RESTORATION DESIGN

REPAIRING OUR DAMAGED WORLD

ESRM 479, SPRING 2012

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ESRM 479 - Restoration Design

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Front cover: Watercolor painting by Gar-Yun Ho

This book is dedicated to all the late nights spent on Google Docs, the coffee and cookies provided during lab, Jim's and Kern's sense of humor...

to our natural landscapes that constantly inspire us, and all of our loved ones who provided us support during this project marathon.

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INTRODUCTION

This book is a culmination of a quarter's worth of work in ESRM 479 Restoration Design at the University of Washington. Our group consisted of five students, Jake Dawe, Rob Edsforth, Gar-Yun Ho, Autumn Netty and Chuhan Zheng. Under the guidance of professors Kern Ewing and Jim Fridley, we created eight restoration design projects throughout the quarter, all compiled within the contents of this book. Each restoration design project required us to think of solutions for difficult to solve problems at eight different restoration sites.

The first project was Wiley Slough, located in the Skagit Wildlife Area. This tidal marsh has many different stakeholders, meaning restoring historical conditions can be a sensitive and tricky ordeal. We had to determine how and what to remove and replace in the area, to maximize restoration within our budgetary restraints. Our second project was trying to come up with a creative solution to restoring the Cedar River transmission corridor so that the corridor does not create habitat fragmentation for local species. We had to make sure downed woody debris and snags were managed in a way that follows power line regulations, while at the same time provided habitat for birds and small mammals.

The Union Bay Natural Area was our third project. In this report, we detail our solutions for the Washington State Department of Transportation in their goal of seeking ecosystem mitigation credits for the Highway 520 bridge project. We had to maximize the amount of wetland creation within the Union Bay Natural Area and try to restore areas that are the most disturbed. Areas considered highest priority for restoration were the E-5 lot and Douglas Road.

The fourth project was trying to restore vernal pool and shrub-steppe ecosystems within the Marcellus Shrub-Steppe Preserve. Vernal pool and shrub-steppe ecosystems are very fragile ecosystems and were under increasing pressure from grazing. We had to ensure the regeneration of these areas while at the same time making sure key stakeholders would be content with these solutions.

Our fifth project entailed deciding between four alternative plans for Padilla Bay

restoration. We had to create a decision matrix with criteria that quantitatively spelled out our choice of alternative. We had to then defend our criteria and final alternative and determine an action plan for the first year of the project.

The Nisqually Gravel Pit, near Ashville, Washington, was the subject of our sixth project. In this project, we had to restore a decommissioned gravel pit into an ecosystem that resembles the surrounding forest. This project was particularly challenging, because there is no clear source of water and is distant from any real sources of soil or plant material. The city of Tacoma had an excess of Tagro (commercial biosolid) available for use in the gravel pit in aid of our restoration. We then had to come up with solutions for transporting Tagro to the site and management of the site after restoration is completed.

Our seventh project was restoring trail damage at Cascade Pass in the upper regions of the Skagit River Watershed. There was major damage to the fragile sub-alpine site, due to off-trail hikers and illegal campsites. Restoring this area is particularly challenging, as the only access is through a 3.7 mile trail that is 23 miles (by road) out of Marblemount on the Skagit River and the sub-alpine site regenerates at a very slow pace. We had to determine how to transport materials to the site, and how to restore it once the materials were there.

Our eighth and final project was to decide between a number of potential restoration sites for Thorton Creek, which meanders through northern Seattle. We had to create a decision matrix with criteria to determine which projects were most important, and then come up with a site design for the highest ranked site according to our decision matrix.

All of these projects were created and edited by the group members listed above, and reviewed by professors Ewing and Fridley. The chapters that follow are the completed form of these weekly project assignments and contain our solutions, site history/analysis and all related information. The assignment prompts can be found in Appendix A.

THE WILEY SLOUGH

SALTWATER MARSH RESTORATION

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image source: http://fc01.deviantart.net/fs70/i/2012/005/9/d/dawn_on_wiley_slough_by_nightheronphoto-d4lernq.jpg

INTRODUCTION

SITE ANALYSIS

The Headquarter Unit, where the Wiley Slough Restoration project site located, is a 175-acre land in Skagit Wildlife Area. (WDFW, 2008) This tidal marsh on Fir Island is mainly vegetated by cattail and sedge. Salmon and waterfowl use this intertidal estuary as habitat. It is also a site that attracts hunting, bird watching, jogging and fishing. (WDFW, 2012) Since the late 1800s when diking, ditching and filling started on this land, most vegetated tidelands were being used for agriculture and pasture. The drainage patterns and silt deposition in the remaining tideland were also changed due to human disturbances since then. (Kunze, 1984) Around mid 1900s, waterfowl and pheasant hunting became popular. More areas were diked and tide gates were installed aiming to offer foot access for hunters. (WDFW, 2008) Direct and indirect impacts of diking and ditching on the natural environment were huge. There were 80 hectares of marsh and 6.7 ha of tidal channel loss due to the dike construction. (Hood, 2004) Remaining channels became increasingly wider and had less sinuosity, which also changed the sediment accumulation patterns, affecting the downstream tidal channels.

Salmon habitat sharply decreased because of the low velocity flow and loss of deep pools. (WDFW, 2008) Moreover, the loss of floodplain due to dike building prevented the releasing of pressure over the marsh, which increased the possibility of overflow. (WDFW, 2008) Skagit River is home to 6 of the 22 populations of wild Chinook Salmon in the Puget Sound. Ever since Chinook salmon were listed as endangered species under U.S. Endangered Species Act (ESA) by NOAA Fisheries in 2005, Washington Department of Fish & Wildlife (WDFW) has made efforts to restore the intertidal estuaries and recover the salmon population. The Wiley Slough Restoration project was one of the most important outcomes of the recovery action. The project was intended to restore natural tidal and riverine flooding processes both on public owned parcels of land, and through buying privately owned property for bringing back more wildlife habitat. Protecting recreational functions was also an important consideration of the project. Farmers, hunters, birdwatchers, and tribal fisheries are all crucial stakeholders in this case.

GOALS

Our main goal for the Wiley Slough is to restore the estuary as a high primary productivity habitat for juvenile Chinook salmonids. Functional requirements included increasing the tidal channel area through tidal channel sinuosity and anastomosing, and increasing the abundance of saltwater marsh with a passive method of auto-generating which will create a productive primary habitat for the native salmonid species.

OBJECTIVES

With such extreme losses and destruction of our native salmon habitat our main objective is the full restoration of the saltwater marsh. We will provide the infrastructure for the tidal waters and the river to reconnect and hopefully self-generate in a somewhat passive way. To meet our objectives we must first construct and then monitor our built structures and the surrounding habitat for a multitude of elements, which include: hydrology, sediment structure, erosion and build up, plant species, benthic invertebrates, anadromous fish species, birds species and others.

It is our hope that with the success of this part of the restoration project new opportunities will arise for other recreational uses, such as a more diverse bird population for expanded bird watching opportunities, estuary restoration educational opportunities and shellfish and recreational fishing opportunities.

STAKEHOLDERS

Diverting or opening dikes, levees, repopulating the streams, and creating pools where salmon can congregate and feed, will increase the salmon population. This will provide more support for and fees paid from the fisherman, increasing their likelihood of being on our side for restoration. Having this group's input in the process will create a good relationships and provide reasonable assurances that a good result can be accomplished.

WILDLIFE AND ENVIRONMENTAL PRESERVATIONISTS – Restoration activities should be a positive thing for this group. Their input should be sought. Our efforts should be explained to them to avoid any misunderstandings.

TRIBAL COMMUNITY - Environmental benefits being restored should improve ways of life for tribal communities. This group should be approached in the same manner as the preservationists. Environmental function improvement ideas will likely come from this group and cooperation with them will create goodwill.

BIRD WATCHERS – With the increased salmon populations and control over the existing bird population, bird species will become more diverse. Bird watchers will have more variety. By controlling one species with hunting and other predator creation tactics, one bird species will not out compete others.

BIRD HUNTERS – Having this groups input and support is important, as they will provide a method of controlling the bird population. Hunters will feel like they are a part of the process and educate us on how to satisfy their needs while still accomplishing the overall objectives of restoration. Bird hunters will also be paying fees for the hunting privilege.

