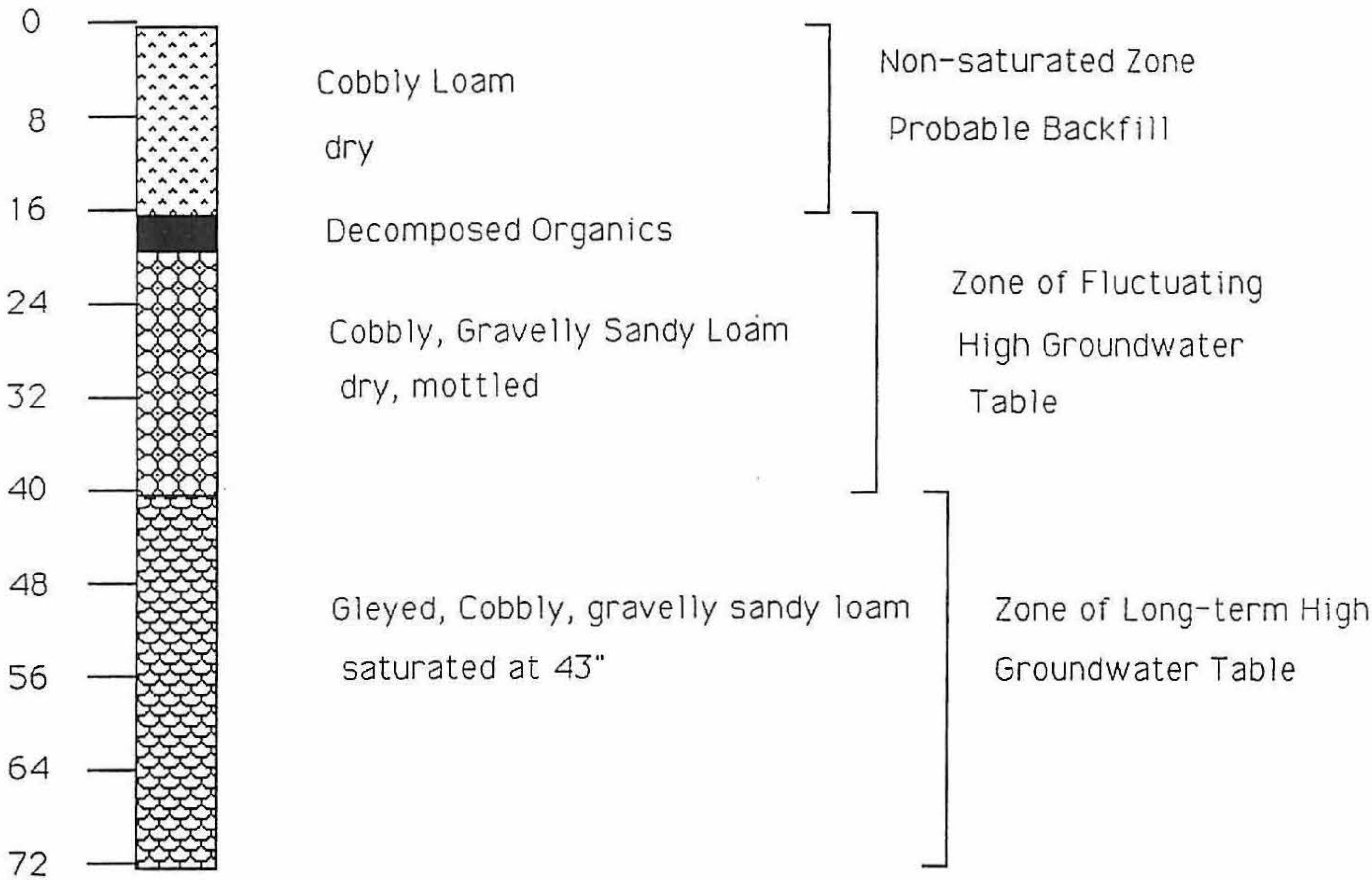
SOIL PROFILE # 8



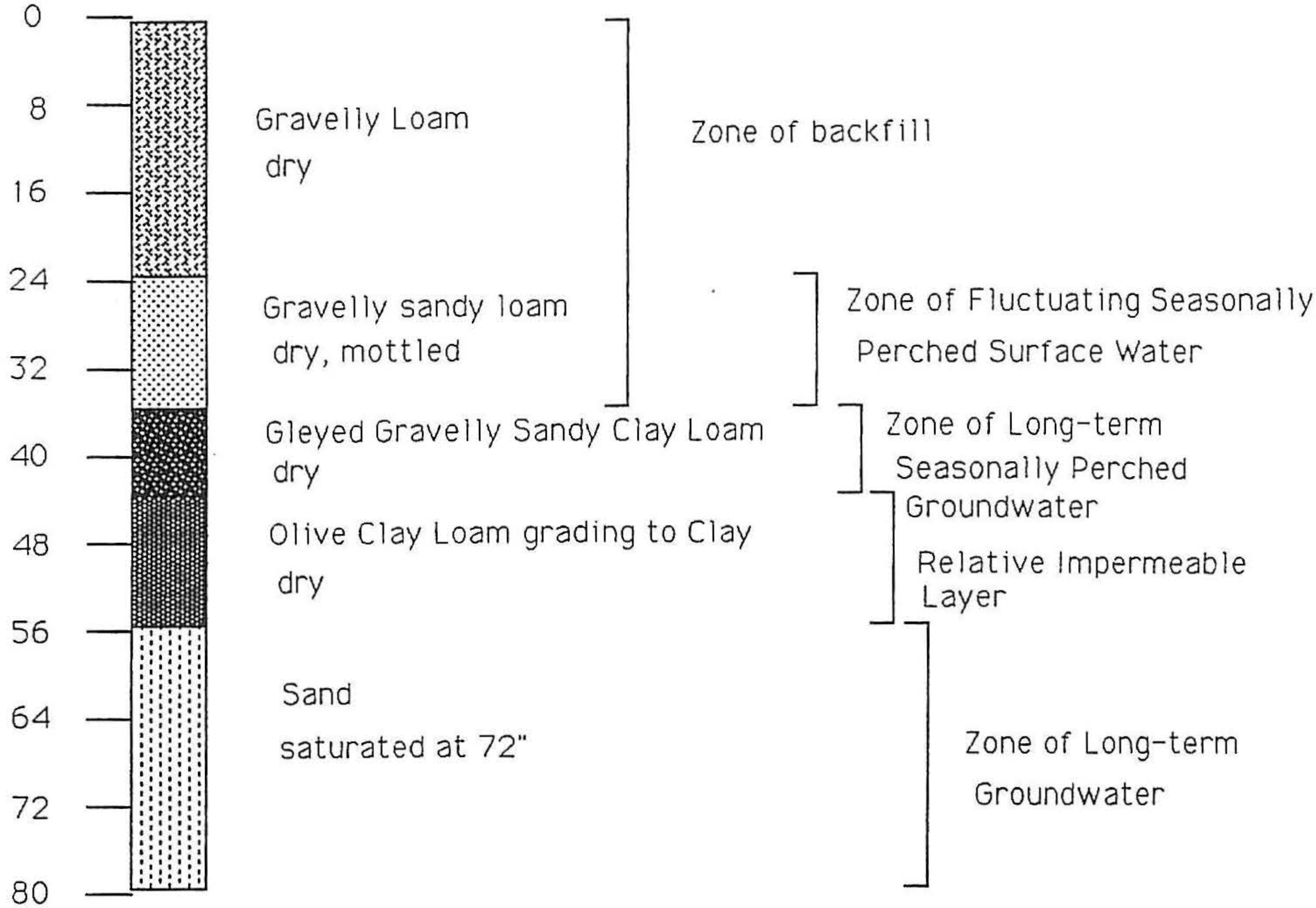
SOIL PROFILE # 9



SOIL PROFILE # 10



SOIL PROFILE # 11



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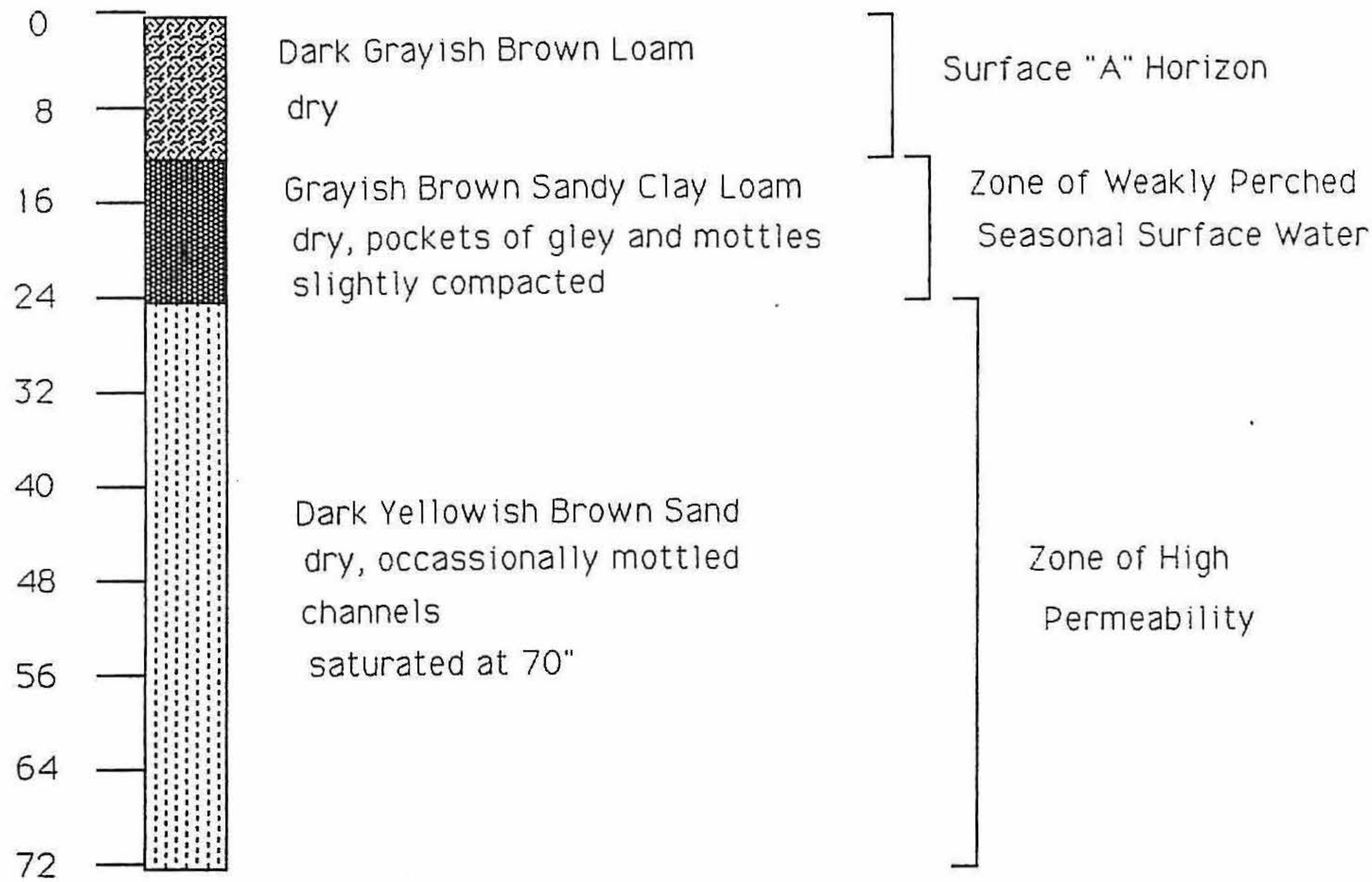


APPENDIX B

Monitoring Data

WEEK OF: AUG 19, 91

LITTLE SQUALICUM CREEK TEST WELL MEASUREMENTS

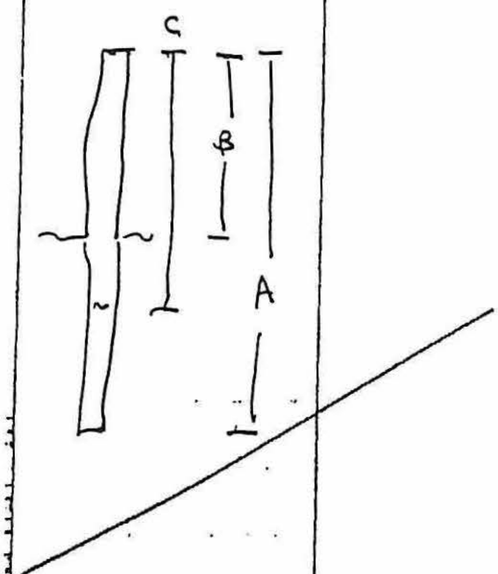
DATE: 8/21/9
WEDS

DEPTH = C-B

WELL	A BOTTOM	B GROUND	C WATER (TOP OF TUBE TO THE WATER)	COMMENTS
1a	8'10"	4'0"	7'2"	3'2" = 38"
1b	93 7'9"	4'7"	DRY	= 738"
12a	6'7"	0'-9"	5'-1"	51"
8a	6'9"	2'4"	5'8"	40"
8b	5'6"	2'3"	5'-0"	33"
10a	7'10"	3'10"	7'7" 91	45"
10b	8'7"	3'4"	7'5"	49"
7a	?? 6'11"	4'9"	7'9"	36"
b	7'10"	4'4"	6'9"	29"
a	6'8"	1'-4"	4'5"	37"
5a	7'4"	3'-0"	6'-0"	36"
a	7'-11"	1'-6"	6'-0"	54"

DATE:

1a
1
2a
8
10a
,
7



9-12-91

Post-It™ brand fax transmittal memo 7671	# of pages ▸ 4
To MIKE Carrol	From ERIN Forrest
Co.	Co. Port of Bellingham
Dept.	Phone # 676-2500
Fax # 735-4289	Fax # 671-6411

WEEK OF :

LITTLE SQUALICUM CREEK TEST WELL MEASUREMENTS DATE: 8/26/91 MON

COMMENTS

WELL	BOTTOM	GROUND	WATER (TOP OF TUBE TO THE WATER)	
1a	106"	48"	85"	37"
b	93"	55"	DRY	> 38"
12a	78"	8"	62"	56"
8a	81"	30"	65"	35"
b	65"	27"	63"	37"
10a	94"	46"	90" ~~[illegible]~~	44"
10b	103"	42"	89"	47"
7a	102"	57" ~~27"~~	85"	28"
7b	93"	53"	80"	27"
[illegible]	74"	16"	55"	39"
5a	87"	37"	72"	35"
[illegible]	96"	19"	71"	52"

DATE: 8/29/91 THURS

1a	105"	48"	80"	32"
1	93"	55"	89"	34"
12a	79"	8"	56"	48"
8a	81"	30"	62"	32"
b	66"	27"	58"	31"
10a	94"	46"	87"	41"
b	103"	42"	84"	42"
7a	105"	57"	80"	23"
7b	94"	53"	77"	24"
[illegible]	73"	16"	52"	36"
5a	87"	37"	70"	33"
[illegible]	96"	19"	62"	48"

WEEK OF:

LITTLE SQUALICUM CREEK TEST WELL MEASUREMENTS DATE: 9/3/91

WELL	BOTTOM	GROUND	WATER (TOP OF TUBE TO THE WATER)	COMMENTS
1a	104 8'-8"	48"	6'-4"	28"
	7-9"	57"	7'-1"	28"
b			[illegible]"	
2a	6'-7"	8"	4-3"	43"
8a	81"	30"	60"	30"
b	66"	27"	56" ~~66~~"	29"
10a	95"	46"	85"	39"
10b	8'-7"	42"	6'-9"	39"
7a	8'-9"	57"	6'-8"	23"
7b	7'-10"	53"	6'-5"	26"
	6-2"	16"	4'-3" ~~[illegible]~~"	35"
	7'-3"	37"	5'-8"	31"
7a	8'-0"	19"	4'-10"	39"

DATE: 9/6/91

WELL	BOTTOM	GROUND	WATER	COMMENTS
1a	8'-7"	48"	6'-7"	31"
	7'-9"	57"	7'-4"	31"
2a	6'-5"	8"	4'-5"	45"
8a	6'-10"	30"	5'-3"	33"
	5'-6"	27"	4'-11"	32"
10a	7'-10"	46"	7'-3"	41"
	8'-6"	42"	7'-0"	42"
7	8'-9"	57"	6'-9"	24"
b	7'-10"	53"	6'-7"	26"
	6'-2"	16"	4'-5"	35"
a	7'-3"	37"	5'-10"	33"
	8'-0"	19"	5'-2"	43"

WEEK OF :

LITTLE SQUALICUM CREEK TEST WELL MEASUREMENTS DATE: 9/10/91

[illegible]	A BOTTOM	B GROUND	C WATER (TOP OF TUBE TO THE WATER)	C–B COMMENTS
1a	8'-7"	48"	6'-9"	33"
[illegible]	7'-9"	55"	7'6"	35"
12a	6'-6"	8"	4'-6"	46"
[illegible]a	6'-10"	30"	5'-4"	34"
[illegible]	5'-5"	27"	5'-0"	33"
[illegible]0a	7'-11"	46"	7'-6"	44"
[illegible]b	8'-6"	42"	7'-2"	44"
7a	8'-9"	57"	6'-10"	25"
[illegible]	7'-10"	53"	6'-7"	26"
[illegible]	6'-2"	16"	4'-6"	38"
[illegible]a	7'-4"	37"	5'-10"	33"
[illegible]	8'-0"	19"	5'-5"	46"

DATE: 9/13/91

1a	8'-7"	48"	6'-10"	34" ✓
[illegible]	7'-9"	55"	7'-6"	35 ✓
12a	6'-4"	8"	4'-6"	46 ✓
[illegible]	6'-9"	30"	5'-5"	35 ✓
[illegible]	5'-6"	27"	5'-1"	34 ✓
10a	7'-10"	46"	7'-7"	45 ✓
b	8'-5"	42"	7'-4"	46 ✓
7[illegible]	8'-9"	57"	6'-10"	25 ✓
1b	7'-10"	53"	6'-8"	27 ✓
[illegible]	6'-1"	16"	4'-6"	~~[illegible]~~ 38 ✓
5a	7'-4"	37"	5'-11"	34
[illegible]	8'-0"	19"	5'-6"	47 ✓

WEEK OF :

ITTLE SQUALICUM CREEK TEST WELL MEASUREMENTS DATE: 9/17/91

...L	A BOTTOM	B GROUND	WATER (TOP OF TUBE TO THE WATER)	COMMENTS
a	8'-8"	48"	6'-11"	35 ✓
	7'-9"	55"	DRY	D ✓
	6'-4"	8"	4'-9"	49 ✓
2a	6'-9"	30"	5'-5"	35 ✓
a	5'-6"	27"	5'-2"	35 ✓
	7'-10"	46"	7'-8"	46 ✓
0a	8'-5"	42'	7'-3"	45 ✓
b	8'-9"	57"	6'-11"	26 ✓
	7'-10"	53"	6'-8"	27 ✓
b	6'2"	16"	4'-7"	39 ✓
	7'-4"	37'	6'-0"	35 ✓
a	8'-0"	19"	5'-5"	46 ✓

DATE: 9/20/91

a	8'-8"	48"	7'-0"	36
	7'-9"	55"	DRY	D
	6'-4"	8"	4-9"	49
2a	6'-9"	30"	5'-6"	36
a	5'-6"	27"	5'-2"	35
	7'-10"	46"	7'-10"	48
10a	8'-5"	42"	7'-5"	47
	8'-7"	57"	7'-0"	27
7	7'-10"	53"	6'-8"	27
b	6'-1"	16"	4'-7"	39
	7'-4"	37"	6'-0"	35
a	8'-0"	19"	5'-7"	48

WEEK OF :

LITTLE SQUALICUM CREEK TEST WELL MEASUREMENTS DATE: 9/24/91

WELL	BOTTOM	GROUND	WATER (TOP OF TUBE TO THE WATER)	COMMENTS
2	8'-8"	4'-0"	7'-1"	37
	7'-9"	4'-7"	DRY	0
12a	6'-4"	0'-9"	4'-11"	50
a	6'-9"	2'-4"	5'-6"	38
8b	5'-6"	2'-3"	5'-2"	35
Ua	7'-11"	3'-10"	7'-8"	46
b	8'-5"	3-4"	7'-5"	49
7a	8-9"	4'-9"	6'-11"	26
7	7'-10"	4'-4"	6'-9"	29
	6'-1"	1'-4"	4'-7"	39
a	7'-4"	37"	6'-0"	35
	8'-00"	1'-6"	5'-7"	49

DATE:

WELL				
a				
1				
2a				
31				
10a				
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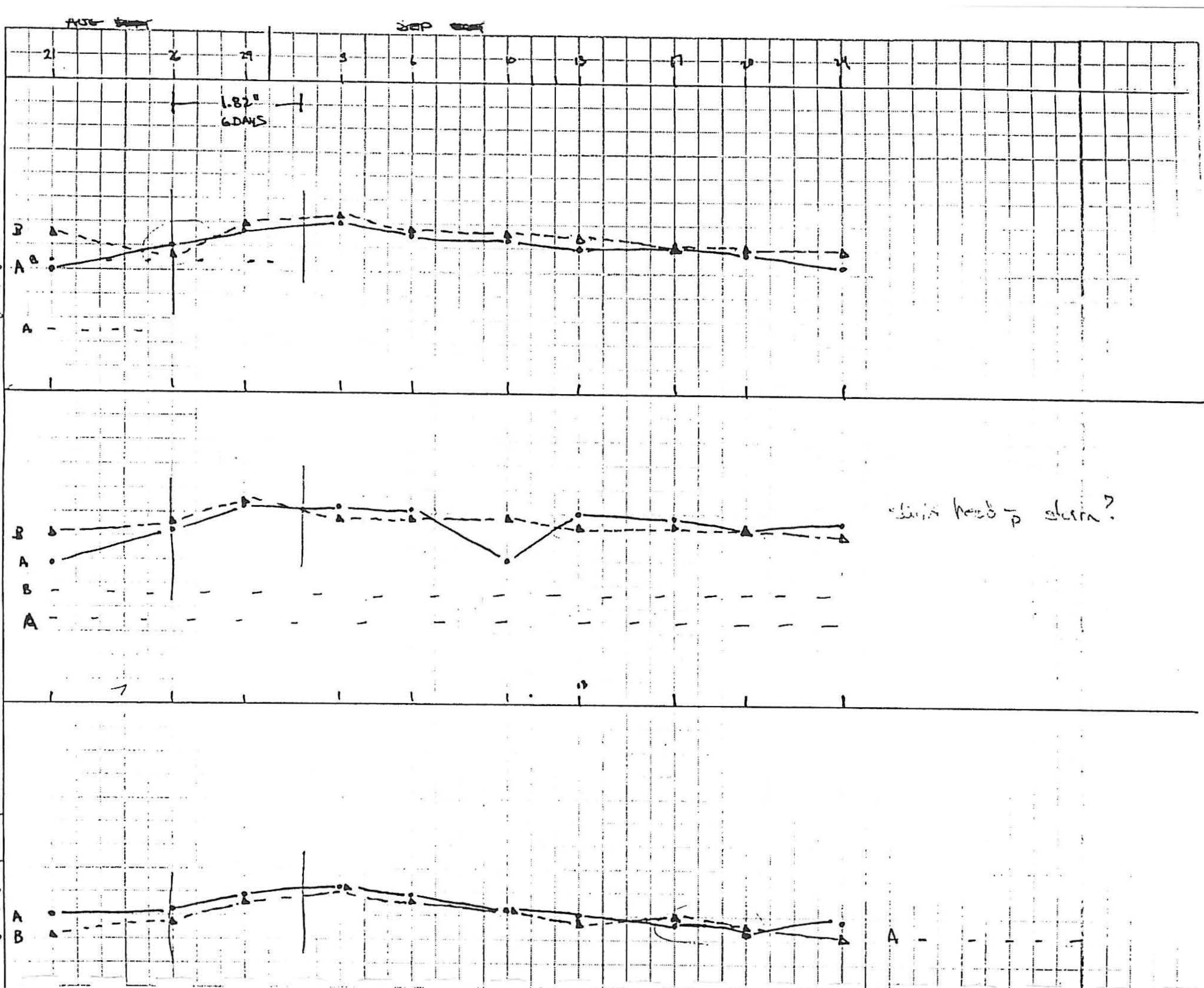
7c				
a				

Project:



AUG
SEP
21
2
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17
20
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6DAYS
-5
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-20
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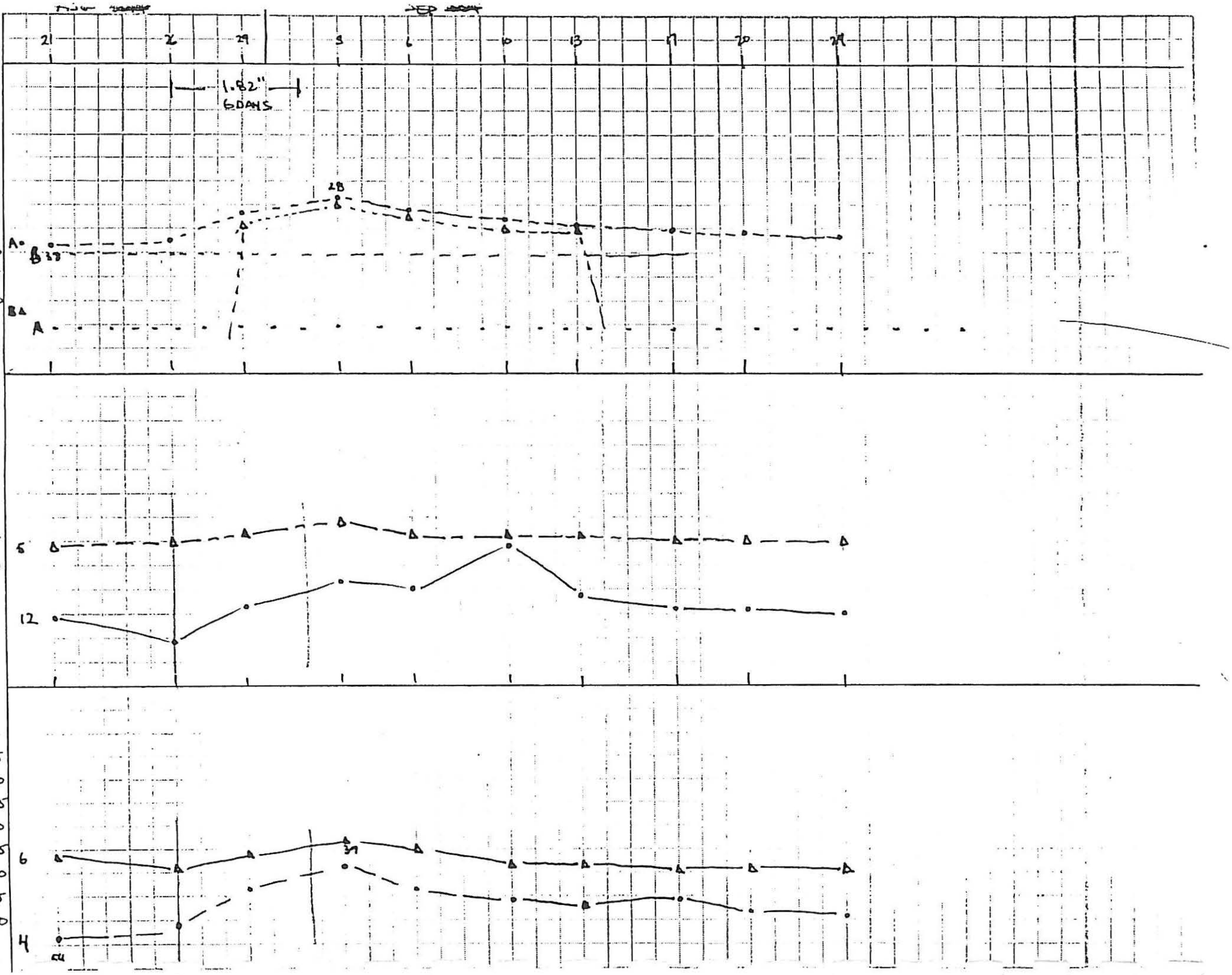
-30
-35
-40
-45
-50
A
B

Project:


21
2
29
3
6
10
13
17
20
27
1.82"
6 DAYS
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
A
B
28
5
12
6
4
37

Post Point Pollution Control Plant
Monthly Log for:
August 1991

Date	Temp Max (F)	Temp Min (F)	Rain (In.)	Flow Max (mgd)	Flow Min (mgd)	Flow Total (mgd)	Fecal Bacteria (#/100ml)	Oil Grease (mg/l)	Final CL2 (mg/l)	Comments
15	80.0	54.0	0.00	15.4	4.6	9.99	6		1.09	
16	81.6	54.0	0.00	15.5	4.5	9.14	5		1.08	
17	81.6	54.1	0.00	12.4	4.1	9.02	5		1.00	
18	78.8	57.7	0.00	14.9	4.3	9.23	5		1.06	
19	77.1	56.5	0.00	15.2	4.4	9.90	5		0.80	
20	79.5	57.2	0.00	14.9	4.7	9.94	5		0.94	
21	77.9	56.6	0.00	13.9	5.3	10.06	5		1.11	
22	74.8	55.4	0.00	14.0	4.5	10.00	6		1.00	
23	74.3	54.5	0.00	13.8	4.6	9.23	1500		1.10	
24	69.2	50.7	0.00	12.2	3.6	8.15	5		1.33	
25	70.1	49.8	0.00	12.9	3.7	7.65	5		1.04	
26	69.0	51.8	0.40	18.8	3.6	9.81	5		0.97	
27	62.6	56.4	0.48	10.8	11.2	13.12	12	6.7	1.06	
28	60.0	54.2	0.06	15.3	4.7	9.97	9		1.18	
29	76.0	57.0	0.07	21.0	2.1	10.19	5		0.90	
30	73.0	62.0	0.36	27.0	4.6	13.68	180		1.08	
31	65.0	57.0	0.47	27.0	9.6	12.37	5		1.17	
1	68.0	51.0	0.00	13.7	5.5	9.38				
2	69.0	52.0	0.00	14.2	4.8	9.15	6			
3	77.0	55.0	0.00	13.8	4.6	9.59				
4	77.0	55.0	0.00	15.0	5.0	9.70				
5	80.0	55.2	0.00	12.4	4.4	9.16	667			
6	72.8	55.4	0.00	14.5	4.0	6.93				
7	66.3	57.5	0.06	13.6	4.5	8.66	22			
8	72.0	54.5	0.00	11.8	3.5	8.20	6			
9	74.5	51.0	0.00	12.1	3.4	6.25				
10	75.0	53.5	0.00	12.3	3.8	6.66				
11	74.0	58.0	0.00	17.5	4.4	9.03				
12			0.02							
Ave	73.4	54.7	0.06	15.5	4.7	9.65		6.7	1.06	
		Total	1.84			270.14				
Min	60.0	49.8	0.00	11.8	2.1	7.65	5	6.7	0.80	
Max	81.6	62.0	0.47	27.0	11.2	13.68	1500	6.7	1.33	

Post-it™ brand fax transmittal memo 7671 | # of pages ▸ 1
To: Mike Carroll | From: Erin Forest?
Co. | Co. Port of B'ham
Dept. | Phone # 676-2500
Fax # 735-4289? | Fax # 671-6411

Highlighted area = rainfall for post point

MIKE: AS YOU REQUESTED. ABOVE IS THE RAINFALL AMOUNTS FOR BELLINGHAM FROM 15 AUGUST THRU 12 SEPTEMBER 1991.
THIS RAIN GAUGE IS LOCATED @ POST POINT WHICH SHOULD BE THE SAME AS THE LITTLE SQUALICUM [illegible]

APPENDIX B

Draft Report

Surface Water Quality and Soil Assessment for the Proposed Little Squalicum Creek Wetlands Compensation Project Bellingham, Washington

January 14, 1992

Prepared for

Port of Bellingham

Prepared by

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INTRODUCTION

This report summarizes our observations, field sampling activities, and laboratory test results, and presents conclusions and recommendations developed for the proposed Little Squalicum Creek Wetlands Compensation Project in Bellingham, Washington. The scope of services outlined in our November 26, 1991 proposal to the Port of Bellingham (Port) included: 1) assessing the present soil quality conditions and the suitability of site soil for development as wetlands compensation, 2) assessing the stormwater quality for suitability as recharge to the proposed wetlands compensation cells, 3) obtaining site soil samples for potential future evaluation of their physical properties, and 4) presenting the stormwater and soil evaluation results in a brief report. Landau Associates was also authorized, in a December 18, 1991 memorandum from Mr. Bill Hagen (Port of Bellingham), to perform geotechnical and hydrologic evaluations, and incorporate the results of those evaluations into the previously authorized report.

Our scope focused on the present conditions in the proposed wetlands compensation areas. It was not intended to provide comprehensive environmental site characterization, or identify past site (or adjacent site) practices that may impact the wetlands compensation areas in the future.

As discussed in the conclusions and recommendations section of this report, additional soil quality assessment is recommended; therefore, this is presented as a draft report. The final report will incorporate the results of the additional soil quality assessment and geotechnical recommendations.

BACKGROUND

The Little Squalicum Creek site (Site) is located within the Little Squalicum Creek drainage in Bellingham, Washington, as shown on the Vicinity Map, Figure 1. The Site is an irregularly shaped parcel of approximately 20 acres. The interior of the Site is relatively level with a gentle downward slope from northeast to southwest. The perimeter of the Site is bounded by steep slopes rising away from the Site boundaries, except the southwest Site boundary that abuts Bellingham Bay.

The Port is evaluating the feasibility of developing wetlands on the Site as compensation for wetlands that will be lost because of the planned expansion of the Bellingham International

Airport. The present conceptual plan for wetlands compensation calls for several wetland cells and an energy dissipation pond (Cell 3), as shown on the Site Map, Figure 2.

According to the Site history provided in the Draft Wetland Compensation Design (Shelton & Associates 1991), the Site has an extensive usage history, including substantial excavation and filling of the Site. The Site was mined for sand and gravel from the 1920s to the 1960s, resulting in the broad, flat drainage feature present on the Site. A number of basins were created onsite for washing gravel during gravel mining operations. These were filled in periodically as mining progressed. The Site was used as a raw log storage facility for 1 to 5 years in the early 1970s. Test pits excavated as part of the Site Hydraulic Assessment (Watershed Dynamics 1991) indicate these Site activities resulted in the placement of up to 3 ft of fill of variable composition (silt to gravel) over a large portion of the Site.

The Little Squalicum Creek drainage upstream of the Site was filled sometime in the past, and upstream stormwater runoff is conveyed via a 36-inch diameter corrugated metal pipe (CMP) that discharges near the north end of the Site. Other stormwater discharges outfall at the Site, including an outfall from the Oeser Cedar facility, which is located a short distance downstream from the 36-inch CMP outfall.

A site hazard assessment (SHA) was recently performed for the Site (Parametrix 1991) because of documented upgradient releases by the Oeser Cedar facility to Little Squalicum Creek via storm sewer outfall. These releases included pentachlorophenol and, possibly, creosote. Little Squalicum Creek was ranked on the Washington State Department of Ecology (Ecology) State Superfund sites list as a result of the SHA, based on elevated concentrations of phenols, semivolatile organic compounds, and TPH in soil, sediment, and/or groundwater samples collected from the Little Squalicum Creek Drainage. It should be noted that the SHA soil samples were reportedly collected within the Little Squalicum Creek drainage course, not from portions of the Site proposed for wetlands compensation.

Analyses of groundwater samples collected at the Site subsequent to the SHA, as part of the wetlands compensation evaluation for the Port, identified elevated concentrations of certain metals and polynuclear aromatic hydrocarbons (PAH). However, the concentration of total suspended solids in the groundwater samples was very high, suggesting the detected constituents may not be elevated in a low-sediment groundwater sample.

STORMWATER SAMPLING AND ANALYSES

One stormwater sample (SW-1) was collected from the Little Squalicum Creek 36-inch diameter CMP outfall during a rainfall event on December 18, 1991. The outfall location is indicated by the stormwater sample location (SW-1) shown on Figure 2. Storm water was collected at the outlet according to accepted stormwater sampling procedures, using a flow-weighed composite sample for most analyses. Field sampling procedures are discussed in Appendix A. The sampled storm event began with light rain at approximately 7:00 a.m. and continued until approximately 12:00 p.m. A few scattered showers occurred after 12:00 p.m. The National Weather Service reported 0.14 inches of precipitation from 4 a.m. to 4 p.m. on December 18. A total of 0.15 inches of precipitation was reported during the 24-hour period from 4 a.m. December 18 to 4 a.m. December 19. The most recent measurable rainfall in Bellingham prior to December 18 was 0.24 inches for the 24-hour period ending December 13 at 4 a.m.

Stream flow at the outfall was visually estimated at approximately 5 gallons per minute (gpm) prior to the storm event. During the initial sample collection, flow increased to about 10 gpm. Flows remained at approximately 10 gpm during the remainder of the flow-weighted composite sample collection.

The stormwater sample was analyzed for total petroleum hydrocarbons (TPH) (EPA Method 418.1), nitrogen as ammonia, nitrate and nitrite, total phosphorous, soluble recoverable phosphorus, dissolved oxygen, hardness, total suspended solids, turbidity, fecal coliform, pH, conductivity, and temperature. pH, conductivity, and temperature data were collected in the field by Landau Associates' personnel. The other analyses were performed by Analytical Resources, Inc. in Seattle, Washington. Analytical results for the surface water sample are presented in Table 1.

SOIL SAMPLING AND ANALYSES

Ten test pits were hand-excavated on December 18, 1991, at the locations (SC-1 through SC-10) shown on Figure 2. The depth of excavation ranged from about 1 to 2 ft below ground surface. Soil conditions were highly variable and included silt, silty sands and gravels, and clean (low silt content) sands and gravels. Fill was encountered at many locations, and in some locations exceeded the depth of exploration. Fill materials encountered varied in composition, but consisted primarily of dense sand and gravel deposits with varying amounts of silt. At some locations, fill contained small amounts of non-putrescible refuse (SC-1, SC-4, and SC-8), wood waste (SC-8), or ash (SC-4). Native soil encountered also consisted primarily of dense sand and gravel deposits with varying amounts of silt, although a very dense silty sand glacial till unit was encountered at one location (SC-8). Groundwater was encountered at two locations (SC-8 and SC-9).

Soil encountered was classified in general accordance with the soil classification system described in Appendix A. Test pit logs are also presented in Appendix A.

Soil samples were collected for chemical analyses from the five locations shown on Figure 2. Sample collection and handling procedures are described in Appendix A. Soil samples were collected from each exploration location for grain-size analyses. Grain-size analyses samples were collected from the uppermost soil unit underlying the surficial root zone.

The soil samples collected for chemical assessment were analyzed for TPH (EPA Method 418.1), semivolatile organic compounds (EPA Method 8270), and selected metals (arsenic, cadmium, chromium, copper, lead, nickel, and zinc) (ICP Method). Soil samples were analyzed for TPH and semivolatile organic compounds because these constituents were detected during the SHA (phenolic compounds are included in semivolatile organic analyses). The metal analyses were performed for general soil quality characterization purposes. The analytical results for soil samples are summarized in Table 2.

Mechanical grain-size analyses were conducted on Site soil samples in general accordance with ASTM D421-58 procedures. The primary purpose of the grain-size analyses is to provide a basis for estimating hydraulic conductivity for Site soil units. Grain-size analysis is also useful for (qualitatively) evaluating soil compaction characteristics.

Hydraulic conductivity was estimated using the empirical relationship:

$$k = Ad_{10}^2$$ (Freeze and Cherry 1979)

where k = hydraulic conductivity (cm/s)

d_{10} = 10 percent finer by weight grain size (mm)

A = empirical coefficient, equal to 1.0

Hydraulic conductivity estimates using this relationship are presented in Table 3. The percent fines (percentage of material finer than the U.S. Standard No. 200 sieve) is also presented in Table 3.

CONCLUSIONS AND RECOMMENDATIONS

Based on data available at the time of report preparation, preliminary conclusions and recommendations were developed regarding soil and stormwater quality, and soil physical characteristics. As discussed in the Introduction, this is a draft report. Additional evaluation of soil quality is recommended in a following subsection, and should be completed prior to development of conclusions and recommendations for the final report. Also, project-specific geotechnical recommendations will be presented in the final report, although general conclusions regarding Site geotechnical conditions are presented in this draft report.

Geotechnical Conditions

Site soil consists primarily of slightly silty to silty sand and gravel, which is suitable as structural fill for the small embankments and pathways currently anticipated for the Site. The high permeability of some of these soil units may necessitate soil amendment or construction of a low-permeability liner system to develop the water retention characteristics needed for wetlands development.

Silty soil units will be moisture sensitive. It may be necessary to reduce the moisture content of some Site soil units prior to placement as structural fill to achieve adequate compaction. It may not be practicable to attain adequate compaction for some of these soil units if construction occurs during wet weather.

Soil containing organic matter, construction refuse, and other deleterious materials were observed during the Site investigation. These materials are not suitable for structural fill, and may not be suitable for other site uses. Offsite disposal of these materials may be necessary.

Dense glacial till was encountered at Exploration SC-8. Excavation of glacial till (if needed) may require the use of a dozer-mounted ripper prior to excavation.

Water Quality

Water quality standards that specifically apply to waters discharged to wetlands are not presently available for Washington State. However, Washington State Surface Water Quality Standards (WAC 173-201) can be used as general guidance to assess the advisability of stormwater pretreatment prior to entrance into the proposed wetlands. Washington State Surface Water Quality Standards are provided in Table 1. As indicated in Table 1, concentrations of zinc and (marginally) lead exceed surface water quality standards. As a result, a biofiltration swale or other type of stormwater pretreatment may be advisable prior to storm water entering the proposed wetlands compensation cells.

Soil Quality

Freshwater sediment quality standards are not currently available for Washington State. However, the Washington State Model Toxics Control Act (MTCA; WAC 173-340) provides soil cleanup criteria that are applicable to general soil quality. MTCA soil cleanup criteria are presented in Table 2. As shown in Table 2, the sample collected at Exploration SC-6 equaled (but did not exceed) MTCA Method A cleanup criteria for the summation of carcinogenic PAH.

PAH were identified during the Oeser Cedar SHA along with phenolic compounds and TPH. However, neither phenolic compounds or TPH were detected in the sample from Exploration SC-6. Because of the absence of associated compounds (phenols and TPH) and because Exploration SC-6 was located in an area unlikely to be impacted by the Oeser Cedar outfall, it is improbable that the PAHs detected are related to the Oeser Cedar outfall.

PAH are ubiquitous. They are present in asphaltic concrete, high-molecular weight or weathered petroleum products, typical urban stormwater runoff, as well as other materials. The PAH detected onsite may have originated from one of these sources, or resulted from other activities that occurred on the Site.

The mere exceedance of MTCA cleanup criteria does not automatically require remedial action. At the low concentrations detected, further action may not be needed if the distribution of PAH is limited, signifying that the detection at Exploration SC-6 is anomalous and not indicative of a widespread condition.

We recommend collecting three additional samples in the vicinity of Exploration SC-6 to evaluate the PAH distribution in the area of concern. Samples should be collected at a distance of about 5 to 10 ft from Exploration SC-6, approximately equally spaced around the original exploration. Samples should be analyzed for PAH. Conclusions and recommendations concerning PAH distribution, the scope for additional investigation or remediation (if needed), and the viability of the Site for use as wetlands compensation (with respect to the issues addressed in this report) should be developed based on the results of these analyses.

* * * * *

Landau Associates, Inc. has prepared this draft report for the Port of Bellingham for their use on the Little Squalicum Creek Wetlands Compensation Project in Bellingham, Washington. Our investigation was accomplished in accordance with generally accepted environmental and geotechnical engineering practices at the time these activities were accomplished. No other warranty or representation, express or implied, is applicable.

This is a draft report. Until the additional activities described in this report are completed, all conclusions and recommendation are preliminary and subject to modification. Should you have any questions, please contact me.

LANDAU ASSOCIATES, INC.

By: DRAFT

Lawrence D. Beard, P.E.
Project Manager

LDB/KGC/sms
No. 01-18.10

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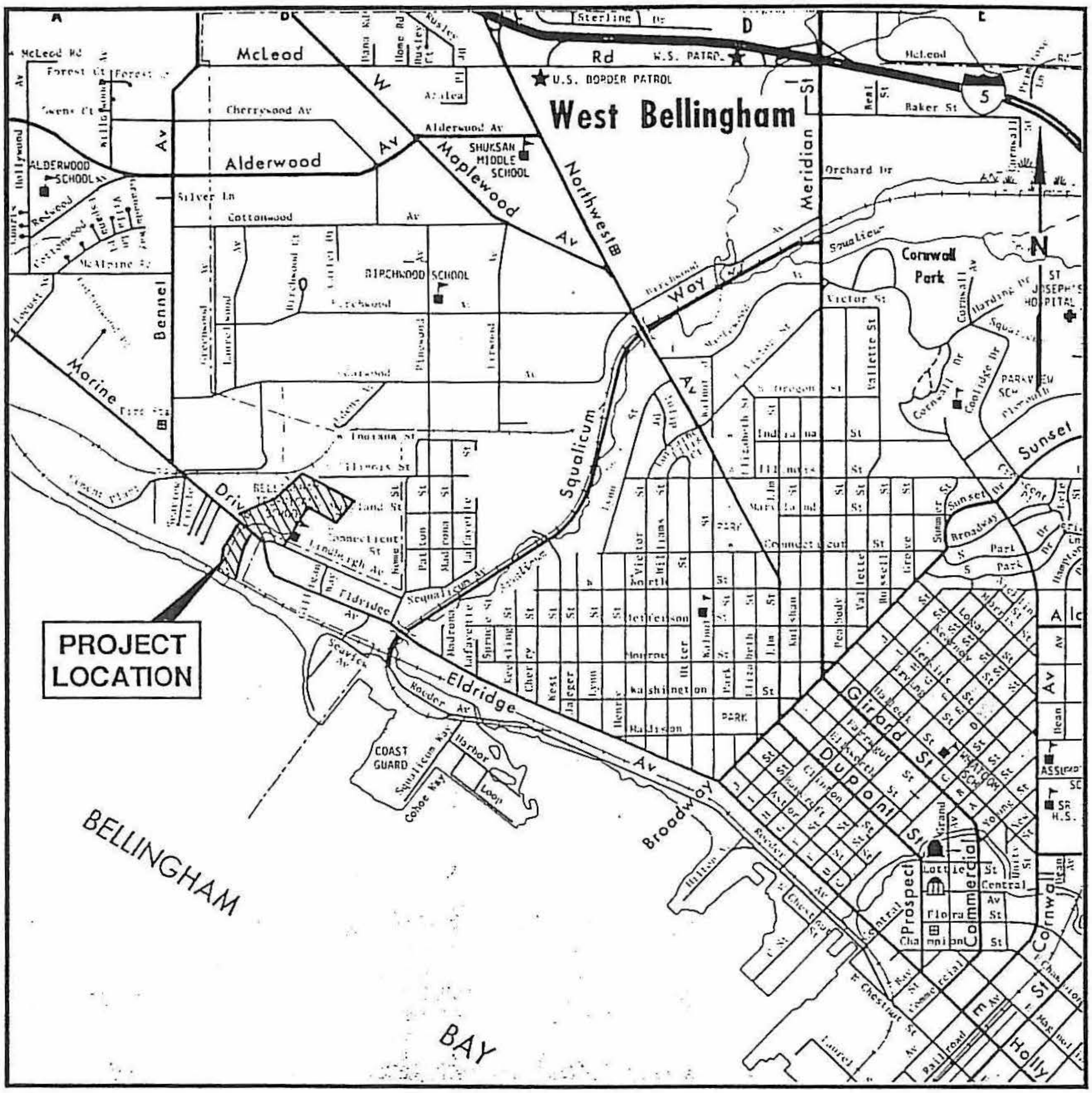


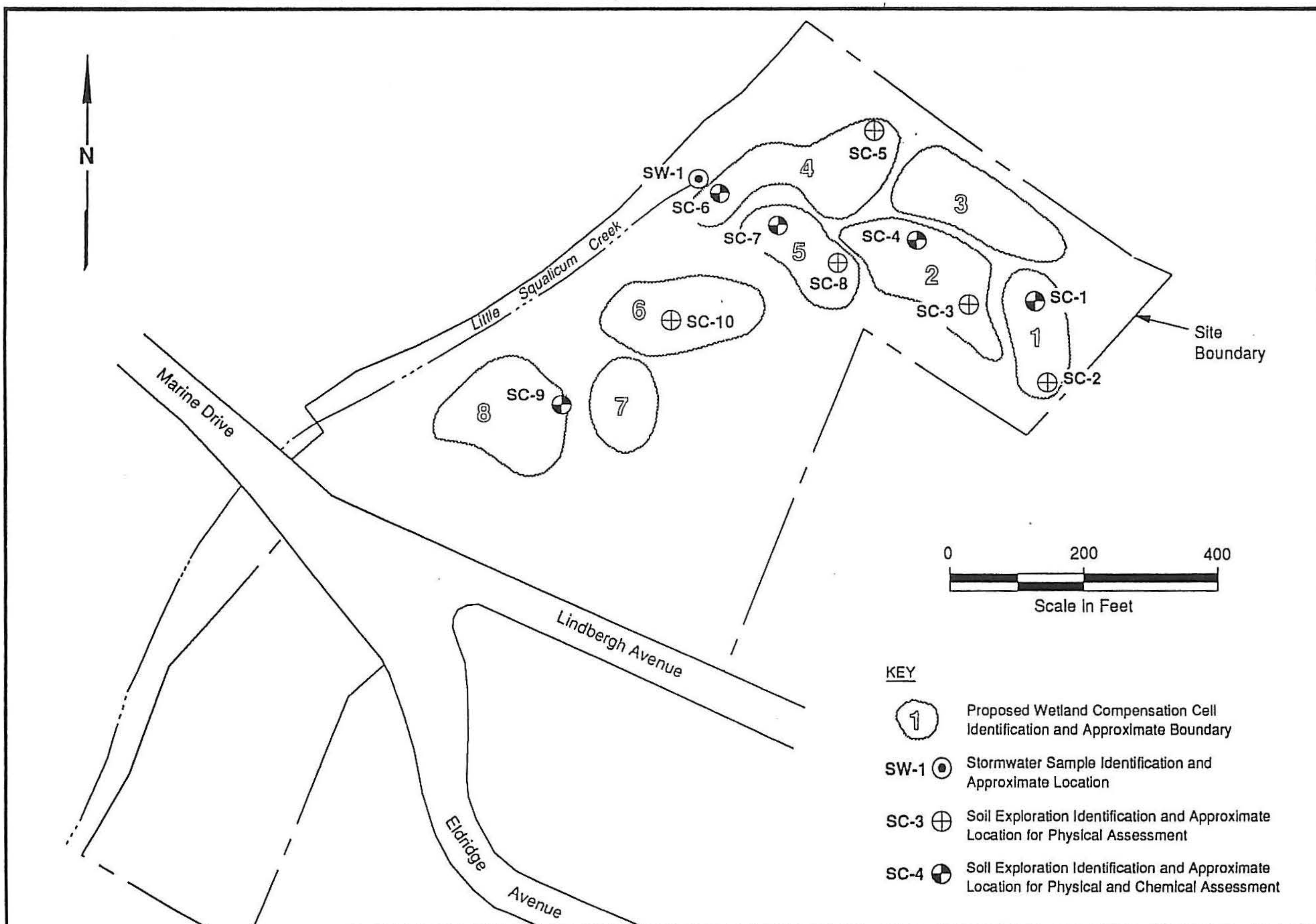
0 2000 4000

Scale in Feet

Vicinity Map

Figure 1

01-18.10 Port of Bellingham/ Little Squalicum Creek/ Wetlands Compensation/ Geotechnical/Environmental Report 1/92



Source: Reid Middleton (1991).

Site Map

Figure 2

TABLE 1

SUMMARY OF STORM WATER ANALYTICAL RESULTS[a]

Constituent	SW-1	Surface Water Quality Standards[b]
TPH	<1	--
Nitrogen as Ammonia	0.132	--
Nitrogen as Nitrate and Nitrite	1.080	--
Total Phosphorus	0.150	--
Soluble Recoverable Phosphorus	0.114	--
Dissolved Oxygen	11.16	>8.0
Hardness	86.5	--
TSS	9.3	--
Turbidity (NTU)	20	--
Fecal Coliform (#/100 mL)	56	100
Zinc	0.221	0.094[c]
Copper	0.009	0.010[c]
Lead	0.005	0.003[c]
pH (pH units)	7.6	6.5-8.5
Conductivity (µS)	305	--
Temperature (°C)	11.0	<18

(a) All results in parts per million, unless indicated otherwise.
(b) Based on WAC 173-201, Class A waters.
(c) Fresh water chronic criteria.

DRAFT

TABLE 2

SUMMARY OF SOIL ANALYTICAL RESULTS[a]

Constituent	Sample Location SC-1	SC-4	SC-6	SC-7	SC-9	MTCA Soil Criteria[b]
TPH	28	ND[c]	ND	ND	ND	100
Metals						
Arsenic	ND	ND	ND	ND	ND	20
Cadmium	ND	0.4	0.5	0.5	ND	2.0
Chromium (total)	36	36	44	45	32	100.0
Copper	31	25	64	42	21	3200[d]
Lead	38	51	19	15	ND	250.0
Nickel	49	37	52	61	36	1600[d]
Zinc	241	100	123	119	40	16000[d]
Semivolatile Organics Compounds[e]						
Benzo(a)anthracene	ND	ND	0.053 J[f]	ND	ND	--
Chrysene	ND	ND	0.250	ND	ND	--
Benzo(b,k)fluoranthene	ND	ND	0.280	ND	ND	--
Benzo(a)pyrene	ND	ND	0.150	ND	ND	--
Indeno(1,2,3-cd)pyrene	ND	ND	0.200	ND	ND	--
Dibenz(a,h)anthracene	ND	ND	0.067 J	ND	ND	--
Benzo(ghi)perylene	ND	ND	0.061 J	ND	ND	--
Total PAHs[g]	--	--	1.00	--	--	1.0

(a) All results in mg/kg.

(b) MTCA Method A soil residential criteria, except where indicated otherwise.

(c) ND = Not detected.

(d) MTCA Method B soil residential criteria.

(e) Analyses included the full list of EPA Method 8270 constituents. Only detected constituents are presented in this table.

(f) J = laboratory estimated value.

(g) Summation of carcinogenic polycyclic aromatic hydrocarbons. Value listed for sampling location SC-6 includes all the listed semivolatile compounds except benzo(ghi)perylene.

TABLE 3

ESTIMATED SOIL HYDRAULIC CONDUCTIVITY AND PERCENT FINES

Exploration Number	Wetland Cell Number	Estimated Hydraulic Conductivity[a] (cm/s)	Percent Fines[b]
SC-1	1	$6X10^{-3}$	10.6
SC-2	1	$9X10^{-4}$	21.2
SC-3	2	$9X10^{-2}$	7.4
SC-4	2	$4X10^{-4}$	27.9
SC-5	4	$9X10^{-2}$	6.4
SC-6	4	$1X10^{-4}$	39.0
SC-7	5	$1X10^{-4}$	43.8
SC-8	5	$2X10^{-3}$	21.0
SC-9	8	$9X10^{-2}$	5.0
SC-10	6	$9X10^{-4}$	21.7

(a) Estimated using correlations between grain-size distribution and hydraulic conductivity. Estimates are only approximate, and may vary significantly with location and depth below ground surface.

(b) Percentage of sample passing the U.S. Standard No. 200 sieve.

APPENDIX A
FIELD PROCEDURES

STORMWATER SAMPLE

One stormwater discharge sample (SW-1) was collected from the primary Little Squalicum Creek outfall shown on Figure 2. Stormwater sampling was initiated shortly after the start of a rainfall event on December 18, 1991. Grab samples for dissolved oxygen, total petroleum hydrocarbons, specific conductance, pH, and temperature were collected as discharge flows began to increase. Stormwater for other constituents was collected as a flow-weighted composite sample, consisting of 3 grab samples obtained over the first 3 hours of the rainfall event. Specific conductance, pH, and temperature were measured in the field with meters calibrated according to the manufacturers recommended procedures.

Samples were stored in a cooler with ice and delivered to the testing laboratory at the end of the work day for analysis.

SOIL SAMPLES

Near-surface soil conditions at the Site were explored using a shovel and pry bar at the 10 locations shown on Figure 2. Soil encountered was described in the field using the Soil Classification System (Figure A-1), in general accordance with ASTM D-2448, "Standard Recommended Practice for Description of Soils (Visual-Manual Procedure)." Logs of the test explorations are included in this Appendix (Figures A-2 through A-6). The exploration logs represent our interpretation of the field logs and the results of grain-size analysis testing.

Five samples were collected for soil quality analysis at the locations shown on Figure 2. Sample were collected by removing undisturbed soil from the sidewall of the exploration, and homogenizing the soil in a stainless-steel bowl. The sample from each location was composited from about 0.5 to 1.5 ft below ground surface. Sample bottles were filled from the stainless-steel bowl, stored in a cooler with ice, and delivered to the testing laboratory at the end of the work day for analysis.

Test pit locations were located in the field by pacing and estimating distances from Site features. The ground surface elevations shown on the test pit logs are interpolated from a topographic survey prepared by Reid Middleton, dated October 1991. The elevations refer to City of Bellingham datum.

Soil Classification System

MAJOR DIVISIONS			GRAPHIC SYMBOL	USCS LETTER SYMBOL[1]	TYPICAL DESCRIPTIONS[2][3]
COARSE-GRAINED SOIL (More than 50% of material is larger than No.200 sieve size)	GRAVEL AND GRAVELLY SOIL (More than 50% of coarse fraction retained on No.4 sieve)	CLEAN GRAVEL (Little or no fines)		GW	Well-graded gravel; gravel/sand mixture(s); little or no fines
				GP	Poorly graded gravel; gravel/sand mixture(s); little or no fines
		GRAVEL WITH FINES (Appreciable amount of fines)		GM	Silty gravel; gravel/sand/silt mixture(s)
				GC	Clayey gravel; gravel/sand/silt mixture(s)
	SAND AND SANDY SOIL (More than 50% of coarse fraction passed through No.4 sieve)	CLEAN SAND (Little or no fines)		SW	Well-graded sand; gravelly sand; little or no fines
				SP	Poorly graded sand; gravelly sand; little or no fines
		SAND WITH FINES (Appreciable amount of fines)		SM	Silty sand; sand/silt mixture(s)
				SC	Clayey sand; sand/clay mixture(s)
FINE-GRAINED SOIL (More than 50% of material is smaller than No.200 sieve size)	SILT AND CLAY (Liquid Limit less than 50)			ML	Inorganic silt and very fine sand; rock flour; silty or clayey fine sand or clayey silt with slight plasticity
				CL	Inorganic clay of low to medium plasticity; gravelly clay; sandy clay; silty clay; lean clay
				OL	Organic silt; organic, silty clay of low plasticity
	SILT AND CLAY (Liquid Limit greater than 50)			MH	Inorganic silt; micaceous or diatomaceous fine sand or silty soil
				CH	Inorganic clay of high plasticity; fat clay
				OH	Organic clay of medium to high plasticity; organic silt
HIGHLY ORGANIC SOIL				PT	Peat; humus; swamp soil with high organic content

Notes: 1. USCS letter symbols correspond to the Unified Soil Classification System. Dual letter symbols (e.g., SM-SP) for a sand or gravel indicate a soil with an estimated 5-15% fines. Multiple letter symbols (e.g., ML/CL) indicate borderline or multiple soil classifications. Only the first letter symbol's respective pattern is shown on logs.

2. Soil descriptions shown on logs are based on the general approach presented in the *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)*, as outlined in ASTM D 2488.

3. Soil description terminology (which is based on visual estimates of the percentages of each soil type) is as follows:

Primary Soil Type(s) - e.g., "GRAVEL," "SAND," "SILT," "CLAY," etc.
Secondary Soil Type(s) (>15%) - e.g., "gravelly," "sandy," "clayey," etc.
Modifier(s) (>5% and ≤15%) - e.g., "with gravel," "with sand," "with clay," etc.
Minor Component(s) (≤5%) - e.g., either "trace gravel," "trace sand," "trace clay," etc., or no mention of minor soil type

Soil Classification System | Figure A-1

SC-1

Depth (feet)	Unified Soil Classification System Symbol	Description (Approximate Elevation 41 Ft)[a]
0.0-1.6	SW	Gray-brown, fine to coarse SAND with silt, fine gravel, and cobbles; two pieces of asphalt observed (dense, moist) (fill)
1.6-2.0	SW	Dark brown to gray brown medium to coarse SAND with fine gravel and silt (dense, moist)

Test pit completed to 2.0 ft on 12-18-91.
No groundwater seepage encountered.

SC-2

Depth (feet)	Unified Soil Classification System Symbol	Description (Approximate Elevation 41 Ft)
0.0-1.5	GM	Dark brown silty, gravelly fine to coarse SAND with organic matter and cobbles (dense, moist)

Test pit completed to 1.5 ft on 12-18-91.
No groundwater seepage encountered.

(a) Elevations interpolated from a topographic map prepared by Reid Middleton, October 1991. Elevations referenced to City of Bellingham Datum.

SC-3

Depth (feet)	Unified Soil Classification System Symbol	Description (Approximate Elevation 39 Ft)
0.0-0.4	GM	Dark brown SILT and GRAVEL (dense, moist)
0.4-1.5	GW	Gray-brown fine to coarse SAND and GRAVEL with silt, and cobbles (dense, moist)

Test pit completed to 1.5 ft on 12-18-91.
No groundwater seepage encountered.

SC-4

Depth (feet)	Unified Soil Classification System Symbol	Description (Approximate Elevation 39 Ft)
0.0-0.4	GM	Dark brown SILT with gravel and broken glass (dense, moist) (fill)
0.4-1.2	SM/GM	Dark brown and dark gray silty fine to coarse SAND with fine gravel, trace of ash material and a piece of rusty pipe (dense, moist) (fill)
1.2-2.0	GM	Red-brown SILT with fine to coarse gravel (dense, moist) (fill)

Test pit completed to 2.0 ft on 12-18-91.
No groundwater seepage encountered.