FARM OWNERS – Farmers will benefit from better quality soils as a result of restoration, resulting in better crops, feed for livestock, etc. This financial gain should be communicated to the farmers to gain support for our efforts. Although some farm land will be restored, this restoration will improve the overall land quality, and ecological benefit such as flood attenuation resulting in minimal land

productivity loss for farmers. They need to be made aware of that.

HIKERS, BIKERS, OFF ROAD RECREATION, BOATERS – Controlled use of portions of the land can be set aside for recreational uses such as hiking, biking and even off road activities. Although fees for these types of activities will be minimal, their support in our efforts can go a long way in community education and awareness of the importance of this project. (Public outreach meetings)

GOVERNMENTAL AGENCIES, ARMY CORP OF ENGINEERS, WDFW – Fee increases for salmon fishing and hunting permits can subsidize the cost of restoration. Financial and environmental gains associated with habitat creation, water quality improvements, erosion control, soil quality improvements, flood attenuation, storm abatement and the permit fees should be communicated. These gains can be used to offset our restoration costs.

As communicated above, a partnership between all stakeholders and other users of the land should be established. Education on benefits to each side: both financial and environmental, will increase the likelihood of agreement to activities. Compromise at this initial stage on all sides will decrease the likelihood of inefficiencies created by poor communication and lack of understanding of points of view. Representatives from each group should be part of this restoration taskforce. The benefits of this will provide financial efficiencies for restoration efforts and create goodwill. Hostilities on areas being taken away or added too close to some groups can be discussed and resolved. Also, although a good portion of public land will be lost, due to hydrology reconnection, other areas can be created. These new areas can be carefully looked at by all parties. Less ecologically critical areas can be used for the public access. By being strategic in the land use, and the education to all parties of the financial and ecological benefits of this use, coalitions will form and all parties will work together for the common good. Most inefficiency is created by lack of communication and hostility. These can be minimized with a small amount of resources being expended to have meetings, doing research and making compromises.

DESIGN

STRATEGIES

Our strategy for accomplishing these goals and objectives is to remove a portion of the dike and to create a new dike farther upland. A small culvert with a footbridge will be built into the new dike so as to allow a better flow of fresh water into the tidal saltmarsh. We feel that our placement of the new dike will allow for the most increase in tidal channel surface area.
Another way to increase the tidal channel surface area is to place some large woody debris (LWD) in the high saltmarsh habitat area. This helps the tidal channel in anastomosing, which creates structural diversity and higher marsh productivity. Our strategy is to construct the infrastructural elements and observe the site for natural succession into a saltmarsh estuary habitat for juvenile salmonid. These activities will also have an influence on surrounding areas, as wildlife, wind and tide spread the effects of our restoration to all sides of our site. With our site being centrally located, the greatest impact will be made on the surrounding areas at the landscape and wildlife scale.
Our observations of the site will then guide our next steps toward the restoration of the Wiley Slough.

POTENTIAL COMPLICATIONS

When removing and creating dikes there is the potential for unintended flooding of the surrounding area not subject to restoration. This can be due to malfunctioning of or miscalculations in the removal/building of the dike, tidegate malfunctioning, sediment infilling of the culvert and/or topography or elevation changes. These potential difficulties will be addressed with scientifically sound established methods for dike removal/creation and careful monitoring of the process. The culvert will need to be built at the correct height, diameter and slope so as to reduce the risk of sediment infilling. The dike will need to be constructed with correct proportions so as not to fail. Both the dike, the tidegate and the culvert will need to be monitored closely after construction to assure proper functioning. The installation of the LWD will

need to be monitored for potential unmooring which could cause damage to the dike or culvert.

Another potential hazard would be the establishment of nonnative invasive species that can significantly alter the saltwater marsh, creating a habitat that is inhospitable to anadromous aquatic species and native marine vegetation. Monitoring for all conditions will be paramount and continuous.

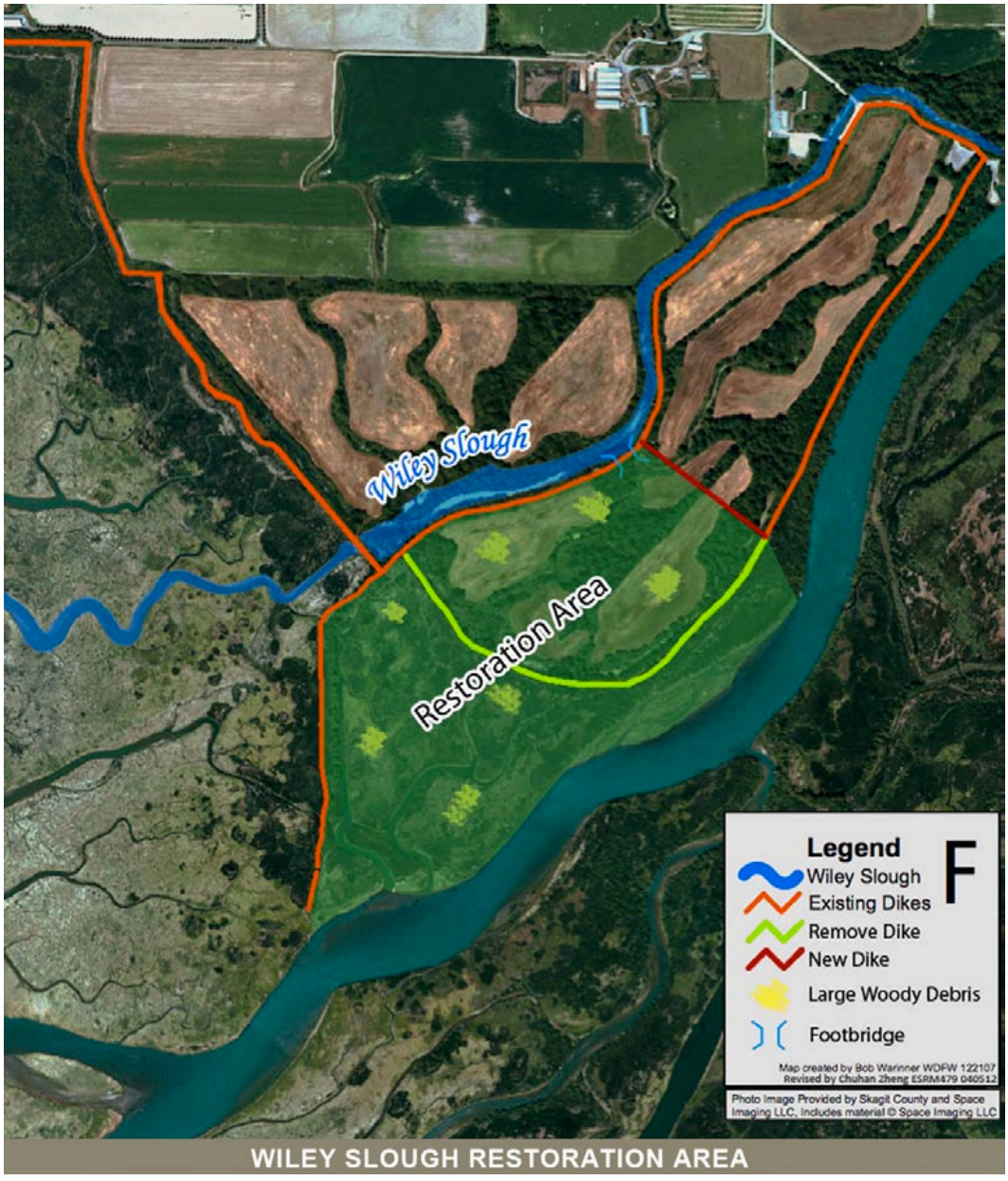

Figure 1. Map of Skagit Wildlife Area and Restoration Site

PLANNING

PROCESS

A number of steps were taken in our evaluation of the multiple alternatives for the site's restoration design. For our initial assessment of the Wiley Slough, we performed a brief analysis of the site, important stakeholders, environmental functions, changes and impacts on the historical ecosystem, any perceivable constraints, predicted level of repair and likelihood for autogenic repair, the range of restoration options, and estimated requirements.

The Wiley Slough is a complex area, not only physically and ecologically, but historically and socially as well. Nevertheless, we established that the most important functional requirement that should be addressed in our site design for the Wiley Slough was the restoration and management of juvenile salmon habitat. This functional requirement would be accomplished by restoring natural tidal and riverine processes to the Wiley Slough, which would then allow for autogenic repair.