Log of Test Pits | Figure A-3

SC-5

Depth (feet)	Unified Soil Classification System Symbol	Description (Approximate Elevation 40 Ft)
0.0-0.4	GM	Brown silty GRAVEL with wood chips (dense, moist) (fill)
0.4-1.7	GW	Brown and light yellow brown fine to coarse SAND and GRAVEL with cobbles and silt, one pocket of till-like clay material (dense, moist to wet) (fill)

Test pit completed to 1.7 ft on 12-18-91.
No groundwater seepage encountered.

SC-6

Depth (feet)	Unified Soil Classification System Symbol	Description (Approximate Elevation 40 Ft)
0.0-1.8	SM	Dark gray silty fine to coarse SAND with fine gravel, cobbles, and organic matter (dense, moist)

Test pit completed to 18 ft on 12-18-91.
No groundwater seepage encountered.

SC-7

Depth (feet)	Unified Soil Classification System Symbol	Description (Approximate Elevation 39 Ft)
0.0-1.7	SM	Dark brown and gray-brown silty fine to coarse SAND with fine gravel, organic matter and a 2-inch lense of brown fine sand (dense, moist)

Test pit completed to 1.7 ft on 12-18-91.
No groundwater seepage encountered.

SC-8

Depth (feet)	Unified Soil Classification System Symbol	Description (Approximate Elevation 39 Ft)
0.0-0.8	GM	Dark brown and gray-brown silty sandy GRAVEL with a trace of wood chips and broken glass (dense, moist to wet) (fill)
0.8-1.1	SM	Gray-brown silty fine to coarse SAND with gravel (very dense, moist) (till)

Test pit completed to 1.1 ft on 12-18-91.
Groundwater observed at 0.4 ft below ground surface.

01-18.10 Port of Bellingham/Little Squalicum Creek/Wetlands Compensation Geotechnical/Environmental

Log of Test Pits	Figure A-5

SC-9

Depth (feet)	Unified Soil Classification System Symbol	Description (Approximate Elevation 30 Ft)
0.0-0.4	SM	Very dark brown sandy SILT with organic matter (loose, moist)
0.4-1.2	SW	Gray-brown with red-brown mottling fine to coarse SAND with trace of silt (loose, moist)
1.2-1.8	SP/SM	Red-brown fine SAND and silty fine SAND with a 0.5-inch layer of roots at 1.2 ft (loose, moist to wet)

Test pit completed to 1.8 ft on 12-18-91.
Groundwater observed at 1.4 ft below ground surface.

SC-10

Depth (feet)	Unified Soil Classification System Symbol	Description (Approximate Elevation 33 Ft)
0.0-0.4	SP/ML	Dark brown fine SAND and SILT with gravel (loose to soft, wet)
0.4-1.7	SM	Gray-brown silty fine to coarse SAND with fine gravel (very dense, moist to wet)

Test pit completed to 1.7 ft on 12-18-91.
No groundwater seepage encountered.

Log of Test Pits | Figure A-6

APPENDIX C

UPLAND VEGETATION AND WETLANDS ANALYSIS REPORT

FOR LITTLE SQUALICUM CREEK MITIGATION SITE

by Sheldon and Associates

Upland Vegetation. About 40% of the site is highly disturbed meadow, most of it upland. Much of the upland meadow is dominated by several upland grasses and common tansy (Tanacetum vulgare), with a wide variety of other weedy upland herbs present. Throughout the upland meadow community there are also many scattered weedy shrubs, vines and trees such as ornamental hawthorn (Crataegus monogyna), Himalayan blackberry (Rubus discolor), red alder (Alnus rubra) and black cottonwood (Populus trichocarpa). A detailed species list of all species observed on site with common, scientific names and wetland indicator status is provided in Appendix A. Generally vegetation communities present on site are shown on Figure 5.

Roughly 50% of the site is disturbed forest, much of it upland. The upland portions of the forest were dominated by red alder, black cottonwood, ornamental hawthorn, and in some areas by big-leaf maple (Acer macrophyllum). Common understory shrubs and vines included Himalayan blackberry, and common snowberry (Symphoricarpos albus), Pacific blackberry (Rubus ursinus). The herbaceous layer was generally depauperate. Field horsetail (Equisetum arvense) was the most common species on the herbaceous layer.

The approximately 10% of the remaining upland was scrub/shrub habitat, most of it dominated by Himalayan blackberry and ornamental hawthorn.

Small areas of the disturbed meadows were wetlands. In those wetlands common tansy was absent or not dominant. A variety of rushes (Juncus spp.) and sedges (Carex, Eleocharis, Scirpus spp.) were present, and the grass species were mostly hydrophytic. Although some scattered ornamental hawthorn and Himalayan blackberry were present in the meadow wetlands, these species were often found with or replaced by various willows (Salix spp.).

The largest and most diverse wetlands were within or at the edge of forests on the site. Though these wetlands were within the forest canopy, most of the wetlands were only partly forested themselves. In the wetlands, the most prevalent tree species included red alder, black cottonwood, and Pacific willow (Salix lasiandra). Big-leaf maple was prevalent in one wetland. Common shrubs include Sitka willow (Salix sitchensis), coast black gooseberry (Ribes divaricatum), and in more disturbed areas, Himalayan blackberry. Common herbaceous layer species include Watson's willow-herb (Epilobium watsonii), smooth rush (Juncus effusus), field horsetail, and giant horsetail (Equisetum telmateia).

Wetlands

The site was checked for the presence of wetlands as defined by the Corps of Engineers (COE), "those areas inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions." (40 CFR Section 230.3(t)).

The wetlands on site were assessed using the three parameter approach as provided within the Federal Manual for Identifying and Delineating Jurisdictional Wetlands (FICWD, 1989). In order for an area to be identified as wetland it must have positive indicators of hydric (wetland) soils, hydrology, and hydrophytic (wetland) vegetation. Each parameter, including field sampling techniques, is discussed in this report.

The site inspection was conducted over 4 days, during the dry season, between August 9 and August 26, 1991 by James Hartley and Deborah Dole of Sheldon & Associates. See Figure 6 for the surveyed wetland boundaries.

Hydric Soils. Hydric soils are defined as soils that are saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper part (U.S.D.A. Soil Conservation Service, 1987).

Soils on site were examined by digging soil pits and re-checked with a handheld auger. The draft Whatcom County Soil Survey (SCS, in press) was checked for the presence of mapped hydric soils.

Hydrophytic Vegetation. Hydrophytic vegetation is defined as macrophytic plant life growing in water, soil, or on a substrate that is at least periodically deficient in oxygen as a result of excessive water content (FICWD, 1989).

Vegetation on site was identified after Hitchcock and Cronquist (1973). Wetland plant species indicator status was determined using Reed (1988).

Hydrology. An area has wetland hydrology when saturated to the surface or inundated at some point in time during an average rainfall year. It is generally required for an area to be saturated to the surface for at least one week or ponded at least two weeks during the growing season (FICWD, 1989). Wetland hydrology was determined by examining field evidence.

Individual Wetlands. Fourteen separate wetlands were identified on site, only four of which are greater than an acre in size. Five of the six largest wetlands on site are located at the toe of slopes leading into Little Squalicum Creek Valley. The following wetland descriptions will follow the order the wetland delineations were done in the field, generally from the upper part of the Little Squalicum Valley near the Vo Tech parking lot down towards Bellingham Bay. The uplands adjacent to each wetland are described briefly. Table 2 summarizes the wetland community types and acreages of the wetlands located on the Little Squalicum site.

Wetland classifications provided are based on the U.S. Fish & Wildlife Service classification, Classification of Wetland and Deepwater Habitats (Cowardin, 1979).

Wetland #1. This wetland is located at the eastern end of the site in a depression bordered on the east by the fill for the Vo Tech parking lot, on the north by the fill over the stormwater sewer which enters from the east, and to the south and west by flat areas of disturbed meadow. The surrounding uplands are 3 to 6 feet higher in elevation. Wetland #1 is a palustrine, forested, broad-leaved deciduous, semipermanently flooded wetland (PFO1F), acres in size.

Pacific willow and black cottonwood were the dominant trees with Pacific willow, Sitka willow and black cottonwood the dominant species in the sapling and shrub layer. The herbaceous layer was depauperate, probably due to a combination of lengthy flooding and shading from the dense canopy. Reed canarygrass (Phalaris arundinaceae) is a significant component in a portion of the wetland near the edge where there is less shading.

The dark gray (10 YR 4/1) silt loam soil was saturated to near the surface and the water table was encountered at 10 inches below the surface. The soil met the color criteria for hydric soil.

The source of hydrology for this wetland is surface and groundwater flow which cannot escape the closed depression.

The uplands from the southeast to the southwest around the wetland are disturbed meadow dominated by upland grasses and common tansy. The steep slope emerging from the northwest to the southeast sides of the wetland is dominated by red alder, and Himalayan blackberry.

Water Source. Water source for this wetland includes surface and subsurface runoff from north portions of the site and the Vo Tech parking lot, precipitation and groundwater. This wetland most likely developed as a result of the construction and presence of the storm drain line and trail. Water entering this wetland is held against the raised sewer line and remains throughout the winter and well into the summer.

Wetland Functional Value. Wetland #1 is a small closed depressional wetland. Its small size limits the functional values which it provides. Because it is a closed depressional area it provides limited stormwater attenuation. The wetland provides limited wildlife habitat, probably primarily for small passerines, small mammals and amphibians. Small pockets of standing water provide some habitat for insect production. The wetland has no apparent outlet, thus no biofiltration functioning would be provided and no groundwater recharge is likely as the wetland is perched on top of fill.

Upland Functional Value. Upland buffers surrounding this wetland include a forest community and a meadow. Both the forest community and the meadow provide wildlife habitat for small passerines and small mammals. Although wetland #1 is disturbed and contains trash, surrounding upland forested areas provide some buffering from disturbance on the east side of the wetland.

Wetland #2. Wetland #2 is a long linear wetland complex consisting of a series of mostly unvegetated narrow channels, which connect wider vegetated sections of the wetland. It is situated along the south side of Little Squalicum Creek Valley beginning south of the sewer line near wetland #1 in the eastern section of the site, and extending in a westerly direction before ending at a culvert which empties into Little Squalicum Creek near the Marine Drive Bridge. Wetland #2 includes palustrine, emergent, persistent, saturated (PEM1B); palustrine, scrub/shrub broad-leaved deciduous, saturated (PSS1B); and palustrine, forested, broad-leaved deciduous, seasonally flooded (PFO1C) habitats.

A portion of the eastern end of this wetland is a narrow depression with little vegetation. Much of this area has a gravel substrate. Vegetation within this depression include several black cottonwood and red alder saplings with some smooth rush in the herbaceous layer. This area was determined to be wetland based on the presence of hydrophytic vegetation and topography. Evidence of ponding in the depression indicated that it holds water early in the growing season and drains west towards the main body of the wetland.

West of the gravel depression the wetland expands into a palustrine emergent meadow vegetated with reed canarygrass. To the north and south of the gravel depression two parallel lobes of wetland #2 are also dominated by reed canarygrass. This area of the wetland was delineated focussing primarily on vegetation and topography. The wetland was demarcated at the confluence of reed canarygrass and common tansy.

To the northwest, wetland #2 extends in a lobe of disturbed palustrine, emergent and scrub/shrub habitats dominated by reed canarygrass, smooth rush, Watson's willow herb, field horsetail, birdsfoot trefoil (Lotus corniculatus), as well as saplings of black cottonwood and ornamental hawthorn. The end of this lobe is separated from wetland #5 by a path which appears to be on an abandoned road. Several small patches of upland occurring within this lobe have been included due to their small size. Vegetation was the primary visual to the wetland boundary in this portion of wetland #2.

The unforested sections of wetland #2 described above are fed by surface and groundwater, and join adjacent to the southern side slope of Little Squalicum Creek Valley before narrowing and entering a forested area to the southwest following the toe of the southern slope. The rest of wetland #2 is either partially forested or closely enclosed by the forest canopy. Much of the rest of wetland #2 follows a channel of varying width, portions of which appear to have been excavated. Some areas are more expansive complexes of emergent and scrub/shrub vegetation.

The uplands to the north and east of these eastern portions of wetland #2 are disturbed meadow dominated by various upland grasses, common tansy, chicory (Cichorium intybus), and a variety of other weedy upland herbs.

Where wetland #2 enters the forest, the canopy layer consists of red alder, black cottonwood with an understory of red-osier dogwood (Cornus stolonifera), reed canarygrass, and field horsetail. Some slough sedge (Carex obnupta) is present. Several black cottonwoods blew down this past winter in this section of wetland #2. The wetland boundary is obvious in most of this area because of sharp topographic breaks along the channel. There is evidence of ponding on the substrate and the soil was still saturated during the August site visit in some places.

This channeled portion of wetland #2 culminates in a narrow ditch lined with common snowberry (Symphoricarpos albus) and a trace of salmonberry (Rubus spectabilis). Continuing west, the ditch connects to an area of forested wetland with a canopy of red alder, and Pacific willow. Shrubs consist of salmonberry, coast black gooseberry, red-osier dogwood and a trace of Douglas' spirea (Spiraea douglasii). Herbs consist of large-leaf avens (Geum macrophyllum), Watson's willow-herb, creeping buttercup (Ranunculus repens), small-fruited bulrush (Scirpus microcarpus), smooth rush, American manna grass (Glyceria grandis), sawbeak sedge (Carex stipata), lady fern (Athyrium felix-femina), and stinging nettle (Urtica dioica). The wetland boundary was easily identified by topographic break and the presence of common snowberry in the surrounding uplands.

Much of the rest of wetland #2 to the west is a sharply demarcated depression with a depauperate herbaceous layer overtopped with Himalayan blackberry rooted slightly above the wetland. This portion of the wetland was delineated primarily on the basis of soil, topography and the presence or evidence of hydrology. Vegetation for the most part was used as a secondary criteria, though in areas red-osier dogwood and Pacific willow are common components of the overstory. This western-most portion of wetland #2 terminates in a depression which held standing water after moderate short-term summer rains. A culvert located in this depression drains into Little Squalicum Creek.

Soils in this large, disturbed wetland are variable. In a portion of the wetland, dark gray (10 YR 4/1) sandy clay loam with bright mottles is encountered below the dark surface horizon.

Sources of hydrology for this wetland are also variable. In the eastern portion of the wetland, precipitation, and surface runoff provide most of the hydrologic budget except for those areas next to the side slope of the valley where groundwater flow is an important component. Further to the west near the Marine Drive Bridge, two storm sewers add to the surface water fraction of the hydrologic budget. The western end of wetland #2 is obviously wetter, for longer periods and probably more frequently, than the eastern "upstream" portion of the wetland.

The uplands adjacent to the forested portion of wetland #2 are also forested, dominated by red alder and black cottonwood in the overstory, Himalayan blackberry and common snowberry in the shrub layer, and Pacific blackberry in the understory.

Water Source. The water sources for wetland #2 include overland and subsurface flow from the upper (southeast) portion of the site and from the north facing slopes to the south of the wetland, groundwater, precipitation, and storm drains entering from the south.

Stormwater and surface flows entering the system during the winter, the growing season or during flood events flows through the braided unvegetated channels of the wetland. These channels are periodically interspersed with larger, flatter areas where water slows down. When in these areas, water slows down and percolates slowly through the more vegetated areas. The channel becomes incised and at least six feet deep at the west end of the wetland. This incised channel at the west end holds water during the winter and throughout much of the growing season. Water exits the wetland via a culvert at the west end and flows west towards the beach.

Wetland Functional Value. Wetland #2 provides good wildlife habitat because of the variety of habitat types (palustrine emergent, scrub/shrub and forested), the species diversity and the structural diversity of the tree canopy, shrub layer and ground cover. Downed logs, brush piles and blackberry topped channels increase the habitat diversity. A variety of small mammals such as mice, voles and ground squirrels, as well as small passerines most likely use the area for nesting, feeding and resting. The blackberry bushes provides impenetrable cover for the escape of prey species and provide nesting locations for small passerine birds.

In the presence of a sediment source, the wetland may provide limited biofiltration of sediments before they enter the Bay. Biofiltration would occur primarily within the wide flat reed canarygrass portion of the wetland.

The wetland provides surface water conveyance via the channels. Dispersed depressional areas within the wetland may provide limited surface water attenuation and flood storage from runoff of surrounding filled areas. Because the site is perched on fill groundwater recharge is unlikely.

Upland Functional Value. Surrounding uplands include forest communities and meadows. These provide additional wildlife habitat. The variety of habitat types, the species diversity and the structural diversity of the tree canopy, shrub layer and ground cover provide good quality habitat. The upland areas provide additional habitats for resting, feeding and breeding for small mammals and passerines.

Upland areas may also provide some stormwater attenuation functioning and may act as a recharge area for the wetland. Upland areas, especially the forested areas and blackberry thickets provide buffering to the wetland from intrusion.

Wetland #3. Wetland #3 is generally located along the toe of the northern slope of Little Squalicum Valley from the edge of the fill for the Vo Tech parking lot, west to the fill adjacent to where the two storm sewers daylight to form the "headwaters" of Little Squalicum Creek. This acre wetland has two parts, a long linear portion which appears to occupy the remnant upper channel of Little Squalicum Creek along the toe of the north slope of the valley, and a parallel lobe of disturbed wetland along the eastern portion of the remnant channel which joins the channel portion via a low spot in the berm. The remnant channel portion includes palustrine, emergent, nonpersistent, permanently flooded (PEM2H); palustrine, forested, broad-leaved deciduous, saturated (PEM1B); and palustrine, scrub/shrub, broad-leaved deciduous, saturated (PSS1B) habitats. The parallel lobe is palustrine, emergent, persistent, saturated (PEM1B) and palustrine, forested, broad-leaved deciduous, saturated (PFO1B) wetland (Cowardin et. al., 1979).

Overstory, sapling, and shrub vegetation within and along the remnant channel includes Pacific willow, Sitka willow, red alder and black cottonwood, western crabapple (Pyrus fusca), Douglas' hawthorn (Crataegus douglasii), ornamental hawthorn and Himalayan blackberry. Prominent herbaceous species include smooth rush, field horsetail, and Canada bluegrass (Poa compressa), with true watercress (Rorippa nasturtium-aquaticum), small-fruited bulrush, and water pepper (Polygonum hydropiper) emerging from the standing water.

In the lobe parallel to the channel, the forested portion is dominated by red alder in the overstory, with scattered ornamental hawthorn saplings and Canada bluegrass in the herbaceous stratum.

Soils were not investigated in the inundated portion of the wetland. In the eastern portion of the parallel lobe portion of the wetland, soils exhibited the strong hydric indicators of dark gray color (N 5/0) immediately below the thin dark A horizon, and a noticeable sulfitic odor when the soil was examined. In addition, the soil was saturated to the surface and the water table was 7 inches below the surface in August. The soil in the connection between the abandoned channel and the parallel lobe had only marginal hydric color characteristics, being either sand (no color taken) or dark brown sandy clay with yellowish brown mottles (10 YR 3/3 with 10 YR 5/6 mottles) in the horizon beneath the dark surface horizon. However the soil was moist at the surface in late summer. Apparently this low area in the berm along the remnant creek channel has sufficient hydrology to develop mottles. Because this sandy soil appears to be an entisol, a matrix chroma of 3 with bright mottles is evidence of hydric soil (FICWD, 1989). In other portions of the parallel lobe the soils are more disturbed, with cobble and gravel apparently having been imported.

Hydrology in wetland #3 is varied. The hydrology in the remnant channel appears to be dominated by springs in the channel itself which is undoubtedly significantly augmented by groundwater flow from the uplands to the north. There was standing water in the eastern portion of the remnant channel in August, though to the west near the filled portion of the channel, there was no surface water. The parallel lobe portion of wetland #3 appears to receive most of its water from a seasonally high water table fed by groundwater flow and surface water runoff from surrounding uplands, possibly including surface flow from the remnant channel of Little Squalicum Creek during storm events.

The uplands to the north of wetland #3 on the steep valley slope are dominated by red alder, Himalayan blackberry and field horsetail. At the eastern end of the remnant channel, common morning-glory (Convolvulus sepium) is common on the disturbed slopes. Along the berm to the south of the remnant channel portion of wetland #3, red alder, black cottonwood, ornamental hawthorn, Himalayan blackberry and bluegrass are common components of the upland forested fringe of the wetland. The disturbed meadow upland adjacent to the parallel lobe of wetland #3 is dominated by a variety of upland grasses and common tansy.

Water Source. Water sources for wetland #3 include precipitation, overland and subsurface flow from the east and north side of the site, and seeps and springs from the exposed south facing hillsides to the north. No outlet was observed for wetland #3.

Wetland Functional Value. Wetland #3 functions as a point of surfacewater discharge. In addition, the wetland provides considerable stormwater attenuation functioning. The presence of the riparian community enhances this wetlands value to wildlife. In addition, the presence of open water, forested and shrub/scrub communities provides a diversity of habitats. The wetland provides recharge to the surrounding riparian area.

Upland Functional Value. Surrounding uplands include forest and shrub communities and meadows. The variety of habitats makes the upland area good habitat for wildlife. Riparian vegetation shades the stream, provides a source of organic debris to the system and provides direct habitat features such as nesting, perching and food sites. The surrounding upland areas provides buffering against intrusion to the wetland. In particular the dense blackberries provide extensive buffering. The upland areas act as a recharge areas for the wetland.

Wetland #4. Wetland #4 is a   acre disturbed and isolated wetland located in a shallow depression in the eastern portion of the Little Squalicum Creek Valley, just to the north of the buried storm sewer pipe which comes from the east and daylights at the head of Little Squalicum Creek. Wetland #4 is classified as palustrine, emergent, persistent, saturated (PEM1B).

Wetland #5. Wetland #5 is located southwest of wetland #4, just south of the buried storm sewer pipeline, at the point where the path turns off the pipeline to the southwest. The northern-most lobe of the meadow portion of wetland #2 is just across the path to the south. Wetland #5 is a acre palustrine, emergent, persistent, saturated (PEM1B) habitat, dominated by reed canary grass, with red-top, bluegrass, toad rush and smooth rush present.

Below the dark surface horizon, the soil is very dark gray (10 YR 3/1) silt loam with dark reddish brown (5 YR 3/3) mottles.

No water table was encountered within 18 inches of the surface in late summer. Hydrology for wetland #5 is from seasonal surface runoff which is trapped in a depression demarcated by the fill over the storm sewer pipe to the north and the path to the south and east.

The uplands surrounding wetland #5 are degraded meadow dominated by tall fescue (Festuca arundinaceae), common tansy, Douglas' aster (Aster subspicatus), and scattered ornamental hawthorn saplings.

Water Source. Water source for wetland #5 is primarily precipitation and overland flow from eastern portions of the site.

Wetland Functional Value. Because of the small size of this wetland, its functional values are limited to storm water attenuation and some songbird habitat and small mammal habitat.

Upland Functional Value. Surrounding areas include riparian communities, forested communities, and meadows. Because of the diversity of habitats, the surrounding upland areas provide good wildlife habitat.

Wetland #6. Wetland #6 is a acre disturbed wetland combining palustrine, emergent, persistent, saturated (PEM1B) and palustrine, scrub/shrub, broad-leaved deciduous, saturated habitats. It is located in a shallow depression to the north of the main path through the site at the eastern end of the central meadow of Little Squalicum Creek valley. Across the path to the south is a lobe of the forested portion of wetland #2.

The dominant vegetation of this wetland is reed canarygrass, colonial bent-grass, smooth rush, Himalayan blackberry and red-osier dogwood.

The soil below the dark surface horizon is very dark gray (10 YR 3/1) silt loam with dark reddish brown (5 YR 3/3) mottles.

No water table was encountered in August within 18 inches of the surface in wetland #6. The hydrology source for this small shallow depressional wetland is surface runoff from the surrounding uplands.

The uplands to the south and southwest are upland grasses and weedy herbs associated with the path. To the east and north, the shrubby uplands are dominated by red alder and ornamental hawthorn saplings and Himalayan blackberry vines. To the west, this assemblage is joined by Nootka rose (Rosa nutkana).

Water Source. The water source for this wetland is primarily precipitation. This wetland may have developed as a result of construction and presence of the trail to the south.

Wetland Functional Value. The small size of this wetland limits its functioning to some stormwater attenuation and as well as songbird and small mammal habitat. Nearby forested uplands and shrub communities enhance the wildlife habitat value of the wetland.

Upland Functional Value. This wetland is surrounded by a shrub community dominated by Himalayan blackberry (Rubus discolor) and a small forested community dominated by black cottonwood (Populus trichocarpa) and red alder (Alnus rubra). These upland areas provide wildlife habitat. Blackberry shrubs provide good buffering from intrusion on one side of the wetland and in addition provide impenetrable cover for the escape of prey species and nesting locations for small passerine birds.

Wetland #7. Wetland #7 is on and immediately south of the main path in the central meadow. This wetland in a shallow depression is a   acre palustrine, emergent, persistent, saturated (PEM1B) habitat, which is being invaded by tree saplings.

The vegetation is dominated by reed canarygrass, red-top, and smooth rush. The invading trees are Pacific willow, Sitka willow, black cottonwood, and ornamental hawthorn.

The soil is very disturbed. The dark surface horizon is a gravelly loam with bark and wood chips present. Beneath this horizon the very dark grayish brown (10 YR 3/1) loam has dark reddish brown (5 YR 3/3) mottles.

No water table was found within the top 18 inches. This wetland is fed by surface runoff from surrounding uplands similar to Wetlands #4, #5, and #6..

The surrounding uplands are very disturbed meadow and trail, dominated by upland grasses, common tansy, common plantain (Plantago major), English plantain (Plantago lanceolata), and scattered saplings of ornamental hawthorn and black cottonwood. Himalayan blackberry is also a dominant.

Water Source. The water source for this wetland is primarily precipitation. The wetland is situated in the middle of an old roadbed and may have developed as a result of the construction and presence of the old roadbed or the trail to the north of it.

Wetland Functional Value. The small size of the wetland restricts its functioning to limited stormwater attenuation and some songbird and small mammal habitat. Nearly forested uplands and shrub communities contribute to the wildlife habitat value of the wetland.

Upland Functional Value. Surrounding forested communities provide wildlife habitat.

Wetland #8. Wetland #8 also intersects the main trail through the site, with most of this acre wetland occupying shallow depressions which are apparently portions of old roads. This irregularly shaped wetland is at the western extremity of the central meadow, with most of it classified as palustrine, emergent, persistent, saturated (PEM1B) according to the Fish and Wildlife Classification system. A portion of the wetland which doesn't appear to be on abandoned road bed is palustrine, forested, broad-leaved deciduous, saturated (PFO1B) habitat.

In the emergent portion of the wetland, red-top, bluegrass, velvet grass (Holcus lanatus), smooth rush, slender rush (Juncus tenuis), sedges (Carex sp.), geranium (Geranium sp.), Watson's willow herb, curly dock (Rumex crispus), and English plantain are dominant. In the forested portions, red alder and black cottonwood dominate.

The soil was not examined below 4 inches due to the difficulty in digging through the cobble and gravel of the road bed. However, at 4 inches the very cobbly silt loam has a dark grayish brown (2.5 YR 4/2) matrix with a few strong brown (7.5 YR 4/6) mottles.

The lowest micro depressions in the old roadbed are either not vegetated or the vegetation is stunted, evidence of standing water for an extended period into the growing season. The source of hydrology for wetland #8 is surface runoff from the surrounding uplands.

The upland meadow to the east is dominated by common tansy and upland grasses with black cottonwood and ornamental hawthorn saplings invading. The upland forest surrounding various lobes of this wetland are dominated by red alder and black cottonwood in the canopy, with Himalayan blackberry and common snowberry as the dominant shrubs. Canada bluegrass is found within the shaded area and some common tansy occurs along the forest fringe.

Water Source. Water source for this wetland is primarily surface and subsurface runoff from the adjacent uplands.

Wetland Functional Value. Wetland #8 provides good wildlife habitat because of the variety of habitat types (palustrine emergent, scrub/shrub and forested), the species diversity and the structural diversity of the tree canopy, shrub layer and ground cover. A variety of small mammals such as mice, voles and ground squirrels, as well as small passerines most likely use the area for nesting, feeding and resting.

Depressional areas within the wetland may provide limited surface water attenuation and flood storage from runoff of surrounding areas.

Upland Functional Value. Upland meadows and the nearby beach provide wildlife habitat. The beach provides a variety of public recreation opportunities.

Wetland #9. Wetland #9 is a   acre irregularly shaped disturbed wetland, the western lobe of which is under the railroad trestle adjacent to Bellingham Bay. The northern boundary of the wetland is the road which goes underneath the trestle. According to the Fish and Wildlife Classification system, wetland #9 is combination of a palustrine, forested, broad-leaved deciduous saturated (PFO1B); palustrine, scrub/shrub, broad-leaved deciduous, saturated (PSS1B); and palustrine, emergent, persistent, saturated (PEM1B) habitats. The southern boundary of the forested portion of this wetland is the toe of the steep southern side slope of Little Squalicum Creek valley.

The eastern lobe of wetland #9 is forested, with big-leaf maple, black cottonwood and red alder as the dominant in the canopy. The alders are buttressed in this area. In places, Pacific willow is also a dominant. Dominant shrubs include Himalayan blackberry, and Sitka willow. Giant horsetail, Watson's willow-herb, saw-beaked sedge, small-fruited bulrush, bittersweet nightshade (Solanum dulcamera), and creeping buttercup are prominent in the herbaceous layer.

In the scrub/shrub and emergent lobe closer to the bay, shrub dominant include Pacific willow and Sitka willow with some Himalayan blackberry present. Emergent dominant include common cattail (Typha latifolia), skunk cabbage (Lysichitum americanum), bull thistle (Cirsium vulgare), American manna grass, bittersweet nightshade and giant horsetail.

Soils in the forested area are black (10 YR 2/1) brightly mottled gravelly loams in the deep surface horizon. The next horizon beginning at 14 inches is dark gray (N 4/0) sandy loam with brown (10 YR 4/3) and dark brown (7.5 YR 3/4) mottles. Soil was not examined in the emergent and scrub/shrub portions of the wetland because of the presence of obligate hydrophytes and distinct topographic breaks.

During August, the soil was moist at 14 inches below the surface where examined, and in lower topographic depressions within wetland #9, soil was saturated to the surface. The sources of hydrology for wetland # 9 are varied. Surface water flows coming down the valley and the steep south slopes of the valley appear to be major sources of hydrology, with storm sewers from Eldridge Avenue probably providing a significant component of surface water input. Groundwater flow from up valley and the surrounding uplands is an important contribution to wetland hydrology, particularly at the toe of the southern slope and in depressional areas within wetland #9.

The uplands on the south slope of Little Squalicum Creek Valley adjacent to wetland #9 are dominated by big-leaf maple and red alder, with Himalayan blackberry and morning glory prominent in the understory. On the valley floor to the east, big-leaf maple, red alder and Himalayan blackberry are the dominant. To the north, the fill for the road demarcates the wetland boundary. To the west, the high water mark of Bellingham was 20 to 40 feet from the wetland boundary.

Water Source. Water sources for wetland #9 include precipitation, overland and subsurface flow from the southern portions of the site, groundwater and storm drains entering from the south.

Stormwater and surface flows entering the system enter into a deep hole at the southwest portion of the wetland. This hole holds water during the winter and throughout much of the growing season. The wetland is crossed with shallow unvegetated channels through which water flows west. Outflow from the wetland is through a berm towards the beach.

Wetland Functional Value. This wetland provides good wildlife habitat because of the species diversity and the structural diversity of the tree canopy, shrub layer and ground cover. Downed logs, brush piles and blackberry topped channels increase the habitat diversity. A variety of small mammals such as mice, voles and ground squirrels, as well as small passerines most likely use the area for nesting, feeding and resting. The blackberry bushes provide additional wildlife habitat. The variety of habitat types, the species diversity and the structural diversity of the tree canopy, shrub layer and ground cover provide good quality habitat. The upland areas provide additional habitats for resting, feeding and breeding for small mammals and passerines. The beach area provides resting areas for waterfowl and the open water provides foraging and resting areas for waterfowl.

Upland areas may also provide some stormwater attenuation functioning and may act as a recharge area for the wetland. Upland areas, especially the forested areas and blackberry thickets provide buffering to the wetland from intrusion.

The open water and beach areas provide opportunity for public recreation such as birdwatching, fishing and boating. In addition these areas provide open space, often in short supply within a city.

Wetlands #10, #11 and #12. Wetlands #10, #11 and #12 are discussed together because they are so similar and located very near each other. Each of these disturbed wetlands is located in a small closed depression, and they are classified as a palustrine, emergent, persistent, saturated (PEM1B) wetlands. They are located along either side of the road through the valley and are between 200 and 400 feet from Bellingham Bay.

Vegetation is dominated by red-top, colonial bent-grass, velvet grass, saw beaked sedge and smooth rush. In wetland # 10, tall fescue and scattered Himalayan blackberry are added to this assemblage. In wetlands # 11 and #12, scattered black cottonwood saplings are evident.

Soils were not examined in wetlands #10, #11 and #12, because of the difficulty in digging through the surface cobble and gravel.

Hydrology was not directly observed during the August site visit. The primary source of hydrology to these closed depressional wetlands is surface water runoff from the surrounding uplands. It is possible that groundwater flow also plays a part in the hydrologic budget of these wetlands early in the growing season.

The upland meadows surrounding these wetlands are dominated by upland grasses, common tansy, and goldonrod (Solidago canadensis), with scattered Himalayan blackberry. The forest to the south of wetlands # 11 and #12 were dominated by big-leaf maple and red alder, with common snowberry, Pacific blackberry and Himalayan blackberry in the understory.

Vegetation in this emergent wetland includes red-top (Agrostis alba), colonial bentgrass (Agrostis tenuis), foxtail, (Alopecurus sp.), reed canary grass, smooth rush, toad rush (Juncus bufonius), and spike rush (Eleocharis sp.). In addition, scattered cottonwood saplings and willows are found in wetland #4.

Soils are highly disturbed with so much cobble and gravel at the surface that digging with a shovel is not practical. However, given the strongly hydrophytic vegetation, the closed depression and the evidence of long-term surface ponding, investigation of soil characteristics is not necessary for the soils to meet the hydric soil criterion (FICWD, 1989).

At least portions of wetland #4 are ponded during the growing season. The presence of very hydrophytic species and also a dried algal mat in portions of the wetland are strong evidence of inundation during the growing season. The source of hydrology in wetland #4 is surface water runoff from surrounding uplands. Since the closed depression is shallow, it is unlikely this wetland expresses a seasonally high water table.

The uplands surrounding wetland #4 are also degraded. To the east and south the uplands are weedy meadows dominated by upland grasses, mountain tarweed (Madia glomerata), and common tansy. To the west and north, the uplands are dominated by shrubs, including ornamental hawthorn and Himalayan blackberry.

Water Source. This wetland is situated on fill. The water source for this wetland is primarily precipitation which perches on top of the fill. The presence of the trail to the east causes subsurface and surface runoff to collect in the area. This wetland may have developed as a result of the construction of the trail.

Wetland Functional Value. If viewed in isolation this wetland provides limited functional values. Because it is a closed depressional area, it provides some storm water attenuation functioning. This wetland clearly dries out in the summer. Taken in conjunction with the surrounding areas, this wetland provides additional habitat diversity.

Upland Functional Value. Surrounding uplands include riparian and forest communities and meadows. The diversity of upland habitats provides habitat for a number of small passerines and mammals. The nearby riparian area provides critical functioning in providing resting and feeding spots near water.

APPENDIX D


LYNDEN Pop 4,430
EVERSON Pop. 1040
STRANDELL
NOOKSACK
Custer
FERNDALE
LAUREL
BELLINGHAM AIRPORT
VAN WYCK
MARIETTA
BELLINGHAM Pop 46,010
SILVER BEACH
GENEVA
BIRCH BAY
BIRCH BAY STATE PARK
Cottonwood Beach
STRAIT
Cherry Point
Neptune Beach
Sandy Point
LUMMI BAY
LUMMI INDIAN RES.
BELLINGHAM BAY
Point Migley
Lummi Point
Fern Point
Gooseberry Point
Squalicum Lake
Squalicum Mtn 1925
Agate Bay
Green Lake
Fazon Lake
Wiser Lake
Fountain Lake
Willey Lake
Keefe Lake
Tennant Lake
Barrett Lake
Mountain View
NOOKSACK RIVER
Tenmile Creek
Fingalson Creek
California Creek
Portage Slough
Squalicum
King Mtn.
Hampton
N

sunset

Mt. Baker Hwy Wet Meadow
Preliminary Plant List August 1991, Binda Colebrook
Achillea millefolium
?x Agropyron repens
Agrostis ?alba (robust, slightly later blooming form) Oregonensis / alba var palustris
Alnus rubra
x Anthoxanthum oderatum
x Aster sp ?subspicatus/occidentalis
Betula papyrifera
Campanula ?rotundifolia
x Carex limophila - stipata - leporina
Circium arvense
Crataegus douglasii
Crataegus monogyna
x Epilobium ?watsonii
Equisetum arvense
x Festuca ?rubra; a semi-stoloniferous var.?Hrs o tell due to numerous small mammal tunnels that increase cespitose appearance
Festuca pratense
Holcus lanatus
Hypericum perforatum Hyp. anagaloides
Juncus effusus
x Juncus ensifolius
Juncus tenuis
Lathyrus perennis (road edge)
x Lupinus polyphylus
Myosotis laxa -
Phleum pratense
Poa pratensis palustris?
Pteridium aquilinum
Pyrus communis
x Ranunculus acris
x Rosa pisocarpa
Rosa sp not in bloom or fruit (Nootka?)
Rubus ursinus
Salix scouleriana
x Solidago sp. ?canadensis
Spirea douglasii
Symphoricarpos albus
Taxaracum officionalis
Trifolium pratense
Trifolium repens
x ~~Unknown grass~~ Arrenharium
mosses
Veronica scutuleria
Viccia; adventive spp

(1)

12.30.91 Sunset Red Fescue Wetland
Water abt 5-6" lower than Normal

H_2O averaging 3-6" in swales,
Source Storm drain from B'ham Christian Schl Prop.
Observed flooded for 2 weeks +, after major storm event or in wet winters

#1

Juncus ensifolius	10-15 %		✓
Carex stipata	5-8. %		✓
? { Agrostis oregonensis / Poa palustris	15		✓
Epilobium sp. watsonii ?	5		✓
Juncus effusus	3		✓
Aster subspicatus	15		✓
Carex limophila	5		✓
Festuca rubra	15	humocks	✓
Holcus lanatus	5	"	
Carex sp fine leaved	5	(canescens / oderi type)	✓
Agropyron repens ?	1 %	(Lolium p. ?	
Ahrenarea –	1 %		
Solidago sp	1 %	SAT	✓
Phleum ?	3		
F. prat	3		
(Anthox)			

laeviculmulus

Mostly wet Meadow c̄ Pockets of 6" SWALES
SAT. Red fescue / Aster / Solidago c̄ lupine swales

Ref. # 3

Carex stipata	5%
~~Ca~~ Junc. ensifolius	10%
Junc. acuminatus	60%
Bare ground	10%
Veronica americana	10%
Epilobium watsonii (spp)	3% (new)
Potentilla palustris	<1%
Veronica scutellaria	<1%
Spiraea douglas	<1%
Galium ~~trifolium~~ (spp)	<1%
~~Rubus~~ Carex spp	<1%
Juncus bolanderi	1

{ boreale ?
{ trifidum ?

Carex canescens/ or arderi/ or spp
C. obnupta
Scirpus microcarpus
typha
Alopecurus aquatilis

(2)

Refs. #1 3-6" water depth

Veronica scutellaria	10%
X Ranu repe	5%
Potentilla palustris	7%
Carex Stipata	5%
Agrostis ~~spp~~ alba	40%
Junc. effu	5%
Sparganium emersum	3%
Junc. acuminatus	5%
Myosotis laxa	5%
Junc. tenuis	15%
Alisma plantago-aquatica	10%

Refs. #2

Junc. tenuis	10%
V. scutellaria	8%
Alisma plantago-aqua	15%
Sparganium emersum	5%
Potentilla palustris	30%
Agrostis alba	50%
Junc. ensifolius	8%
X Ranu repe	5%

FIP (3)

1 v ⊖

> 50% Tape record 19 p

T2 F

C lep as before 11 p

T2 E Festuca

open mix Cag A +or P?	5	
Carex lep?	15	
Leontodon	20	-?
J tenuis varten	8	
RCG	10	
Hypericum anagaloides	2	
anthoxanthum	40	

T2 D 56 p (13 paces edge)

Opuntia colony	50%	
Carex leporina	10	
Holcus lanatus	10	
Fine fescue	10	(rubra)
Leontodon a	5	
anthoxanthum	15	

T2 C 22 paces

Above + (Redo)

Plantago lanceolata

Aster? ? Rubus small col 10

(Swale 20)

T2 B 40 p

agrostis	15
sweet vgrass	20
Holcus L.	10
Taraxacum	1
Ranunc	8
Rosa sp.	5

(15 swale)

T2 A2 30 Ditchedge +10 p

Rose Colony Nut + ?	20
Crat monogyne	5
Amelanchier ?	5
Ag alba	75 herb level

Crataegus douglasii many along ditch at least 20 yrs old

H T2 A1 56

Ditto up +1B

T3 A [illegible] [illegible]

Phleum pratense	50±
ag/Lolium	10
Trifolium pratense	5
Leontodon	5
J eff	10

T3 B1

Ag alba/tenuis	35
Ranunculus	5
Hieracea	2
Holcus l.	10
Leontodon a	10
Trif prat	5
Festuca arund / prat?	10

T3 B2

Holcus lan.	30
Phleum prat	20
Ranunc rep	5
Carex lep?	10
Plantago lan	5
Crat monogyna	1 seedling
ag rep	20

T3 C

Aster hesperius / subspicatus ?: 50
Phleum p.
Lolium/ag
Holcus
Ranunc
P. lanceolata

T3 D 28 p right above >50

as above +

Jeff	10	10
Carex limnophila		10
agrostis		8 ? (4?)
Xantho		15
C leporina		10

>50%

Plantago media
RCG 45%
Jeff Carex lep Red Wing BB
Leon
ag rep Holcus J tenuis leegrostis

Aug 4

DATA FORM
ROUTINE ONSITE DETERMINATION METHOD[1]

...stigator(s): ______ Date: ______
...ite: Enger CHURCH State: ______ County: ______
...t/Owner: ______ Plant Community #/Name: G
...If a more detailed site description is necessary, use the back of ...orm or a field notebook.