For constraints, we had to accommodate for the interests of farm owners, governmental agencies and special interest groups, bird watches, environmental preservationists, and Skagit Native American Tribes. We also had to keep in mind our project budget, which was half of what the WDFW Wiley Slough Estuarine Restoration Design had calculated, was significantly limited.

A range of restoration options were available to us to choose from. Key elements included: the removal of about 6,500 feet of existing dikes/levees; reinforcement of existing dikes/levees, construction of 2,840 feet of new dikes/levees, retention of 3,750 feet of existing dikes/levees to maintain agricultural drainage, moving a new and larger tide gate structure at a new location, filling 3,470 feet of borrow ditches to facilitate redevelopment of historical drainage networks, the maintenance or improvement in existing upstream agricultural drainage features, and the maintenance of the spur dike trail and the addition of new recreational trails (WDFW, 2008). (See the map) Our group decided to remove about 2,700

feet of dike/levee from the southwestern upstream marsh area, and add about 930 feet of dike/levee in a position that was not proposed in the original plan.

Other interventions included reinforcement of dikes, footbridges for recreation, and increased flow of water from the river to flood into our target area for restoration. Budgetary and temporal constraints had to be taken into account in our solution. Therefore, we reasoned that, due to the fragmented process of accomplishing the project in phases, our interventions would allow for the greatest amount of restoration for juvenile salmon habitat and the least disturbance to agricultural farming land, recreational areas, and fowl habitat.

SEQUENCING

Projects should be ranked by following priority:
1. Install LWD
2. Removal of ~800m (2700ft) of dike
3. Add ~300m (930ft) of dike using used dike material
4. Create footbridge across new dike opening for access to the rest of the dike

MANAGEMENT AND MONITORING

MANAGEMENT

Monitoring for all conditions will be paramount and continuous. We envision one day that the entire Wiley Slough Restoration Project will be managed with all parties involved actively and willingly working together to replace and maintain our destroyed estuaries with continuous monitoring and corrective action. The native salmon species will be used as an indicator species for the management direction of this estuary restoration project, with steps taken to rectify damaging influences if, when and as they occur.

POST RESTORATION MONITORING

Taking the lead from the Nisqually Delta Restoration, further estuary studies will be placed in this area in long term including mapping of nearshore topography and habitats, hydrology processed controlling fluvial and tidal flow, and estuarine mixing and sediment and nutrient transport to relate changes in ecosystem response. (Nisqually Delta Restoration team, 2012) Sediment composition and elevation changes will be monitored as well as plant species, aquatic anadromous marine species and benthic invertebrate composition and amount.

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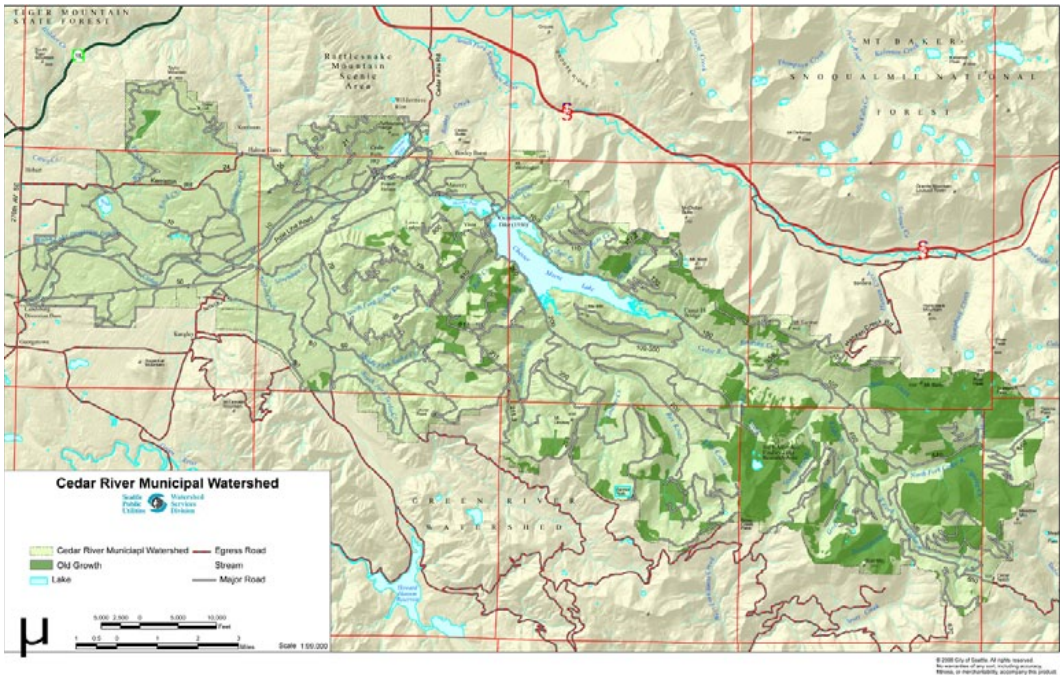

THE CEDAR RIVER WATERSHED

TRANSMISSION CORRIDOR RESTORATION

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http://www.seattle.gov/util/About_SPU/Water_System/Water_Sources_&_Treatment/Cedar_River_Watershed/index.asp

INTRODUCTION

SITE HISTORY AND ANALYSIS

Providing habitat and protection to a rich biological diversity, the Cedar River Watershed is a cross section of habitat from the central Cascade Mountains crest to the Puget Sound lowlands near North Bend, Washington. Prior to the late 1800's the lower watershed area was old growth forest. Evidence suggests that, from 1650 to 1675, a large fire swept through the higher area of the shed above 1600 feet. By 1900 the forest in this area was about 250 years old. Between 1900 to1924, logging practices began with little regard for the watershed area. The removal of 30,000 acres of trees caused hillsides to be denuded and increasingly susceptible to fire hazard dangers, and second forest growth potential to be suppressed. Prior to 1924, attempts were made at restoring the forest. However, these attempts failed, as frequent fires, due in large part to the careless logging practices, destroyed all of the plantings. Other environmental destruction occurred during this time as well. Tree removal led to the loss of wildlife species and diversity, and poor sanitary practices by sawmills and logging camps resulted in water and air pollution. (SPU, 2012)

In 1924, the City of Seattle hired Dean Hugo Winkenwerder of the University of Washington - College of Forestry to come up with a plan to restore the area. Upon the recommendation of the restoration plan, a permanent forester was hired. Logging did continue, but better practices were observed so that the sanitary and operating conditions minimized threats of fire and further degradation of the ecosystem. Logging no longer occurs in the watershed. In 1962, landowners signed the Cedar River Watershed Cooperative, which lead to the City of Seattle's complete control of the area. This resulted in more fire control and public access restrictions by 1996, when City of Seattle took ownership from the USDA Forest Service. In 2000 the HCP, Habitat Conservation Plan, established the entire watershed area as a no logging zone.

Ranging in elevation from 500 to 5000 feet above sea level, the watershed provides two thirds of the drinking water for 1.4 million King County residents.

The watershed also serves as habitat for 19 species of fish, three of which are considered endangered: the bull trout, steelhead trout, and Chinook Salmon. Other wildlife in the watershed are 125 species of birds, some of these being threatened, and 40 mammal species including bear, deer and elk. Habitat types within the watershed include lakes and streams, ponds, forests, wetlands, meadows and rock formations. Small wetlands occur in the lower portion of the watershed. The upper portion is forested, interspersed with rock formations and meadows. (Friends of Cedar River Watershed, 2012)

The transmission corridor area runs through the watershed and supplies power to many King County residents. The watershed is being managed as one of the 6 remaining ecological preserves in the country and to promote old growth forest conditions. Preservation of wildlife and drinking water are the main reasons for this management. Therefore, the area is protected and has access restrictions. The removal of all tall vegetation and trees along the 5 mile corridor and the building of the transmission corridor have resulted in the disturbance of this ecosystem. These activities have resulted in the fragmentation from the surrounding heavily forested ecosystem. The area has road access, a wetland area, and riparian zone.