****

...ormal environmental conditions exist at the plant community?
... ___ No x (If no, explain on back)
...s the vegetation, soils, and/or hydrology been significantly disturbed?
Yes x No ___ (If yes, explain on back)

****

VEGETATION

Dominant Plant Species	Indic. Stat.	Strat.	Dominant Plant Species	Indic. Stat.	Strat.
1. Alopecurus pratensis	FACW	HERB	11.		
2. Polygonum persicaria	FACW	HERB	12.		
3. Eleocharis palustris	OBL	HERB	13.		
4. Sparganium emersum	OBL	HERB	14.		
5. Phalaris arundinacea	FACW	HERB	15.		
6.			16.		
7.			17.		
8.			18.		
9.			19.		
10.			20.		

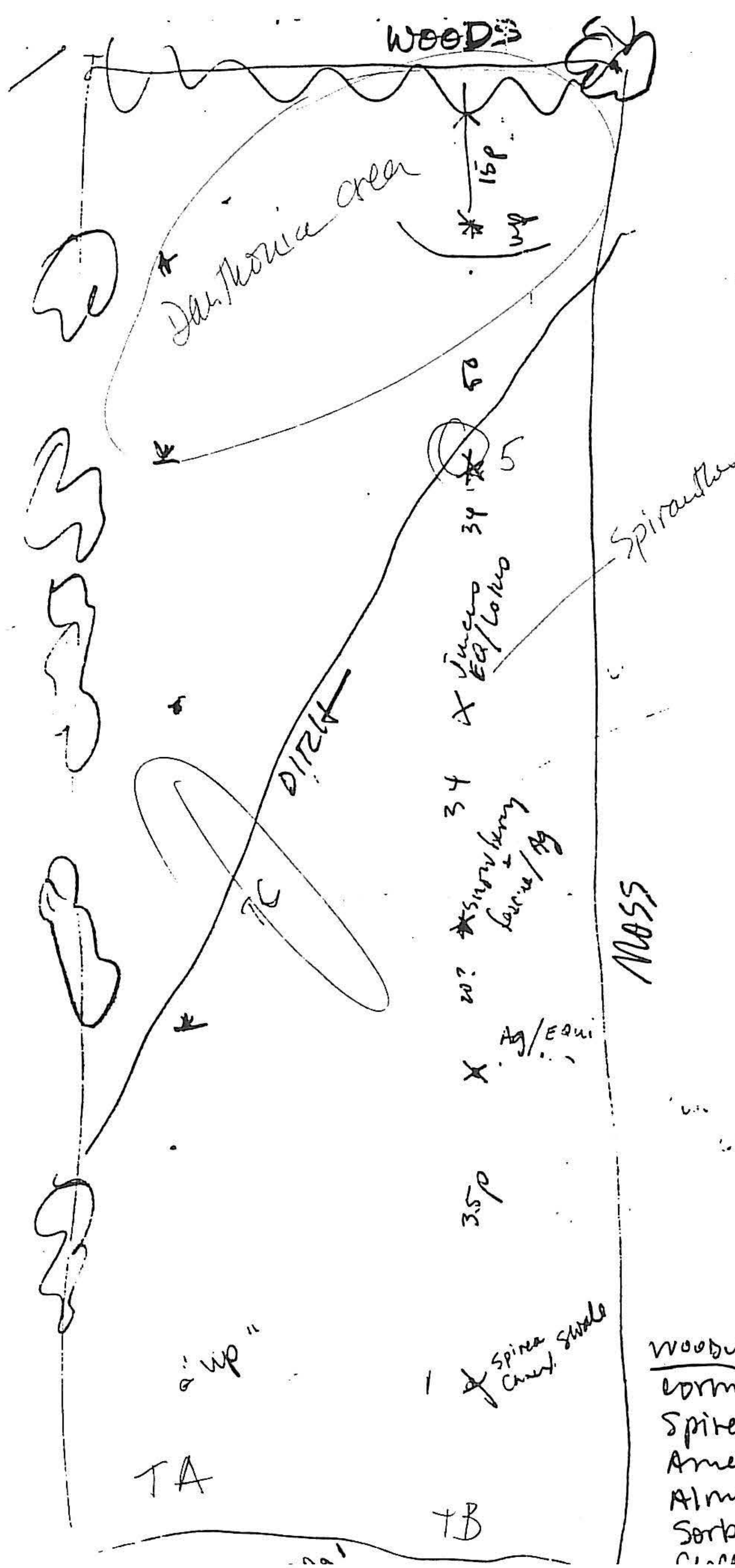
Percent of dominant species that are OBL, FACW, and/or FAC ——
Is the hydrophytic vegetation criterion met? Yes x No ___
Rationale: Rim of Alopecuris pratensis 88%
Central area of other dominates 73%

SOILS

Series/phase: WHATCOM LABOUNTY Subgroup:[2] ______
Is the soil on the hydric soils list? Yes ___ No x Undetermined ______
Is the soil a Histosol? Yes ___ No x Histic epipedon present? Yes ___ No ___
Is the soil: Mottled? Yes x No ___ Gleyed? Yes ___ No ___
Matrix Color: ______ Mottle Colors: DRK ORANGE, GREY
Other hydric soil indicators: ______
Is the hydric soil criterion met? Yes x No ___
Rationale: MOTTLES

HYDROLOGY

Is the ground surface inundated? Yes ___ No x Surface Water Depth: ______
Is the soil saturated? Yes ___ No x BUT VERY MOIST AT 20"
Depth to free-standing water in pit/soil probe hole: ______
... of surface inundation or soil saturation.



Meadow Complex Spp

Aster subspic ?
Agrostis sp
Anthoxanthum oderatum
Carex leporina
Carex unoplia
Carex obnupta
Juncus tenuis
Juncus ensifolius
Juncus balticus
" effusus
Danthonia calif.
Luzula sp (campestris?)
Festuca rubra var
Festuca prat (?) ciliate
Ranunculus acris
Lotus corniculatus
Phalaris arundinacea
Epilobium wats
Equisetum arvense
Pteridium aquilinum
Chrysanthemum leucanthemum
Taxaracum
Euphrasia off?
Crepsis type fall bloomer
Leontodon? autumnalis
Hypochaeris
Plantago lanceolata
Rubus laciniata / discolor/ ursin
Malus ~~fusca~~, seedlgs
Trifolium pratense
Circum
Epilobium wats
Solidago canadensis (?)
Potentilla anserina
Holcus lanatus
Equisetum arv.
Spiranthes roman Zoffiana
Prunella vulgaris var lanc
Mentha arvensis

WOODY

Cornus sericea
Spirea douglasii
Amelanchier
Alnus rubra
Sorbus aucuparia
Rosa pisocarpa
Salix sitchensis
Prunus emarginata
Salix scouleri
or hook?
Betula occi

#2 Carex leporina 40% swales
✓ Agrostis sp 10
✓ Holcus lanatus 5 hummock
✓ Festuca rubra 10 hummocks
✓ Juncus eff 10
Spirea do. edge
Agropyron rep 5 5
Aster subsp edge
Crataegus doug. "

#3 saturation to surface H₂O (1.5" below)
Agrostis alba var palustris 25
" oregonensis or PP 10
Epilobium sp 8
Juncus eff 10
Agrostis tenuis 40
Lonicera involucrata 3
Aster subspic edge
Rosa pisocarpa edge
Hypericum anagaloides

(1) Sunset

BD wet meadow Red fescue 12-31-91
Whithorn silt loam over W. Sandy L.

J. eff 30%
Lotus 20
J tenuis 10
Ag alba v. palustris 20
Carex lep 10
Ag ten 5
Ranunculus ? 3
~~Lotus 10~~
Eq arv 3
Spiranthes 1
Hypericum

(see summer data too)

SITE (5) BIRCH BAY

Mostly wet Meadow c̄ wet swale ~ 3-6, & 1 ditch @ 14. Red F. dom c̄ misc. pasture grasses

Lindsey & Trapline (#) 1.2.92

Swale run ~ E-West - PEM # c
6-9" draw down. Tony Says [illegible]
cross it in Aug - Sept

#1 Sunny No Side

Alopecuris ?geniculatus	85 %		
myosotis laxa	5		
Veronica americana	5		
Polygonum ?persicaria	3		
Bidens	1		
RCG		deeper	edge
polyg sp	1		deeper
Alisma sp			
Juncus sp [illegible]			Shallower

#2 Shady So side	10"	
Alopecuris sp	20	
myosotis laxa	20	
Polygonum sp	5	
Potamogeton	15	
Carex stipata	3	
alisma p-a	3	
Carex sp		small

Central Rd (between Ev-Goshen & Noon)
water level [illegible]

#1 No of Rd 3"
Grazed

30%	Carex sp (leporina / oederi?)	3"
20	RCG	
15	Agrostis sp	
10	Ranunculus	
10	Myosotis laxa	
10	Composite (Hypochaeris / Leontodon aut.)	

#2 30	Myosotis laxa	5"
15	Alopecuris sp (geniculatus?)	
5	Ranunculus rep/acris ?	
25 ~~30~~	RCG	
15	Agrostis sp	
5	MISC pasture grasses?	

#3 South of Rd Dry meadow (mowed at 1")

50	C. leporina (oederi?)
10	Ranunculus
10	J. effusus
3	plantago

#4 4"

Galium	20	Rumex
Alope	10	Parentucellia
J eff	10	Mentha arv.
RCG	50	
Polygonum	10 ?	

(6)

Figure B
8

Mor Bay, The
"Ferndale" 2 years 3 - 5" swale

Deschampsia C.	15	seedlings 45
Aster subspic (?)	3	sprigs
Epilobium watts	3	seedlings
Agrostis ten?	10	adventive
Bare ground	15	
Trifolium repens	5	seed adventive
Polygonum coccineum	15	sprigs 2 YR
Prairie grass	10	seed
Carex leporina	5	sprig 1 YR
Veronica americana	3	seed No
Plantago	1	
Composite		
Myosotis laxa		seed (No
Ranunculus acris	1	

Marsh Shelf 3 - 11" many spp. large clusters
Clark Terrill

	depth	%
Scirpus acutus/validus	@ 7"	20
Eleocharis p	3" → @ 7" & 11"	40
Alopecurus aequalis	→ 6" "	60
Oenanthe	3"+	10
Polygonum sp	3	15
Scirpus "	3	3
Juncus acuminatus	3	10
Gnaphalium sp	3	8
willow seedlings		15
Sparganium eurycarpum	5 +	15
Alopecurus aequalis	6 +	20 +
Glyceria borealis	10 +	20 +
(Sparganium emersum	3 - 7")	
wapato	3 - 14"	
Epilobium watsonii	3"	
Polygo		
Sium suave	3"-6" 3+	

Note These spp are at diff depth % figure rep cover at that depth

Ugate Bay Lane - Ugate Pond Preserve
Willow shelf Restoration: SQ gravelly loam subs.

#1 Moss 30 — H2O Normally @ 3"
Baregravel 5 — Now @ 1/2"
3 years

Juncus acuminatus 10
Potentilla palustris 5
Veronica scuttelata 5
Agrostis sp 5
Juncus buffonis 5
Juncus eff? seedlings 5
" tenuis " 3
Carex Canescens (?) 3
" " seedlings 5
RCG 1
Veronica am. 1
?
Plantago lance
Epilobium ? seedlings
willow seedling

WW
#2 Scirpus microcarpus 45
Festuca pratensis 10
Juncus eff 15
" buffonis 10
" bolanderi 5
Veronica scut 5
Hyperica anagalloid 1

#2 cont
Moss 10
Carex stipata 1 seedling
Alism Plantago aquatica 1
J acuminatus 2
Agrostis sp
alnus seedlings 3

(8)

ABP — Sand on SQ
Deep
Pond edge 3" to 16" deep (draws down to apx 6"
Some sand over SQ G. Loam

Eleocharis ovata 3"
" palustris 4-10
Myosotis laxa 7"
Agrostis sp (alba v. palust?) 3"
Juncus acuminatus 8"
Alisma p-a 10"
Juncus sp at 16"
Epilobium "
Myosotis l. "
Alopecurus aequalis "
RCG 6"
Brasenia s. 36"

(8) water down 3-6" from Normal winter levels

JAMES
S. Shrub

woody

	%	
Malus fusca	80	
Salix sitchensis	5	
Rubus spectab	5	Ribes?
Lonicera involucrata	3 (at edge)	

Herb

Ranunculus rep	80	
RCG	10	
J eff	3	
Atherium felix	3	
Glyceria grandis	2	
Epilobium wats?	1	
Scirpus micro	1	
Veronica americana		
Carex dewey	} edge 1%	
Tellima		

1a 5" H_2O		6"
Oenanthe s.	50	50
Ranc rep	45	45
V. am	5	5

Cornus sericea	65
Rubus spec	25
Lonicera INV.	10
1 dead Birch	

<u>Herbs</u>

Moss	80
Ranc	5
Scrip micro	5
C. deweyana	10
RCG	3
sword fern	3

(9) S.S. w/ Populus overstory in Many places

Appendix D

Deciduous Forested Wetland Reference Site Description

The forested wetland community present at the south end of the impact zone, in wetland #3, provides an excellent reference community. The area has been cleared historically, likely within the last 25 to 35 years; however, the species composition and spatial complexity within the forested zone is diverse and well stratified. It also represents a stable young forest community which may be a more appropriate community to attempt to replicate than a fully mature system.

The soils within the forested zone appear to be relatively undisturbed Whatcom–Labounty silt loams. The first 10 inches of the soil pit indicates damp friable clayey loams; good structure, little to no sand, and some gravel present. Many fine roots and rhizospheres are present within the first 10 inches. The Munsell soil colors are 10YR3/2. At 10 inches the soils are very dense tills, with an extremely fine sand component. The soil had pods of dense clays within it. Soil color is 10YR 5/2.

If this area of the impact zone is to be cleared and maintained in grassland, it would be appropriate to salvage a portion of these hydric soils, with their accompanying roots, seeds, and tubers, and use them for backfilling within the proposed compensation zones.

Detailed community composition data was collected on the forested community within the southern portions of wetland #3 on the project impact site. Vegetation was sampled by running four transects north to south through the forested zone and collecting plant species percent cover within a square meter sample plot every 50 feet (approximately) along the transect. Plant densities were recorded using the Braun–Blanquet sampling method noting percent cover. The data is provided in Appendix C; it is summarized below.

The forested site is characterized by a canopy of black cottonwood trees which occur in rather an open canopy. Few plots were dominated by cottonwood, however, it often visually appeared to be the largest tree within the canopy zone. In addition to cottonwood, red alder, Hookers willow, and large Pacific willow are present in almost equal numbers in the canopy.

The sub–canopy was dominated by alder and willow saplings when a sub–canopy was present. The shrub community was comprised of very large specimens of red–osier dogwood, snowberry, wild rose, twinberry, and scattered Douglas spirea. Presence of dogwood and snowberry often reached 100 percent coverage in several plots.

The herbaceous layer was sparse in some areas dominated only by Pacific blackberry. Wood rush was relatively common as was a large geum. In certain zones there was a 100 percent coverage by slough sedge in combination with large manna grass (Glyceria grandis). The sedge/manna grass stands seemed to be present where shallow water was ponded for longer periods of time.

The forest appeared to have a seasonal level of saturation; it is likely that the forest soils are saturated all winter and into the growing season, but they clearly dry out come mid–summer. The vegetation composition is reflective of the seasonal saturation, the species present range from facultative to facultative wet: only the slough sedge and manna grass are rated as obligate species, and these are the species found within the long–term ponded areas of the site.

APPENDIX E

Memorandum:	Technical Memorandum No. 1
Date:	January 15, 1992
To:	Bill Hagar, Port of Bellingham
From:	Dave Carlton, Bob Aldrich, Wally Chen
Subject:	Hydrologic and Water Quality Assistance
c:	*Sono Hashisaki, Springwood Associates*

INTRODUCTION

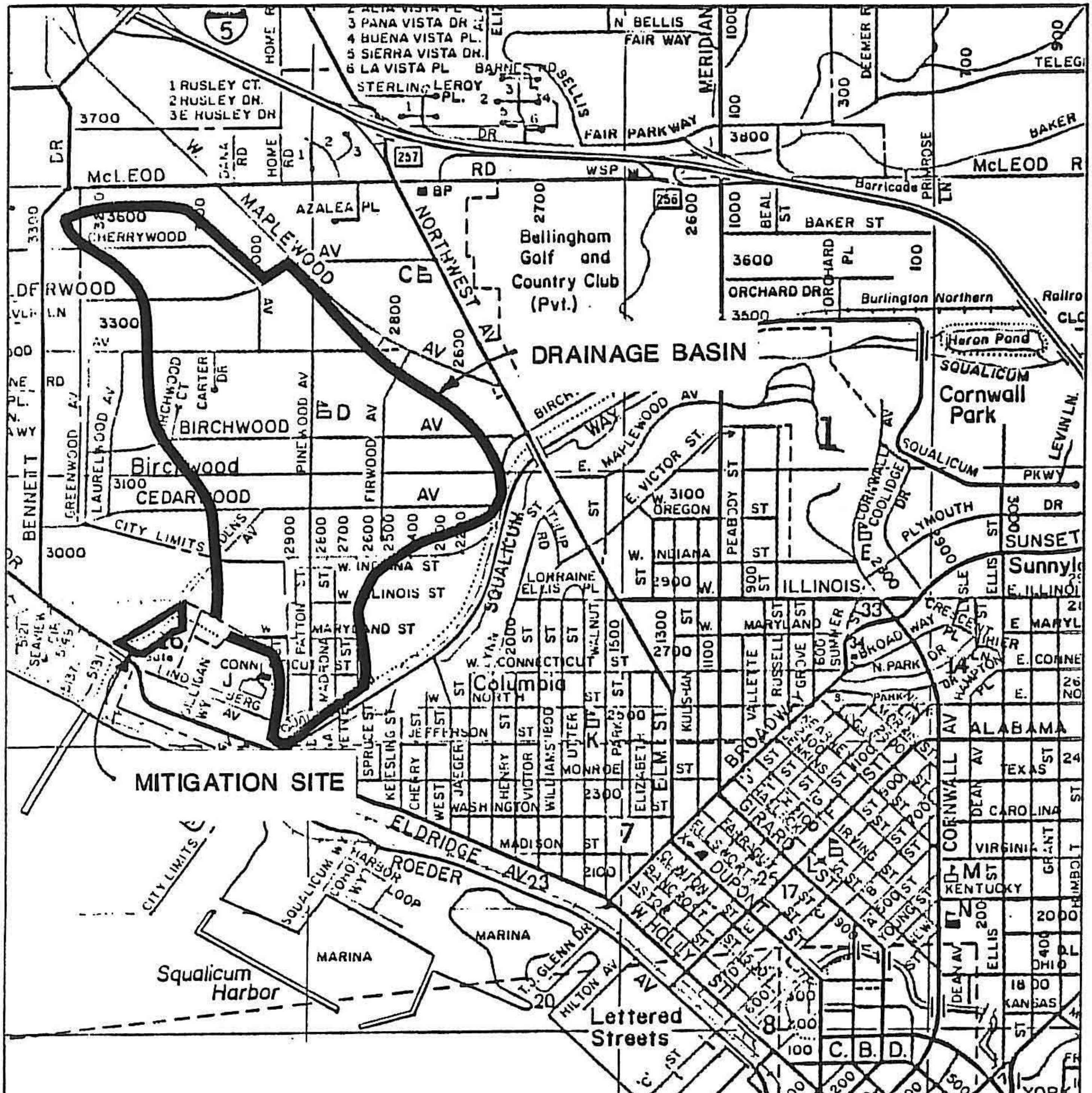
On December 18, 1991, Kramer, Chin & Mayo, Inc. (KCM) was authorized by the Port of Bellingham to assist Springwood Associates in the development of a wetland mitigation area. The proposed wetland area will cover 4.7 acres of property owned by Whatcom County. The area is located adjacent to the Bellingham Vocational Technical Institute in the City of Bellingham, as shown in Figure 1. The area will consist of approximately 1.4 acres of marsh wetlands and 3.26 acres of wooded wetlands. Approximately 0.72 acres of the marsh wetlands will be open water. The objectives of KCM's assistance are as follows:

1. To determine if there is sufficient runoff from the drainage basin upstream of the mitigation site to create and maintain the proposed new wetlands. If this cannot be determined from existing data, to describe the type of data and analysis which is needed to ensure there is sufficient moisture.

2. To make design recommendations, which, if followed, will help ensure the success of the project.

3. To develop conceptual recommendations addressing the need to treat stormwater before it enters the mitigation wetlands so that the entry of pollutants into the wetlands is prevented.

4. To describe the primary concerns which should be addressed in the design of treatment facilities, Best Management Practices (BMPs), and maintenance practices for this mitigation project.



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Port of Bellingham HYDROLOGIC AND WATER QUALITY ASSISTANCE	Figure 1 VICINITY MAP

Previously developed information concerning the hydrology and hydraulics of the basin and the proposed conceptual design of the wetlands was obtained from Springwood Associates. This information was then used to help determine if the runoff from the basin during the months of November through May is sufficient to support the proposed wetlands. Wetland cell areas were determined from a copy of a mitigation plan provided by Springwood Associates at a scale of 1 inch equals 100 feet. A reduced copy of the plan is shown in Figure 2. The hydrologic analysis, water quality assessment, and recommendations are presented in the following sections.

HYDROLOGIC ANALYSIS

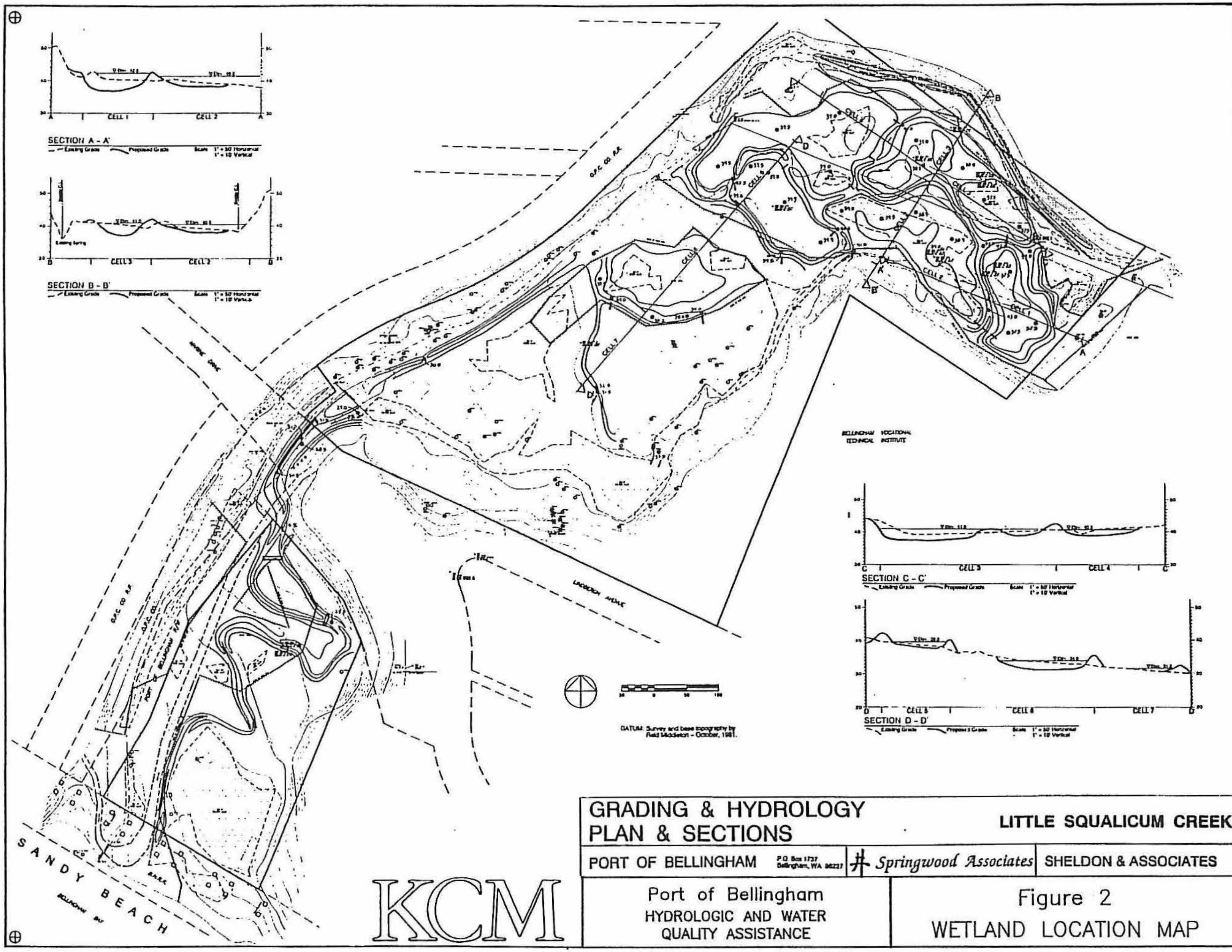
Analytical Approach

Due to time and budget constraints, a decision was made to develop a simple water budget for each month from November through May. In order to simplify the analysis, it was assumed that each month received its average historic rainfall and that land use conditions remain constant. Existing data was used and no new data (except some soils analysis) was obtained for these calculations. The steps in the hydrologic analysis were as follows:

1. The necessary data and maps were collected.
2. Land use was determined from existing topographic maps and a site visit.
3. The total runoff from the drainage basin was determined for each month.
4. The total evapotranspiration from the proposed wetlands was determined for each month.
5. The total infiltration from the wetlands was determined for each month.
6. The water balance was determined by comparing the total average runoff for each month to the total monthly evapotranspiration and infiltration.

Land Use

The drainage basin and the location of the proposed mitigation wetlands within the City of Bellingham are shown in Figure 1. The drainage basin encompasses approximately 340 acres of mostly residential development. The average density of development is



GRADING & HYDROLOGY PLAN & SECTIONS		LITTLE SQUALICUM CREEK
PORT OF BELLINGHAM P.O. Box 1737 Bellingham, WA 98227	Springwood Associates	SHELDON & ASSOCIATES
KCM	Port of Bellingham HYDROLOGIC AND WATER QUALITY ASSISTANCE	Figure 2 WETLAND LOCATION MAP

estimated to be approximately 2.5 dwellings per acre, and the basin is fully developed. Based upon the existing land use and Table III-1.7 in Chapter 3 of the draft Stormwater Management Manual [Washington State Department of Ecology (Ecology) 1991], it is assumed that approximately 30 percent of the basin is impervious. The remaining pervious areas are primarily lawns. There are also a few small forested areas scattered in the basin.

Soils Data

The U.S. Soil Conservation Service (SCS) has not yet published soils data maps for Whatcom County. From the soil borings and test pits which have been completed on the site, and general knowledge of the area, it is believed that the soils in the drainage basin will be classified as Type B by the SCS for drainage purpose. These soils have moderately fine to moderately coarse textures, and moderate infiltration rates when thoroughly wetted. This classification is a conservative estimate for the purposes of this analysis. If all the soils are actually of the Bellingham association (a Type D soil), then predicted runoff values would be significantly higher than those calculated by assuming a Type B soil. Therefore, the runoff volumes calculated in this analysis are conservative.

Rainfall Data

Average monthly rainfall amounts were obtained from the Climatological Handbook, Columbia Basin States Precipitation, Volume 2 (Pacific Northwest River Basins Commission 1969), and are shown in Table 1. These are averages for the years 1931 to 1965 for the Bellingham station.

TABLE 1.
AVERAGE MONTHLY PRECIPITATION
IN THE VICINITY OF BELLINGHAM, WA,
1931 to 1965
(inches)

Month	Rainfall
November	4.78
December	4.86
January	4.09
February	2.94
March	2.59
April	2.41
May	1.77

Reference: Pacific Northwest River Basins Commission 1969

Runoff Calculations

For this analysis it has been assumed that 95 percent of the precipitation which falls on the impervious sections of the basin flows into the drainage system and, eventually, into the mitigation site. This allows for some evaporation, infiltration, and storage within the basin. In addition, total runoff from the pervious land has been calculated using the SCS techniques as expressed on page III-1-21 of the Stormwater Management Manual (Ecology 1991). For these calculations a curve number (CN) of 76 has been used. This number has been selected based upon the assumption of type B soils in the drainage basin and a land use which is predominantly suburban. The pervious areas are covered primarily by lawns, with a few small forested areas scattered throughout the basin. These calculations result in the monthly runoff volumes shown in Table 2, and are believed to be conservative due to the use of a low curve number.

TABLE 2.
AVERAGE PREDICTED RUNOFF VOLUMES, NOVEMBER TO MAY

Month	Rainfall (Pr)	Pervious Runoff (Qd)	Impervious Runoff	Pervious Volume	Impervious Volume	Total Volume (acre-feet)
November	4.78	2.36	4.54	46.72	38.60	85.31
December	4.86	2.42	4.62	48.01	39.24	87.25
January	4.09	1.81	3.89	35.85	33.03	68.88
February	2.94	0.97	2.79	19.33	23.74	43.07
March	2.59	0.75	2.46	14.87	20.91	35.78
April	2.41	0.64	2.29	12.71	19.46	32.17
May	1.77	0.30	1.68	5.98	14.29	20.28

Pr is the total average rainfall during the month
Qd is the runoff depth in inches over the area
Qd = $(Pr-0.2*S)^2/(Pr+0.8*S)$
S is the potential maximum natural detention (infiltration over the area)
S = (1000/CN)-10
CN is the SCS curve number for the soil and existing land use
CN = 76
S = 3.16
Pervious acres = 238
Impervious acres = 102
Total acres = 340
Percent impervious = 30

Evapotranspiration Volumes

Monthly totals were estimated for evaporation from the open water in cells 1 through 3 and the total evapotranspiration from the vegetation in the 4.7 acres of proposed mitigation wetlands.

Total monthly evaporation volumes from the free water surface in cells 1 through 3 were estimated and are shown in the Appendix. These estimates are based on a 2-year average of the evaporation data from Washington State University's Agricultural research station in Puyallup. Evaporation data from a monitoring station closer to the study area would be desirable, but no such information was readily available.

Evapotranspiration volumes from the wetland vegetation for the proposed mitigation site was determined via a modified version of the Blaney-Criddle method developed by the Food and Agriculture Organization (FAO) of the United Nations. The FAO Blaney-Criddle method was originally developed in 1951, but was subsequently modified in 1977 in an effort to include additional climatic factors to improve the predictive capability of the equation. The procedure is commonly used to determine evapotranspiration volumes for periods of 30 days or longer. The SCS Water Management Specialist for the State of Washington, Thomas Spofford, highly recommends using the FAO Blaney-Criddle method to determine the evapotranspiration of plants in the Pacific Northwest region (Spofford, T., 2 December 1991, Personal Communication). The parameters, coefficients, and calculations for the monthly evapotranspiration volumes are presented in the Appendix. The calculated evapotranspiration volumes, shown in Table 3, include the total evaporation from the open water surface and the total evapotranspiration from the wetland vegetation.

TABLE 3.
TOTAL MONTHLY EVAPOTRANSPIRATION,
NOVEMBER TO MAY[a]
(acre-feet)

Month	Evapotranspiration
November	0.02
December	0.01
January	0.02
February	0.03
March	0.29
April	0.63
May	1.29

a. Calculated according to FAO Blaney-Criddle method. See Appendix for supporting calculations.

Based on the FAO Blaney-Criddle method, the volume of moisture lost through evapotranspiration from the proposed wetlands during the months of November through April is insignificant.

Groundwater Data/Infiltration

Information concerning hydraulic conductivity and soil types was obtained from Mr. Larry Beard of Landau Associates, Inc. on December 26, 1991. According to Mr. Beard, most of the near surface soils in Landau's ten test pits are composed of fill material, and soil properties are expected to vary a great deal over a short distance. This is a reasonable assessment because the site was previously used as a gravel pit. Much of the site has subsequently been reworked and backfilled. Landau Associates estimated that the hydraulic conductivities for the ten sites range from a low of 0.3 feet/day in cells 3 and 4 (samples 6 and 7), to 255 feet per day in cells 2, 3, and 5 (samples 3, 5, and 9). If a groundwater slope of 0.01 throughout the mitigation site is assumed, the calculations indicate a range of infiltration volumes from 0.8 acre-feet per month per acre to over 700 acre-feet per month per acre.

A report on the hydrology of the proposed site by Watershed Dynamics (September 1991) was also reviewed. Watershed Dynamics dug ten test pits at various locations on the proposed site during August 1991. The pits ranged in depth from 50 to 80 inches. In all except one pit, a zone of long-term groundwater or an impermeable layer which would prevent any downward movement of groundwater was reached.

Because of the variability of the soil within the mitigation site, a determination was made to use a value of 0.5 inches per hour for infiltration from the ponds. This is equivalent to the minimum soil infiltration capacity acceptable to Ecology for an infiltration pond (Ecology 1991). It is also indicative of a Type B soil, or loam. Although there are significant pockets of soil where the potential infiltration rate is much higher, this value is a conservative value which can help determine if there is sufficient runoff to establish the proposed wetlands.

Water Balance

The monthly water balances were determined by calculating the average runoff from the drainage basin for each month during the winter and spring seasons, calculating monthly evapotranspiration and infiltration volumes, and then summing the results. The predicted water balances for the months November through May are presented in Table 4. Runoff values shown in the table include the runoff from the entire drainage basin and the rain falling on the wetlands during the indicated month. Infiltration values are based on the assumption that the only sources of infiltration are the wet cells (i.e., cells 1-3). Evapotranspiration values represent the total evaporation and transpiration volumes from all cells. For all months except for May, evapotranspiration volumes are essentially insignificant.

TABLE 4.
PREDICTED AVERAGE WATER BALANCE FOR THE PROPOSED WETLANDS, NOVEMBER TO MAY
(acre-feet)

Month	Runoff (Inflow)	Infiltration (Outflow)	Evapotranspiration (Outflow)	Excess (Outflow)
November	87.2	21.5	0.02	65.7
December	89.2	22.2	0.01	67.0
January	70.5	22.2	0.02	48.3
February	44.2	20.0	0.03	24.2
March	36.8	22.2	0.29	14.3
April	33.1	21.5	0.63	11.0
May	21.0	22.2	1.29	(2.5)

As shown in Table 4, under the assumed conditions there is sufficient water to keep the wetlands wet during all the months in question, except towards the latter part of May. However, the values shown in Table 4 are estimates based upon available data, and could be significantly refined if more reliable data were available or the assumptions on which this analysis is based were modified. There are several methods available to help increase the probability of having sufficient moisture for the wetlands. These techniques are described in the following section.

WATER QUALITY ASSESSMENT

Requirements of the 401 water quality certification stipulate that water entering the mitigation wetlands proposed for Little Squalicum Creek receive treatment commensurate with the level of contaminants observed in the surface water system. A variety of Best Management Practices (BMPs) are available to remove pollutants from stormwater before it enters the mitigation site. The treatment facilities must meet the policy goals of the Stormwater Management Manual for the Puget Sound basin (Ecology 1991). In this section, preliminary concepts for treatment options are presented.

Volatile hydrocarbons are likely to be present in Little Squalicum Creek, based on the size of the drainage area, amount of impervious area, and data presented in "Site Hazard Assessment, Summary Report for Little Squalicum Creek, Bellingham, Washington" (Parametrix, Inc. 1991). The creek, in turn, affects the water quality of the stormwater entering the mitigation site. It is therefore recommended to treat stormwater for hydrocarbons before it enters the pretreatment facilities. To be most effective, this process should be combined with a program of source identification and control BMPs throughout the watershed. End-of-pipe treatment facilities cannot operate at peak efficiencies without watershed-wide control programs in place.

Landau and Associates obtained samples of stormwater from an outfall near the project site during a 1991 storm event. The sample was analyzed for standard water quality parameters such as nutrients, and hydrocarbons. Concentration of hydrocarbons in the runoff were low. However, the presence of hydrocarbons may have been obscured by the sampling technique, timing of the monitoring, or antecedent storm event conditions.

Best Management Practices

A variety of Best Management Practices (BMPs) are available to remove suspended sediments and surface layer hydrocarbons from stormwater. These range from dry detention ponds to constructed wetlands. The most effective method of treating storm flows is to employ a combination of BMPs. The level of treatment is more refined with each succeeding BMP, from the removal of floating contaminants to the treatment of dissolved constituents. Generally, the series of BMPs consists of an oil/water separator, a biofiltration system, and a pond treatment facility. These are described below.

Oil/Water Separators

Recommendations for selecting, sizing, and siting oil/water separation facilities are presented in the Draft Ecology Stormwater Manual (Ecology 1991). In general, there are three types of oil/water separators available. In order of descending effectiveness, these are as follows:

- Coalescing plate interceptor separator (CPI) consisting of an underground vault filled with bundles of closely spaced plates made of polypropylene or fiberglass
- American Petroleum Institute (API) separator, consisting of an underground vault with a series of baffles and a "T" type outlet
- "T" type separator, consisting of an underground vault with a T outlet.

The effectiveness of the separators depends to a large degree upon the runoff generated in the watershed, the concentration of oil in the runoff, and the degree of treatment required for the proposed application. The "T" type separator is used for containing small spills and generally is not effective in removing emulsified oil. The API separator is used in situations where removal of emulsified oil is necessary, such as where stormwater will impact wetlands or salmon-bearing streams; or for other receiving waters that are sensitive to the effects of oil and grease contamination. The CPI separator is used in situations where higher concentrations of oil are common (i.e., usually greater than 10 mg/L per day), or where space requirements dictate a smaller installation than an API separator.

Biofiltration System

It is considered good stormwater treatment practice to install grass- or vegetation-lined swales upstream and downstream of oil/water separator installations. At the very least, swales should be installed downstream of the separator. Since few species of vegetation can resist high levels of oil and grease contamination, care should be exercised during design to ensure that concentrations of such constituents do not unduly impact swale vegetation, or that oil resistant vegetation is planted initially.

Pond Treatment Facilities

After treatment through an oil/water separator and passage through a swale system, treated stormwater should enter a "polishing" phase for the removal of dissolved ions. The polishing phase typically occurs in a constructed wetland, extended detention pond or wet pond. Although other options are available, these three alternatives are the most applicable to the proposed project site. Each is described below.

A constructed wetland differs from a mitigated wetland in the following ways: a constructed wetland is designed to treat stormwater; has engineered inlet and outlet control structures; and the structures and plant communities are maintained. Regulatory requirements for constructed wetlands are less stringent than those for mitigation wetlands. For example, maintenance procedures are not allowed on mitigation wetlands.

An extended detention pond could be installed in place of a constructed wetland, although the benefits of vegetative processing of contaminants would be lost. However, extended detention ponds often evolve into wetlands depending on maintenance procedures, frequency of maintenance, and timing of periods of inundation of the pond.

A wet pond has many of the same attributes as an extended detention pond, but hydraulic residence time in the pond is shorter (usually on the order of one day or less). The effectiveness of the pond in removing pollutants is correspondingly reduced. Maintenance frequency is approximately the same as for an extended detention pond, but the inlet and outlet flow control structures are different. The outlet control on a wet pond is designed to release more water in a shorter time than a constructed wetland or an extended detention pond.

Design Considerations

The choice of treatment options is generally dictated by design constraints such as depth to seasonal groundwater, contaminants of concern, presence, or absence of water, timing of storm flows, availability of land, available head to drive passive treatment systems, and the sensitivity of the proposed site.

In addition, the size of the facility is normally dictated by the detention/retention requirements of the local jurisdiction or the responsible agency. In this case, sizing recommendations for the water quality treatment facilities should follow the guidelines of the Ecology manual discussed earlier, that is, control and treatment of the 6-month, 24-hour event. Design considerations for the oil/water separator, biofiltration system and pond treatment facilities are discussed below.

Oil/Water Separators

Most oil/water separators are sized by the manufacturer based on flow calculations, inlet/outlet size, and expected concentrations of oil. It is therefore recommended to monitor specifically for oil and grease concentrations prior to installing an oil/water separator. At the very least, an API separator should be considered for the mitigation wetland.

Biofiltration System

Crucial design variables for swales include water velocity, depth, timing, soil suitability, and length. Most failures in vegetation lined swales occur during the initial stages of construction due to improper soil preparation, inadequate slope, excessive slope, improper vegetation, excessive inundation of vegetation, sediment deposition, and erosion of the swale during the vegetation establishment phase.

Constructed Wetland

The primary design consideration for the construction of a wetland is the presence or absence of water. Without a reliable water source, it is difficult to establish and propagate wetland species. Corollary to a need for a reliable water source is the need for proper soil. Most successful constructed wetlands were designed and built using a layer of wetland soil or organically rich soil.

Extended Detention Pond

Achieving adequate detention in an extended detention pond is the most complicated design-related task. Essentially, detention times greater than 24 hours are necessary to achieve predicted pollutant removal expectations. Corollary to the time of detention is the amount of stormwater detained in the facility. Runoff is only partially treated if the incoming flows exceed the capacity of the detention volume. After the capacity is exceeded, pollutant removal performance drops off dramatically.