GOALS

In order to meet local public increasing demand for electricity, the Bonneville Power Administration (BPA) is planning to build a 5 mile long, 150 foot wide new Right-of-Way (ROW) for a new transmission line. During the planning and construction process of the new line, BPA aims to maintain the current environmental quality, minimize the human interruption to the natural world, and at the same time minimize the cost to BPA's ratepayers. More specifically, the functional requirements include ensuring continued high water quality levels in the Cedar River Watershed for drinking use and also fish habitats. Maintaining quantity and quality of forests, snags, large woody debris (LWD), habitat and old forest conditions are also important goals. Finally, recreational and educational uses of the watershed will be protected.

PLANNING

OBJECTIVES

Due to the mixed ecosystem types in the watershed, restoration strategies for each type will be different. Ecosystem and habitat types include wetland, riparian zone, river crossing, upland, snags, LWD and large trees. All the strategies should to be well-fitted to the local circumstances. They should be easy to implement and provide for autogenic recovery. These restoration efforts should also be managed in order to meet the long-term needs and goals of the previously discussed stakeholders. A detailed long-term conservation easement and management plan is also needed for ensuring the regular vegetation upkeep of the corridor. The new line will be built parallel to the existing 500-kV line for its entire length in order to reduce the potential impacts to environment and also to minimize cost. Trees close to the ROW will be trimmed shorter or transferred to other places as snags to create downed woody debris. A comparatively lower area outside of the corridor will be created for the sake of reducing possibilities of trees coming into contact with lines or towers and destroy the network system when they grow too tall or when storm events occur. Other vegetation clearing activities will be limited to the operational and maintenance needs of the transmission lines. Re-vegetation of slow growing plants and protection of snags and large trees will be implemented as part of monitoring and maintenance activities.

STAKEHOLDERS

There are many stakeholders involved at the Cedar River Watershed. Committed to the restoration process, the **CITY OF SEATTLE** had taken many precautions to minimize disturbance to the ecosystem when the transmission corridor was built. Another vital environmental support group is the **FRIENDS OF THE CEDAR RIVER WATERSHED**. They are a great resource for providing volunteers and general information on the area. They have an education center, fund drives for wildlife and other activities that are critical to the preservation of this rich and diverse area. Utilizing this group in our restoration efforts is essential to the long term success of restoration.

CASCADE LAND CONSERVANCY, now called **FORTERRA**, the **DEPARTMENT OF NATURAL RESOURCES**, and **WASHINGTON DEPARTMENT OF FISH AND WILDLIFE** are groups that work closely with the **FRIENDS OF CEDAR RIVER WATERSHED** and the City. The objectives and visions of these organizations are in line with our restoration efforts, and communication and consultation with these important resources will be encouraged.

The **BONNEVILLE POWER ADMINISTRATION (BPA)** built the power lines. They have rules and regulations regarding the allowable size of trees and other vegetation along the line. This group has also worked very well with the City. They have transferred land to the protected watershed, and have agreed not to fill any wetlands. There are also insurance and other legal and safety issues involved with our restoration efforts. Power lines have electric current going through them and water below, which complicates things in terms of volunteers, type of equipment used, plants selected and other matters. City insurance and legal department staff need to be consulted at each step of the way.

Other stakeholders are the community at large since this watershed provides some of the cleanest drinking water in the world (Friends of Cedar River Watershed, 2012). People to whom the power is supplied to are affected as well and need

PLANNING

to be educated on the importance of the watershed area. The Cedar River encompasses a large area, and affects a lot of people. Our restoration efforts will have a long range ripple effect on multiple ecosystems.

Fisherman, wildlife preservationists, hunters and bird watchers close to the watershed and downstream are influenced in some way. Revenues to the City and State for these recreational activities can be influenced. These stakeholders and interest groups need to be made aware that this five mile area, if left disturbed, will have negative impacts on adjacent areas, and will hinder the efforts to preserve land, wildlife and clean drinking water.

POTENTIAL ISSUES AND PLANNING PROCESS

The linear nature of utility corridors fragments landscapes and habitats, and leads to the destruction of habitat and to the loss of biodiversity. Line construction and traffic from heavy vehicles and equipment greatly disturb ecosystems (within corridors), and often result in bare slopes that are exposed to rainfall and high rates of erosion from wind and rainfall (Bochet, 2004). Foliage height diversity, which is positively correlated with bird species richness, is reduced when forests are replaced by low-growing vegetation, and avian species richness is considerably less than in a hardwood forest (Johnson et al., 1979).

Although edge habitat conditions support a wide diversity of wildlife and vegetation, edges always face the potential of being undesirably taken over by more opportunistic, non-native, invasive, weedy species. Therefore, for the conservation of endangered or threatened species, the edges of utility corridors must be maintained and managed on a consistent basis, and prior planning should take care to minimize destruction and fragmentation of habitat.

The construction of the utility corridor could also potentially affect the water quality from the Cedar River Watershed. Utility corridors through Canada were

found to have both altered species abundances and water chemistry. Conductivity and pH of water samples were found to be higher than levels sampled before corridor construction (Magnussen et al., 1987). Maintenance of water quality is important for the Cedar River Watershed for the protection of sockeye and endangered Chinook salmon, amongst other species of concern, as well as for drinking purposes for the residents of King County.

A range of restoration options were available. The edge of the utility corridor could be "feathered" by creating a gradual habitat transition from the forest to the open corridor. Scheduled maintenance of the edge would reduce the "edge effect". Wildlife corridors, like tunnels for amphibians and small mammals, could be constructed for protection and connection for fragmented habitat. Low-growing vegetation provides protective runways and nesting sites for small mammals (Johnson et al., 1979).

Open habitat could be maintained for bird and mammalian species that thrive in early successional habitats and depend on habitat disturbance. Grasslands, savannas, and open pine-barrens support grassland and shrubland birds (Askins, 1994). To minimize the wind tunnel effect and erosion, vegetation buffers could be planted and maintained so that their height will not disturb nor interfere with the power lines and its maintenance.

In general, restoration to historical ecosystem will be impossible, but fragmentation could be alleviated through various site interventions. The potential for autogenic repair is very minimal, and constant management and maintenance will be imperative in restoring and conserving habitat along the corridor.

PLANNING

PARAMETERS AND FUNCTIONAL CONSTRAINTS

Implementation and installation of the additional lines from the Grand Coulee Dam to Kangley, Washington will require the expansion of an existing 300 foot corridor by 150 feet. Tall-growing vegetation within the corridor will be removed, and tall trees outside of the right of way that could fall and damage the line will also be removed. Clearance and management of tree growth along the right of way are essential so that trees will not interfere with power transmission and so that lines will be accessible for management, maintenance, and inspection.

In Magnussen and Stewart's research on effects of disturbances along hydroelectric transmission corridors in northern Manitoba, primary sources of disturbances in right of ways are listed to be the initial clearance and line construction, traffic, and vegetation management with herbicides (Magnussen et al., 1987). To minimize initial clearance and construction, helicopters will be used for tower construction. Careful and periodic removal of tall vegetation on a rotation plan should be implemented so as to minimize disturbance within the corridor. No herbicides will be used within the watershed.

Remnant old growth trees will be retained along with snags, and trees of 20" diameter or greater will be retained, so long as they do not interfere with the power line. There will be a minimum of two large downed logs per acre, and seasonal wildlife should be accommodated. Wetlands will not be filled, and seasonal wildlife should be accounted for. Care should be taken so that operations will be designed carefully to minimize impact to the human environment, minimize disturbance during construction, and minimize costs to ratepayers.

Five miles of the power line corridor goes through the Cedar River Watershed, which is home to 83 species of fish and wildlife, 14 of which are species of concern (SPU, 1995-2011). Although consolidating the new and existing corridors by the expansion of the existing corridor will minimize disturbance and help maintain larger areas of continuous forest, measures must be taken to ensure for

the protection of these key endangered species.

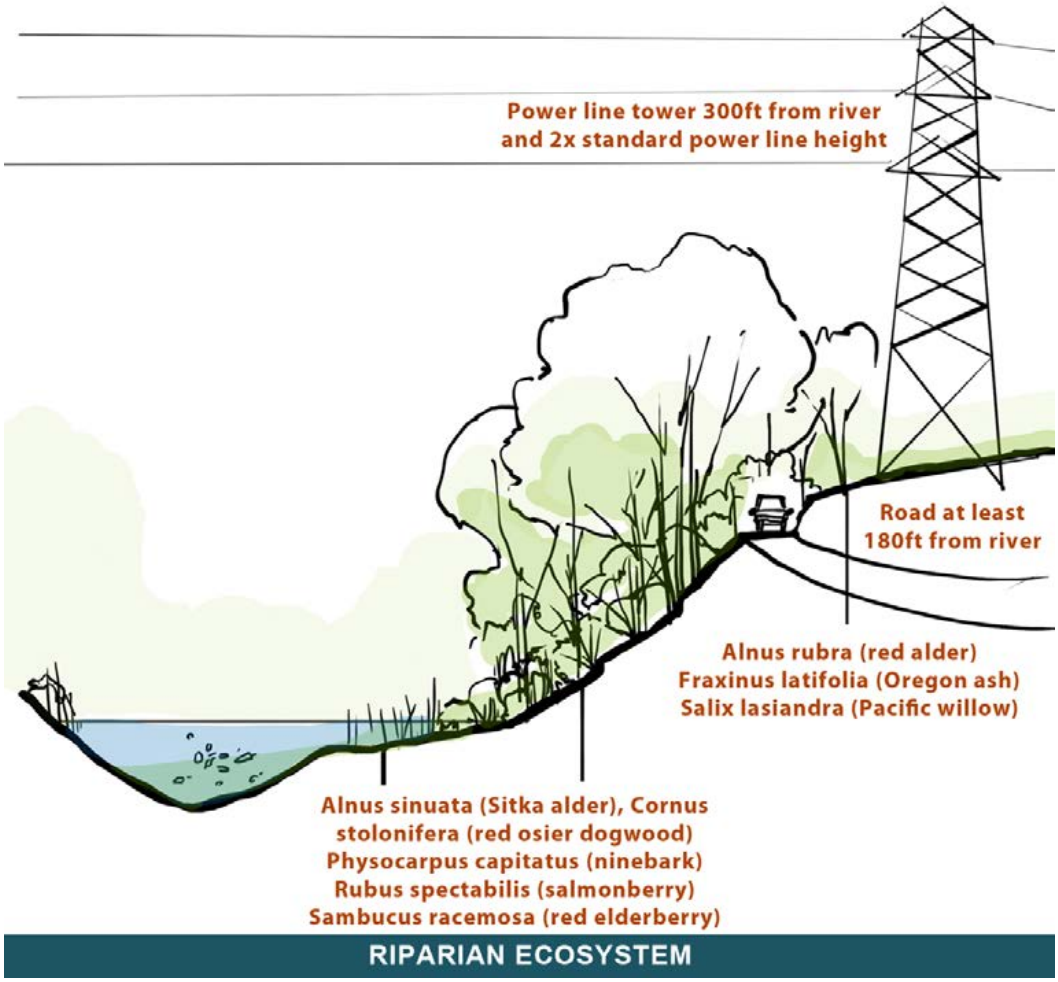
The 14 species of greatest concern include the Haliaeetus leucocephalus (Bald Eagle), Gavia immer (Common Loon), Brachyramphus marmoratus (Marbled Murrelet), Accipiter gentilis (Northern Goshawk), Strix occidentalis caurina (Northern Spotted Owl), Falco peregrines (Peregrine Falcon), Salvelinus confluentus (Bull Trout), Oncorhynchus tshawytscha (Chinook Salmon), Oncorhynchus kisutch (Coho Salmon), Prosopium coulteri (Pygmy Whitefish), Oncorhynchus nerka (Sockeye Salmon), Oncorhynchus mykiss (Steelhead Trout), Canis lupus (Gray Wolf), and the Ursus arctos (Grizzly Bear) (SPU, 1995-2011). In return for the power line corridor expansion, 600 acres of land will be transferred to watershed under a conservation easement to improve quality and habitat, and 500 acres of adjacent BPA land will be placed in a conservation easement.

DESIGN

SOLUTIONS / STRATEGIES FOR ROW RIPARIAN FOREST ECOSYSTEM

For the restoration of the riparian ecosystem we will be planting the native hardwoods Alnus rubra (red alder), Fraxinus latifolia (Oregon ash) and Salix lasiandra (Pacific willow). We will also plant the native shrubs Alnus sinuata (Sitka alder), Cornus stolonifera (red osier dogwood), Physocarpus capitatus (ninebark), Rubus spectabilis (salmonberry) and Sambucus racemosa (red elderberry). Planting tubes will be used for bareroot or container plantings, which will help deter herbivory by the local deer, elk, beaver and other various mammals. The native trees and shrubs will not only begin to restore habitat for the multitude of birds and mammals but will also improve water quality for endangered salmon by providing food, shelter and shade. Red alder is specifically important as a nitrogen fixer. It is also suggested that a greater abundance of deciduous species in the riparian ecosystem will enhance dissolved stream nutrients which are necessary for the growth and survival of juvenile salmon.

To help create a riparian ecosystem with mature growth characteristics while also stabilizing stream bank erosion and improving hydrology and water quality, red alder will be planted along with Oregon ash. Red alder has a usual life span of 100 yrs, topping out in height at about 60 years of age, and Oregon ash can reach the age of 250 years. Red alder can reach heights from 100 feet to 110 feet, and Oregon ash can reach 60 to 80 feet. Both of these trees species are also extremely wind resistant. These characteristics make it a suitable species both for height in relation to transmission corridor restrictions, and minimizing danger of falling as a result of high wind exposure (Owston). Pacific willow is also wind tolerant, and therefore can be used to stabilize stream bank erosion and provide stream bank shading. All tree and shrub species planted are an excellent food source and habitat for native wildlife including elk, deer, songbirds, beaver and salmon. (Riley et. al)


Power line tower 300ft from river
and 2x standard power line height
Road at least
180ft from river
Alnus rubra (red alder)
Fraxinus latifolia (Oregon ash)
Salix lasiandra (Pacific willow)
Alnus sinuata (Sitka alder), Cornus
stolonifera (red osier dogwood)
Physocarpus capitatus (ninebark)
Rubus spectabilis (salmonberry)
Sambucus racemosa (red elderberry)
RIPARIAN ECOSYSTEM