Pond shape, inlet/outlet design, interior characteristics, pond slope, soils, and dead storage are all important factors in performance as well. To adequately assess and design such facilities, designers should be well versed in performance characteristics prior to entering design mode.

Wet Pond

Essentially, a wet pond functions in much the same way as an extended detention pond or constructed wetland, although hydraulic residence time is far less. Pond shape, depth, and size are critical factors in determining pollutant removal performance. Limitations and design considerations for wet ponds are generally similar to those for constructed wetlands and extended detention ponds.

Pollutant Removal Expectations

Pollutant removal expectations for the BMPs are described below.

Oil/Water Separators

Depending on influent concentrations, most API separators are designed to remove oil to a concentration below that set by Ecology (i.e., 10 mg/L). Chronic loading of oil is reduced further by regularly scheduled maintenance practices. In sensitive waters, "T" type separators are ineffective in emulsified oil and should not be used.

Biofiltration System

Depending on sediment removal, influent pollutant concentrations, and vegetation, pollutant removal efficiencies of biofiltration range from 40 to 80 percent effective (Horner 1988).

Constructed Wetland

Depending on design, vegetation, target pollutant, and pollutant influent concentrations, performance of a constructed wetland ranges from 60 to 90 percent. Seasonal variations occur and pollutant removal will vary according to the growth cycle of wetland vegetation.

Extended Detention Pond

Extended detention pond performance ranges from 80 to 90 percent removal of sediments, 40 to 50 percent removal of total phosphorus, 40 percent of nitrogen, 40 to 50 percent of organic matter, and greater than 90 percent of trace metals (Schueler 1987).

Wet Pond

Wet pond pollutant removal expectations are similar to those of extended detention ponds, ranging from 50 to 60 percent for selected pollutants.

Selection Criteria for BMPs

The most applicable BMP for the mitigation site should be selected based on criteria such as design constraints, cost, land availability, recreational attributes, pollutant removal, aesthetics, and public perceptions.

RECOMMENDATIONS

Based on the calculations described above, there is sufficient runoff from the drainage basin to support the proposed wetland vegetation. However, due to the simplistic analyses which have been performed, it is recommended to conduct further data gathering and analyses before the final design is completed. Specific recommendations to ensure that the wetlands function as designed are as follows:

1. All of the new wetlands should be excavated until an impermeable stratum is reached, and then backfilled with suitable material. If an impermeable stratum is not reached, impervious material must be installed beneath the layer of topsoil and organic material which will be placed in each cell. The impermeable stratum should be composed of a minimum of 2 feet of a sandy clay loam material, or any material having an infiltration rate of 0.16 inches/hour or less. This recommendation is made to prevent the infiltration of water into the ground which is then lost to the system.

2. Because of the variability of the soils within the proposed site, it would not be cost effective to provide more soils data. The Port should instead be ready to import impervious material to construct the cells as needed.

3. All earth berms designed to control the water level in the cells should contain a 2-foot-thick impermeable core which extends at least three 3 feet below the natural surface of the ground,unless an impermeable layer is reached first.

4. The hydrology of the wetlands must be monitored to determine if they are performing as desired. This may lead to the modification of the control structures to either increase or decrease the duration and extent of flooding in the cell.

5. The final design for the control structures must allow for future modifications to the controls to allow for changing conditions and refinement of the flow characteristics.

6. If the best possible initial design is desired for the wetlands, a continuous rainfall-runoff model of the drainage basin and the proposed wetlands should be developed. This model would be able to predict the water level in the wetlands at any point during the simulation. Rainfall records for the past 60 years in the Bellingham area are available. These records could be used for the simulation to provide a very good initial design for the control structures and the cells. This would be a more exact design which would greatly increase the probability that the wetlands would function as desired without modification. The wetlands can be designed and constructed without the use of a complex hydrologic model, but they must be monitored much more closely and the control structures have a more flexible configuration.

7. To measure the effectiveness of the system, it is necessary to conduct a baseline and long-term water quality monitoring program. The flow monitoring program should include include flow-proportional and sediment sampling.

   A baseline monitoring program should be conducted to determine critical stormwater loading concentrations, and to establish baseline data for future monitoring and assessment of the facility effectiveness. Establishing a baseline for an individual wetland requires a minimum of one full year of sampling to establish a water quality signature for the wetland.

Recommended parameters, frequency and protocols for both the baseline and long-term monitoring programs are as follows:

— **Parameters.** At a minimum, sampling parameters should include the following:

- Metals (zinc, cadmium, copper and lead)
- Fats, Oils and Greases (FOG)
- Chemical Oxygen Demand (COD)
- Temperature
- Acidity (pH)
- Dissolved Oxygen (DO)
- Conductivity
- Nutrients
  - Nitrogen series
  - Phosphorus series
  - Turbidity
  - Total Suspended Solids (TSS)
  - Fecal Coliform Bacteria (Fecals).

— **Frequency.** At a minimum, flow-proportional samples should be obtained from five storm events. Three to five base-flow samples should also be obtained during non-storm conditions. It is recommended to obtain samples twice during the early growing season, three times during the summer, and three times during the wet season.

— **Procedures.** Sampling protocols should follow the guidelines established by the U.S. Environmental Protection Agency (EPA), or *Recommended Protocols for Measuring Conventional Water Quality Variables and Metals in Fresh Water of the Puget Sound Region*, a publication of the Puget Sound Estuary Program (1989).

APPENDIX A.
FAO BLANEY-CRIDDLE EQUATION

APPENDIX A
FAO BLANEY-CRIDDLE EQUATION

	ET	=	(Kc * ETo) * A
where:	Kc	=	an empirical monthly crop coefficient[a]
	ETo	=	Reference crop evapotranspiration for grass. Grass is defined as an extensive surface 3 to 6 inches tall, green cover of uniform height, actively growing, completely shading the ground surface and not short of water in inches.
	A	=	an altitude adjustment for locations above 3300 feet in elevation
	A	=	1 - (Elev(ft)/33,000) = 1 for this analysis
	ETo	=	D * a / 25 / 4 + b * T * p/100
where:	T	=	mean daily temperature in degrees Fahrenheit (F) over the month considered. Mean daytime temperature = (Tmax ± Tmin)/2
	p	=	mean daily percentage of annual daytime hours
	D	=	number of days
	a & b	=	factor which depends on long term average minimum relative humidities, daytime wind speeds, and ratios between actual measured bright sunshine and maximum possible sunshine hours. The "b" values are presented in Table 3(b).
	a	=	0.0043 RHmin - (n/N) - 1.41
where:	RHmin	=	minimum daily relative humidity
	n	=	actual measured bright sunshine hours
	N	=	maximum possible sunshine hours

a. The monthly crop coefficient (Kc) is an important factor in the determination of the evapotranspiration of wetland vegetation. Very little research, if any, has been conducted to determine the monthly crop coefficient for wetland vegetation native to the Pacific Northwest. However, it is well known that the majority of Pacific Northwest wetland plants are dormant during late fall and winter, (except for a few species of conifers). Therefore, it was possible to derive a monthly crop coefficient for the late fall and winter. Monthly crop coefficients for wetland vegetation in early spring were determined based on the SCS Irrigation Water Requirements, Technical Release No. 21, and FAO Irrigation and Drainage Paper No. 24.

Reference sources for the above information are as follows:

- Maximum and minimum temperatures—Climatological Handbook, Columbia Basin States Volume 1 Part A., June 1969
- Wind speed—Climatological Handbook, Columbia Basin States Volume 3 Part A, June 1969
- Relative humidity and sky cover—Climatological Handbook, Columbia Basin States Volume 3 Part B, December 1968
- Sunrise and sunset—Tide Tables 1990, U.S. Department of Commerce, NOAA
- Mean daily percentage of annual daytime hours—Soil Conservation Services, Irrigation Training Series, Module 220, May 1989
- Factor b—Soil Conservation Services, Irrigation Training Series, Module 220, May 1989.

TABLE A-1

FAO BLANEY-CRIDDLE EVAPOTRANSPIRATION CALCULATIONS

MONTH	PRECIP (in)	TEMPmin (Deg F)	TEMPmax (Deg F)	TEMPmean (Deg F)	RH(min)	WIND (MPH)	p	AVG SUN RISE	AVG SUN SET	% CLOUD COVER	n/N	DAYS in month	FACTOR a	FACTOR b	ET(in) of REF CROP
	note a	note b	note c	note d	note e	note f	note g	note h	note i	note j	note k		note l	note m	note n
NOV	4.78	35	52	43	79	9	6.18	7.1	16.4	83	0.17	30	-1.24	0.68	1.44
DEC	4.86	33	47	40	80	11	5.78	7.7	16.2	83	0.17	31	-1.24	0.69	1.18
JAN	4.09	30	44	37	74	13	6.10	7.7	16.6	78	0.23	31	-1.32	0.79	1.37
FEB	2.94	31	48	40	70	10	6.37	7.1	17.4	78	0.22	28	-1.33	0.80	1.63
MAR	2.59	34	52	43	65	9	8.25	6.2	18.1	78	0.23	31	-1.36	0.84	2.57
APR	2.41	37	59	48	60	9	9.19	5.2	18.8	72	0.28	30	-1.43	0.93	3.68
MAY	1.77	41	65	53	60	8	10.58	4.4	19.5	67	0.33	31	-1.48	0.97	4.97

NOTE a: Average monthly precipitation (1931-1965), from Climatological Handbook, Columbia Basin States, Volume II, September 1969
b: Average monthly maximum temperature (1931-1960), from Climatological Handbook, Columbia Basin States, Volume I Part A, June 1969
c: Average monthly minimum temperature (1931-1960), from Climatological Handbook, Columbia Basin States, Volume I Part A, June 1969
d: Average daytime temperature = (Tmax +- Tmin)/2 as defined in FAO Irrigation and Drainage Paper No 24, 1977
e: Average monthly minimum percent relative humidity between 4:00 am and 10:00 pm, from Climatological Handbook, Columbia Basin States, Volume III Part B, December 1968
f: Average monthly wind speed, from Climatological Handbook, Columbia Basin States, Volume III Part A, June 1968
g: Average monthly percentage of daytime hours, from SCS Irrigation Training Series Module 220, 1989
h: Average monthly time of sunrise in decimal time, from 1990 Tide Tables, U.S. Department fo Commerce, NOAA
i: Average monthly time of sunset in decimal time, from 1990 Tide Tables, U.S. Department of Commerce, NOAA
j: Average monthly percent sky cover during the daylight hours, from Climatological Handbook, Columbia Basin States, Volume III Part B, December 1968
k: Ratio of actual to maximum possible sunshine hours, derived from average monthly sky cover during the daylight hours
l: Factor a = 0.0043(RHmin) - n/N - 1.41 as defined in SCS Irrigation Training Series, Module 220, 1989
m: Factor b extrapolated from VALUES OF "b" TABLE in SCS Irrigation Training Series, Module 220, 1989
n: ETo = Da/25/4 + bTp/100 as defined in SCS Irrigation Training Series, Module 220, 1989

TABLE A-2

MARSH WETLANDS WATER BALANCE

MONTH	PRECIP (in)	Kc	AREA(AC) cells 1-3	% free water surface	ACT EVAP (in)	ET(in)	DEEP PERC (in)	RUNOFF (%)	TOTAL EVAP LOSS(ac-ft)	DEEP PERC (ac-ft)	AVAILABLE PRECIP (ac-ft)	AVAILABLE STRM RUNOFF (ac-ft)	NET(ac-ft) surplus(+) deficit(-)
		PARAMETERS WITHIN THE MARSH WETLANDS											
	note a	note b	note c	note d	note e	note f	note g	note h	note i	note j	note k	note l	note m
NOV	4.78	0.00	1.43	50	0.36	0.00	2.5	0	0.021	0.3	0.570	85.31	85.56
DEC	4.86	0.00	1.43	50	0.16	0.00	2.5	0	0.010	0.3	0.579	87.25	87.52
JAN	4.09	0.00	1.43	50	0.37	0.00	2.5	0	0.022	0.3	0.487	68.88	69.05
FEB	2.94	0.00	1.43	50	0.53	0.00	2.5	0	0.032	0.3	0.350	43.07	43.09
MAR	2.59	0.23	1.43	50	1.61	0.59	2.5	0	0.131	0.3	0.309	35.78	35.66
APR	2.41	0.45	1.43	50	1.35	1.65	2.5	0	0.179	0.3	0.287	32.17	31.98
MAY	1.77	0.70	1.43	50	2.20	3.48	2.5	0	0.339	0.3	0.211	20.28	19.85

NOTES a: Average monthly precipitation (1931-1965),from Climatological Handbook, Columbia Basin States, Volume II, September 1969

b: Monthly crop coefficient derived from SCS, Irrigation Water Requirements Technical Release No 21, 1989 FAO Irrigation and Drainage Paper No 24, 1977 and discussions with plant specialist Sara Cook (1/6/92)

c: Total area of proposed marsh wetland, cells 1 through 3. Delineated from a copy of plans (scale 1" = 100') from Springwood Associates (1/2/92)

d: Estimated percentage of the proposed marsh wetlands to be free water surface

e: Actual average evaporation values from 1985 to 1986 evaporation data for weather monitoring station in Puyallup

f: Evapotranspiration of wetland vegetation for the proposed mitigation site = ETo * Kc

g: Deep percolation of water in the soils. The soils at the mitigation site have been assumed to not limit the estimated evapotranspiration rates. Thus deep percolation is set higher than the evapotranspiration values.

h: Assumed to be negligible for this analysis

i: Total Evap Loss = Evapotranspiration of the Vegetation + Evaporation from free water surface

j: Amount of deep percolation expected from cells 1 through 3

k: Available Precip = Volume of Precipitation - Volume of runoff for cells 1 through 3

l: Available storm runoff = runoff from study basin north of the wetland mitigation site.

m: Net amount of water = AVAIL STRM RUNOFF + AVAIL PRECIP- DEEP PERC - TOTAL EVAP LOSS, excess water will flow to cells 4 through 8

TABLE A-3

FINAL WATER BALANCE

MONTH	PRECIP (in)	Kc	AREA(AC) cells 4-8	ET(in)	DEEP PERC (in)	RUNOFF (%)	TOTAL EVAP LOSS (ac-ft)	DEEP PERC (ac-ft)	AVAILABLE PRECIP (ac-ft)	AVAILABLE STRM RUNOFF (ac-ft)	NET(ac-ft) surplus(+) deficit(-)
		PARAMETERS WITHIN THE WOODED WETLANDS									
	note a	note b	note c	note d	note e	note f	note g	note h	note i	note j	note k
NOV	4.78	0.00	3.26	0.00	4.0	0.0	0.00	1.09	1.30	85.56	85.77
DEC	4.86	0.00	3.26	0.00	4.0	0.0	0.00	1.09	1.32	87.52	87.76
JAN	4.09	0.00	3.26	0.00	4.0	0.0	0.00	1.09	1.11	69.05	69.07
FEB	2.94	0.00	3.26	0.00	4.0	0.0	0.00	1.09	0.80	43.09	42.80
MAR	2.59	0.23	3.26	0.59	4.0	0.0	0.16	1.09	0.70	35.66	35.12
APR	2.41	0.45	3.26	1.65	4.0	0.0	0.45	1.09	0.65	31.98	31.10
MAY	1.77	0.70	3.26	3.48	4.0	0.0	0.95	1.09	0.48	19.85	18.30

NOTES a: Average monthly precipitation (1931-1965), from Climatological Handbook, Columbia Basin States, Volume II, September 1969

b: Monthly crop coefficient derived from SCS, Irrigation Water Requirements Technical Release No 21, 1989 FAO Irrigation and Drainage Paper No 24, 1977 and discussions with plant specialist Sara Cook (1/6/92)

c: Total area of proposed wooded wetland, cells 4 through 8. Delineated from a copy of plans (scale 1" = 100') from Springwood Associates (1/2/92)

d: Evapotranspiration of wetland vegetation for the proposed mitigation site = ETo * Kc

e: Deep percolation of water in the soils. The soils at the mitigation site have been assumed to not limit the estimated evapotranspiration rates. Thus deep percolation is set higher than the evapotranspiration values.

f: Assumed to be negligible for this analysis

g: Total Evap Loss = Evapotranspiration of the vegetation in cells 4 through 8

h: Amount of deep percolation expected from cells 4 through 8

i: Available Precip = Volume of Precipitation - Volume of runoff for cells 4 through 8

j: Available storm runoff = runoff from study basin north of the wetland mitigation site, after the flows have passed through cells 1 through 3

k: Net amount of water = AVAIL STRM RUNOFF + AVAIL PRECIP- DEEP PERC - TOTAL EVAP LOSS

APPENDIX F

PERFORMANCE STANDARDS SUMMARY

A. Wetland Creation Performance Standards

1. Vegetation Establishment

Standards for success of vegetation establishment on this project will be addressed according to the type of vegetative cover (i.e. trees, shrubs, and groundcover) in both wetlands and upland plantings.

TREES AND SHRUBS
Survivability: 75% survival in the first two years.

Species diversity:

1) Minimum of 3 tree species will be present and no individual species will represent less than 10% of the total.

2) Minimum of 4 shrub species will be represented and no individual species will be less than 10% of the total.

Percent Cover:

1. Tree species: Minimum of 25% cover at the end of the monitoring period.
2. Shrub species: Minimum of 30% cover at the end of the monitoring period.

GROUNDLAYER
Percent Cover:

85% cover in each plant community within the monitoring period.

Species Composition:

Minimum of 3 species with no individual species represented by less than 10% of the total.

B. New Stream Channel and Fisheries Enhancement

The Port of Bellingham is proposing to develop the new stream channel to specification approved by the Washington Department of Fisheries, however there are many factors that might result in salmon not using the stream as designed. Therefore, the Port of Bellingham makes no guarantees nor holds itself responsible for the absence of salmonids if the engineering and construction meet approved specifications.

C. Passive Recreation and Interpretive Design

Final design of the constructed berms will be coordinated with the City of Bellingham Parks Department (Parks) to ensure that proposed pedestrian trails will be built to Parks Department's specified standards. A minimum of six enameled interpretive signs will be designed and installed by the Port of Bellingham. Parks will be consulted relative to content and location of the signs. The performance standard for this goal will be for the Corps of Engineers to receive a letter from Port of Bellingham stating the above has been completed within 2 years from the date of permit issuance.

D. Research Opportunities

The evaluation of the recommended surface water BMP's will be sent to DOE and the Center for Water Resources as part of the annual monitoring report. If may be possible to have a graduate student from the University of Washington conduct the water quality monitoring to ensure the transmission of data. Such a contractual arrangement would suffice as a performance standard.

APPENDIX G

Appendix G: Determination of Water Quality Threshold Values

When a water quality baseline has been established, criteria are necessary for identifying when a change from the background condition is large enough to constitute a significant deviation from established water quality standards. These criteria depend on establishment of a threshold value against which acceptable levels of change are identified. The Coefficient of Variation (C.V.) provides a measure of the relative variability or natural variation for each water quality parameter and is calculated by dividing the standard deviation by the mean. The C.V. establishes a confidence interval of one standard deviation around the mean and can be used as the threshold value for change in the system. Deviations from the mean within this interval are attributed to natural variation in the system. Values which fall outside the confidence interval or established maximum values would be considered violations of the water quality standards.

Criteria for determining threshold values for many of the water quality parameters are presented below and in Table 1 (Stevens, 1990).

CRITERIA FOR DETERMINING THRESHOLD VALUES FOR WATER QUALITY MONITORING

1. When baseline monitoring is performed, the mean of observations shall not increase (increase or decrease for pH) by more than the C.V. (in percent) from the baseline mean as shown in Table 1.

2. When baseline monitoring is not performed, the mean of observations shall not be greater than the maximum value given in Table 1.

3. When a wetland is associated with a surface water body, the water quality criteria for that surface water body shall apply.

TABLE 1: THRESHOLD VALUES FOR WATER QUALITY PARAMETERS

Variable	Season	C.V.(%)	Maximum
pH	Each Season	10	N/A
	Annual	10	N/A
Total Phosphorus	Each Season	100	No Criteria
TP	Annual	10	No Criteria
Nitrate/Nitrite	March 1 – May 15	85	None
NO3 + NO2–N	Oct 1 – Feb 28	85	None
	Annual	85	300 ug/l
Tot Susp Solids	Oct 1 – Feb 28	100	None
TSS	Annual	60	10 ug/l
Turbidity	Oct 1 – Feb 28	100	None
	Annual	60	20 – 50
NTU			
Fecal Coli (FC)	Annual	60	
Zinc	Each Season	N/A	59 ug/l
	Annual	N/A	59 ug/l
Sediment Accretion	No data		

Use of the Coefficient of Variation as a threshold value for change in water quality depends on securing adequate background information about an individual wetland or a number of wetlands similar in type and from the same ecoregion. If no previous data has been collected for a wetland or its region, two full years of data would give a more precise estimate of the mean. This would provide a better water quality baseline for determining the acceptable threshold for change.