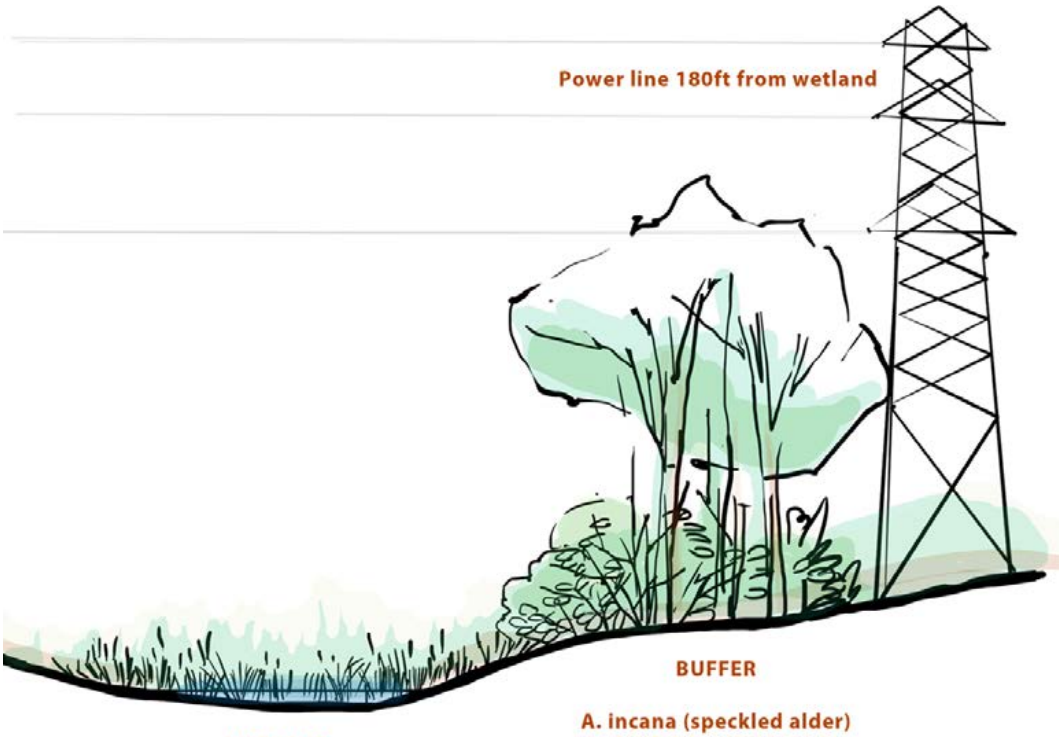
DESIGN

SOLUTIONS/STRATEGIES FOR WETLAND ECOSYSTEMS

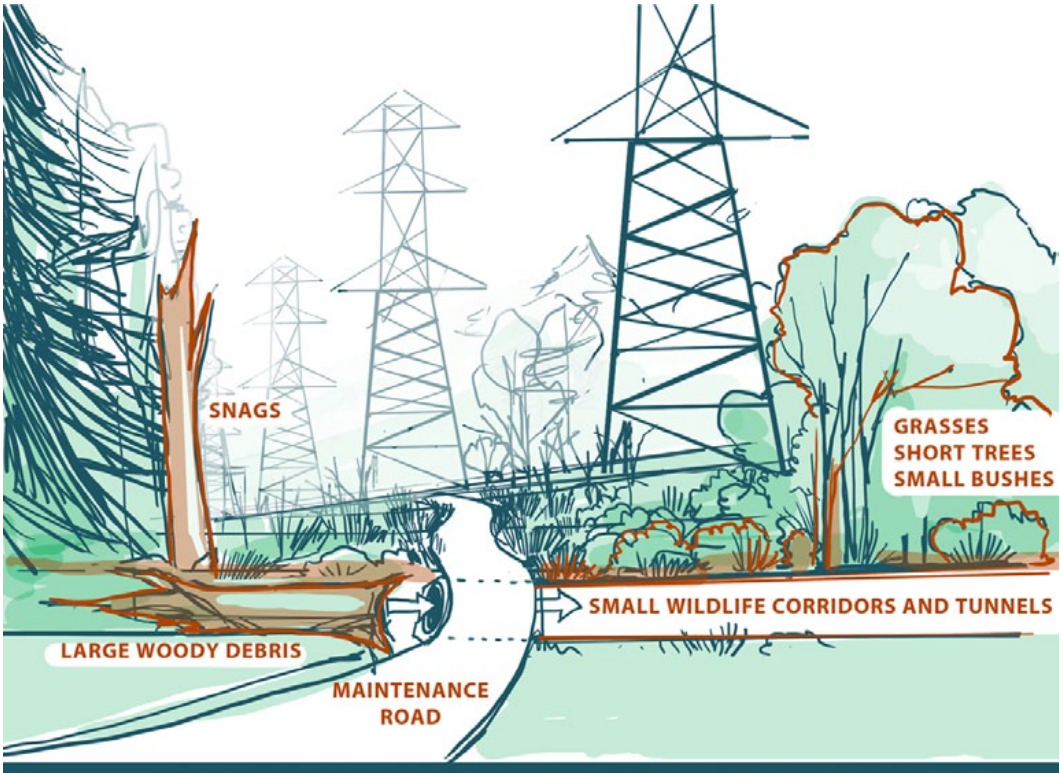
We will focus our efforts on planting obligate and facultative wetland plants native to the Pacific Northwest for the restoration of the wetland ecosystem. A buffer will be planted with A. incana (speckled alder), F. latifolia (Oregon ash) and S. lasiandra (Pacific willow) to deter the invasion of Pseudotsuga menziesii (Douglas fir) and other coniferous native tree species and to serve as a windbreak. The native shrubs C. stolonifera (red osier dogwood) and P.capitatus (ninebark) will be planted for structural diversity and wildlife habitat. For the wetland species, we will plant Carex luzulina (woodrush sedge), C. rostrata (beaked sedge), C. stipata (sawbeak sedge), C. sitchensis (Sitka sedge), Eleocharis palustris (common spike rush) and Juncus balticus (Baltic rush). Because woodrush sedge may not be commercially available, seeds will be collected from regional specimens.

SOLUTIONS/STRATEGIES FOR UPLAND ECOSYSTEM

Forest is the major component of the upland ecosystem. Out of these 85,000 acres of forest, only 14,623 acres are old-growth forest. Due to the logging activities in the past, more than 5% of old-growth trees were lost. These trees are mainly above 2,500 feet and between 190-350 years old. (Seattle Public Utilities, 1995-2011) They are usually very large trees in a large diversity of species and forming a very complex canopy system. Places that had been clear cut or selectively logged are covered by second-growth forest consisting of very tightly packed younger and smaller old growth trees. After the construction of the corridor, trees should be either transferred to other places, or used as commercial timber. Planting strategies should include transplanting certain old growth tree species in order to promote autogenic recovery. At the same time, old-growth forest preservation should be a high priority, as it is a main goal for water quality and wildlife preservation. No trees will be removed unless they are potentially dangerous to the present or future operations of the corridor.



WETLAND ECOSYSTEM



UPLAND ECOSYSTEM: 200' BUFFER CORRIDOR ZONE

DESIGN

SOLUTIONS/STRATEGIES FOR SNAGS, LARGE WOODY DEBRIS AND LARGE TREES

Snags, large woody debris (LWD) and large trees provide the best natural habitats for wildlife because they can provide shelter, store food, and protect wildlife species from predators. Our restoration plan is to retain and expand upon these key forest components in our efforts to minimize fragmentation. Forests in the Cedar River Watershed consist of trees that are around 200-year-old. Major tree species include douglas-fir, pacific silver fir, noble fir, western hemlock, mountain hemlock, western red cedar and red alder. (SPU, 1995-2011) These coniferous trees stand long after they die, becoming ideal shelters and habitats for birds, squirrels and other animals. As part of our restoration efforts, it is very important to have snags to promote a diverse species population.

LWD function similarly to snags. In riparian areas, LWD can create pools and channels, which are ideal habitat for salmon. According to the record of decision released by BPA in 2003, there should be at least 2 large downed logs per acre retained in the watershed. LWD will be placed in areas that do not meet this requirement due to human interruption. LWDs shouldn't be removed from the river if the removal causes harm to river bed sediments or disturbs habitat. Any threat to water quality caused by artificial placement of LWD will be carefully monitored and resolved. (BPA, 2003)

MANAGEMENT AND MONITORING

Until specific goals are met, management and maintenance will be extensive and ongoing with semiannual inspections in early spring and early fall, and necessary actions will be taken to mitigate or enhance the project plan. There is a high probability of invasive species establishing, as well as invasion of native conifers from surrounding forest areas. These conifers could potentially exceed the height restrictions in the corridor area. Therefore, for proper management and maintenance of the corridor, it will be necessary to monitor and prevent the presence of these trees and invasive species regrowth. Plant predation and plant survival rate also needs to be tracked. Once plant establishment has been confirmed, the site will be annually managed for invasive plant removal, tree health safety monitoring, wildlife species and plant composition. A 5 and 10 year plan should also be implemented in order to ensure continued progress towards habitat restoration and recovery, minimization of the effects of fragmentation, autogenic recovery, and ecological succession.

In the circumstance that red alder and Oregon ash produce excessive seedlings, these seedlings will be removed and used for nursery stock production. All trees that reach the corridor boundaries will be used for LWD or snags, either onsite or removed and transplanted to another location. This removal will be done in the most ecologically sensitive way possible.

This five-mile corridor will be a labor and time intensive long term management and maintenance project. It is our plan to work closely with the Friends of Cedar River Watershed and City of Seattle, and the Habitat Conservation Plan will continue to be in force and will provide an added safeguard to our success. It is our vision that, through this restoration effort, not only will the ecosystem eventually begin to repair itself but a positive ripple effect will be felt throughout this regional community by uniting the various interest groups on one common goal: the return of an ecosystem to a close approximation of its condition prior to disturbance.

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UNION BAY NATURAL AREA (UBNA)

FRESHWATER WETLAND RESTORATION

Jake Dawe
Rob Edsforth
Gar-Yun Ho
Autumn Nettey
Chuhan Zheng

Image source: http://www.insidebainbridge.com/tag/hiking/

INTRODUCTION

The Union Bay Natural Area (UBNA) is a 73.5 acre site directly to the East of the E-1 parking lots. This area is managed by the University of Washington and restoration projects are carried out by students and other volunteers. The purpose of this restoration is to restore the ecological function of this area to that of a wetland habitat, and to reconnect fragmented areas surrounding the site. Within the UBNA there is a small gravel parking lot and a road, parking lot E-5 and Douglas Road, which leads into Union Bay area from the north side. These two land uses clearly clash with the surrounding wetland reserve, and inhibit ecological function within UBNA.

The Washington State Department of Transportation is proposing to use the UBNA as mitigation credits for their reconstruction of the 520 floating bridge project which is destroying wetland area just north of the Arboretum. They will earn the most credit for restoring natural function to the E-5 parking lot and Douglas Road. To accomplish this, E-5 and Douglas Road will be excavated down to around lake level so that the area connects with Lake Washington.

In this report, we propose our recommendations to the Washington State Department of Transportation to restore these areas to a wetland and gain maximum mitigation credits for their 520 floating bridge project. Our site design proposes the excavation of the E-5 lot and Douglas Road, the lowering of these areas to Lake Washington water level (roughly 16'-19' elevation depending on the season), and the creation of a berm on the northwest side of the UBNA to redirect surface flows south to and through the E-5 parking lot.

Our plan details recommendations on what excavation/construction should take place, complete with topographic mapping of the site, as well as cross sections that provide a clearer view of the biology of the site. To address recreation and pedestrian circulation, our site design includes a series of viewing platforms, ramps, and a bridge to both connect Wahkiakum Lane to the University of Washington and to enhance the user's recreational experience in the UBNA.

OBJECTIVES

It is our objective to replace the ecological functions lost with similar, if not improved functions. By removing soil, altering the topography, and planting a variety of wetland species, we hope to redirect the seasonal flow of the slough out across the area that had once been Douglas Rd. and into the wetland to the east creating a more continuous wetland habitat used by both wildlife and humans.

It is also our objective to continue and enhance the relationship with the University of Washington as the primary stewards of this land.

PLANNING

FUNCTIONAL REQUIREMENTS AND CONSTRAINTS

The geology, hydrology, and historical uses of the Union Bay Natural Area (UBNA) prevent the safe construction and development of buildings, and thus provide opportunities for ecological restoration and conservation as well as educational and recreational amenities. From 1925 to 1966, the Union Bay area was utilized as a rubbish repository and public dumping site. Afterwards, the land was filled with the intent of converting the Union Bay area into a building development site. However, due to the deep spongy peat deposit that settled unevenly under the landfill, safe foundation construction was impossible (Hamilton et al., 1995).

The deltaic deposits below the Union Bay area – 50’ soft clay, 20’ soft peat, 15’ wood fill, and 20’ landfill (Ewing, 2010) – caused subsidence of the surface, and still continue to do so at a slower rate than before. In May 1985, the Environmental Protection Agency performed a preliminary site assessment on the Montlake Fill, and then delegated the assessment to the Washington Department of Ecology. Due to the hazardous materials that were disposed, the Union Bay area is classified as a C1 site and has strict regulations of any changes in existing drainage patterns and grading activities (Hamilton et al., “Legal Restrictions”, 1995).

Now, the UBNA serves as a major educational and recreational asset to the community and is the second largest natural preserve along Lake Washington (Ewing, 2010). Once a capped landfill overgrown with invasive species like Himalayan blackberry, the UBNA has undergone major improvements because of educational restoration activities, advanced research and improved management.

The most recent 1995 Management Plan for the Union Bay Shoreline and Natural Areas divides the management plan into nine categories of action (Ewing, Chapter 4, 2010):

1. Remove invasive non-native plants and animals.
2. Add native plants.
3. Maximize habitat diversity and native biodiversity.
4. Control human impacts
5. Monitor physical and biological conditions.
6. Increase and coordinate teaching and research.
7. Enhance personal safety.
8. Ensure public accessibility.
9. Provide educational interpretation.

Invasive non-native species management entails the control and eventual suppression of Himalayan blackberry, removal of reed canarygrass, as well as periodic mowing. To minimize the use of herbicides, mulching and live-willow staking to produce shade have produced positive results in the fight against Phalaris arundinacea (reed canary grass). Other invasive species that should be managed and controlled include Lysmachia vulgaris (garden loosestrife), Cirsium arvense (Canada thistle), Senecio jacobaea (tansy ragwort), Lysimachia punctata (yellow loosestrife), Phalaris arundinacea (reed canarygrass), Rubus armenciacus (Himalayan blackberry), Polygonum cuspidatum (Japanese knotweed) and P. sachalinense (giant knotweed) (Hamilton et al., 1995).

The UBNA supports a diverse group of bird, mammalian, reptilian, fish, and insect species; about 200 migratory and resident bird species have been documented, along with mammals like coyotes, beavers, reptiles like turtles, and a vast range of insects. Hundreds of thousands of salmon pass through the Union Bay at the Montlake Cut, including the endangered Chinook salmon.

PLANNING

Habitat diversity and native biodiversity will be maximized by increasing the diversity and range of habitats horizontally and vertically. However, canopy cover in the Loop Trail sub-area cannot exceed 30%. This is mostly to enhance bird habitat, but also is for public accessibility and personal safety. Management practices should be carried out in a manner that minimizes impact on water quality and improves aquatic habitat.

Wahkiakum Lane and the Loop Trail should be maintained and continue to follow ADA standards for Class I trails. These trails must have a minimum width of 8', with a minimum of 2' that is cleared out beside the trail and a 10' vertical clearance (Ewing, 2010). Trail surfaces should be level, clean, and non-rutting with finely crushed, evenly graded aggregate. The trails will continue to be supported and continued, and their maintenance will minimally impact surrounding habitat and wildlife. Proper signage and educational materials will be produced, following WPA and UW guidelines for form and size. These signs will be located at the ends of both sides of the boardwalk bridge that will be crossing over our project restoration site.

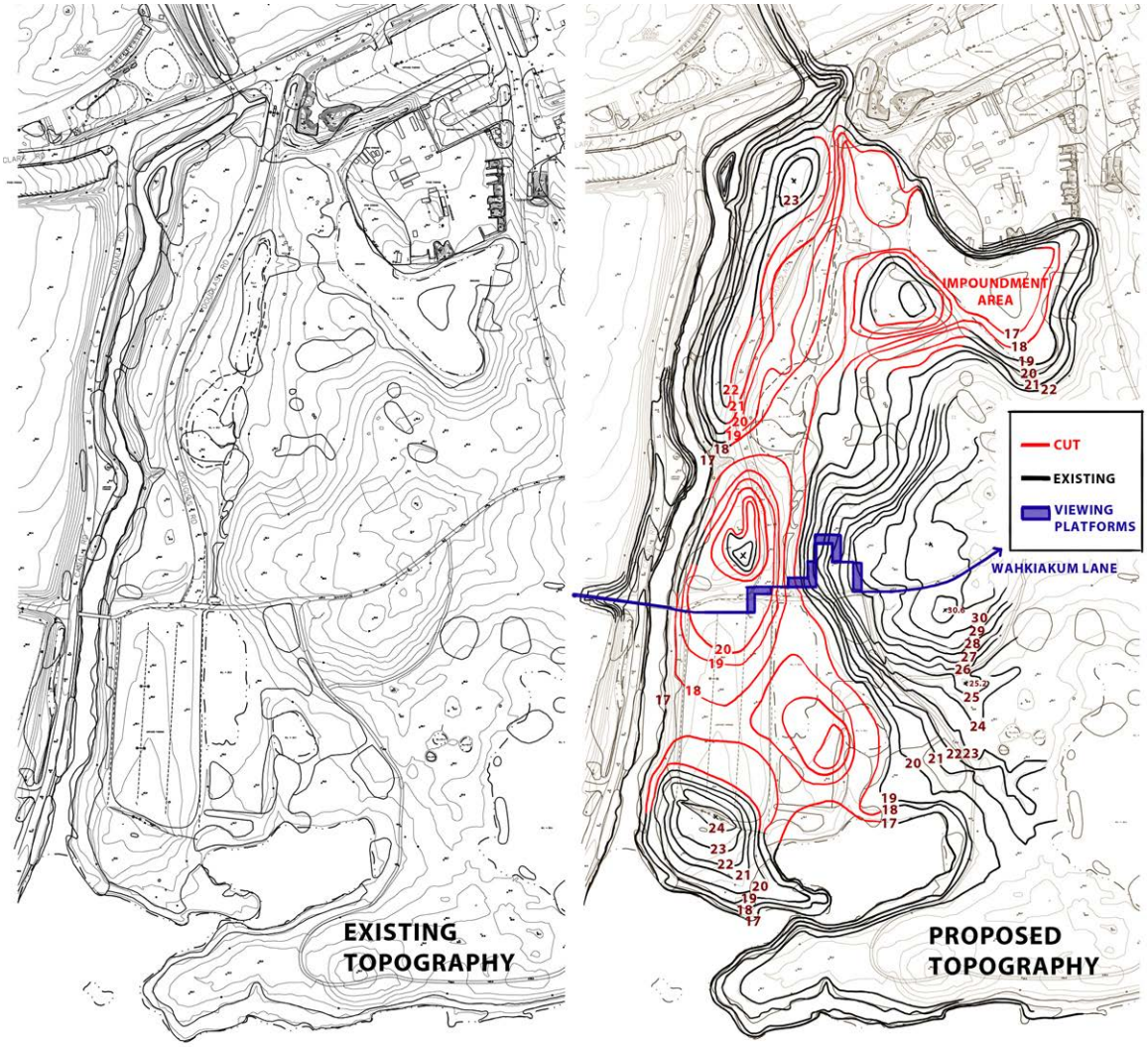
Shorelines and wetlands are two major types of land that are legally protected from development or significant degradation. Shoreline regulations require 200' buffer zone around the water's edge with restricted development limited to pedestrian bridges and pathways, viewing platforms, floats, dikes for seasonal ponds, and plant collections. The University Slough has a riparian corridor designation as a Class B waterway, which requires a 25' riparian buffer (Hamilton et al., 1995). Class IV wetlands of 1000 sq ft or more require 50' buffers and must be protected against development (Ewing, 2010).

STAKEHOLDERS

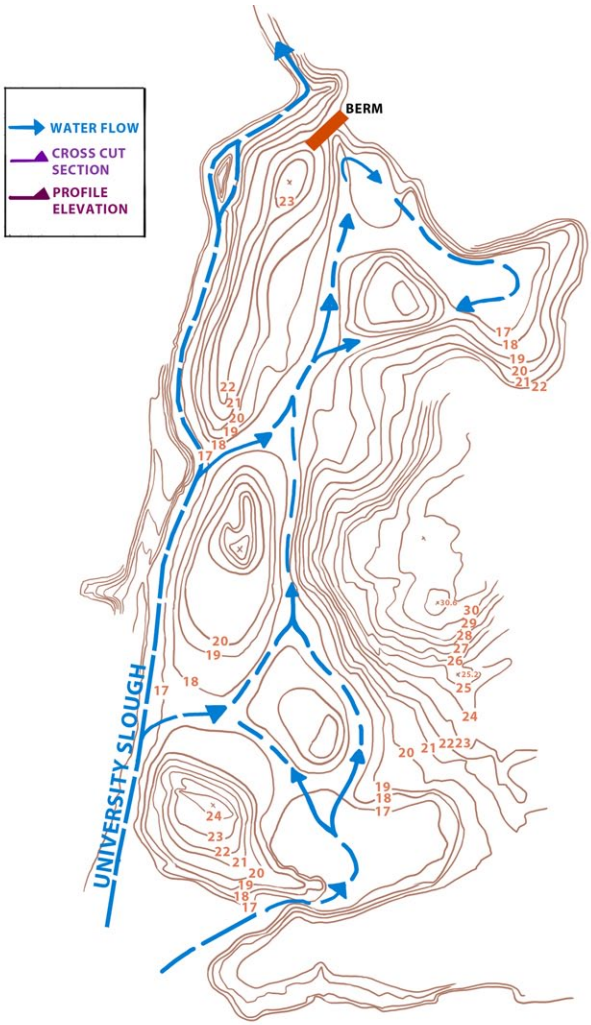
These stakeholder groups hold crucial roles in our endeavor.

1. **THE U.S. ARMY CORP. OF ENGINEERS** – This entity delineates the site as a wetland.
2. **WSDOT** – This group is having the restoration done, and has asked for proposals to accomplish the mitigation.
3. **WASHINGTON STATE DEPARTMENT OF ECOLOGY** – This group put together and enforces the mitigation procedure.
4. **WASHINGTON STATE DEPARTMENT OF FISH AND WILDLIFE** – Working with this group, as well as the other agencies helps to prevent damage to habitat, and to facilitate the creation of habitat.
5. **UNIVERSITY OF WASHINGTON** – The parking lot and road that we are restoring is owned by the University. Since this parking area will no longer exist, other areas need to be available. Communication with the University will assure that other arrangements are made.
6. **OUTDOOR RECREATIONALISTS** – Many people use the Union Bay Natural Area for walks, bird watching and other activities. This group will have more areas for these activities when our proposed area is restored.
7. **GENERAL PUBLIC** – This group may or may not include those that will use this area. These are people who pay tolls on the bridge. These are also people who will be watching how the bridge re -construction is being handled, and what the environmental impacts are.
8. **UBNA** – The Union Bay Natural area land is owned by the State of Washington and is under the care of The University of Washington (Walking in Seattle, 2012). Other restoration projects are being conducted, so our efforts need to take this into account.
9. **SEATTLE AUDUBON SOCIETY** – This group has appreciation for the area and the 200 species of birds that have been seen in UBNA (Seattle Audubon Society, 2012). This group will benefit from our re- connecting this parking area to the surrounding areas.

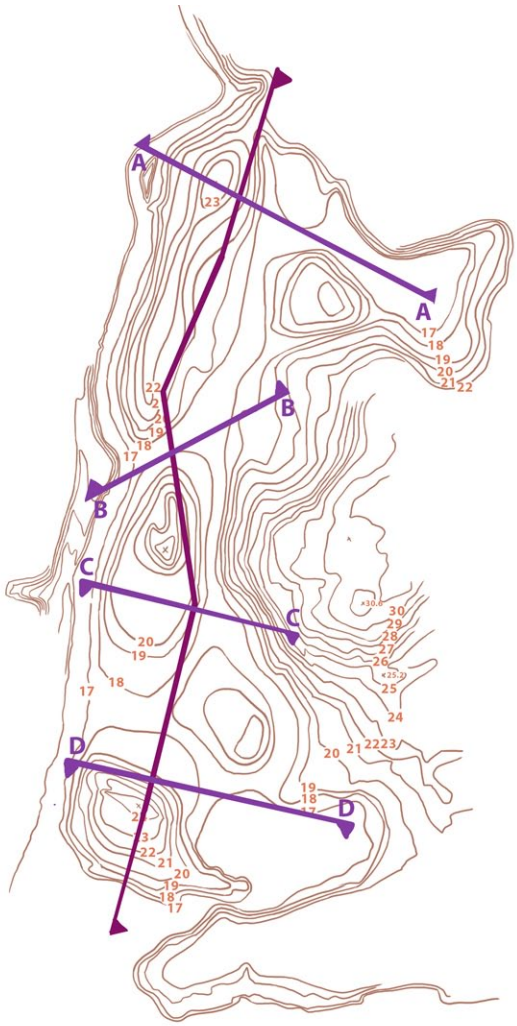
DESIGN



PROPOSED TOPOGRAPHICAL CHANGES



WATER FLOW



CUT LINES

DESIGN

SOLUTIONS

In the process of identifying the objectives that our proposed restoration efforts will accomplish, we researched the ecological functions that will be lost due to the reconstruction of the SR 520 Evergreen Point Floating Bridge. We plan to create a high functioning wetland habitat to mitigate this habitat loss.

The main functions that will be lost in the reconstruction are wildlife habitat, water quality and hydrologic function (Hruby, 2010). We studied the University of Washington Bothell Campus and Magnuson Park as reference sites to gain further insight about these ecological functions. Both reference sites had similar disturbances and losses, and restoration efforts resulted in the return of these functions over a similar landscape.

Providing as much wetland loss mitigation as possible is our main goal. Connecting previously fragmented areas will increase wildlife habitat. Removing the E-5 parking lot and Douglas Road while restoring the site will reconnect fragmented habitat to the surrounding Union Bay area; hydrologic function, water quality, and wildlife habitat functions will each be improved with the reconnection. Eliminating runoff from the parking lot into the slough, establishing water flow, and creating areas with different degrees of saturation will add diversity of vegetation and wildlife, as well as allow for ecological succession and autogenic recovery. Having boardwalks and viewing platforms crossing the site will enable the performance of maintenance and monitoring activities, and will also provide for recreational and educational functions and public accessibility.

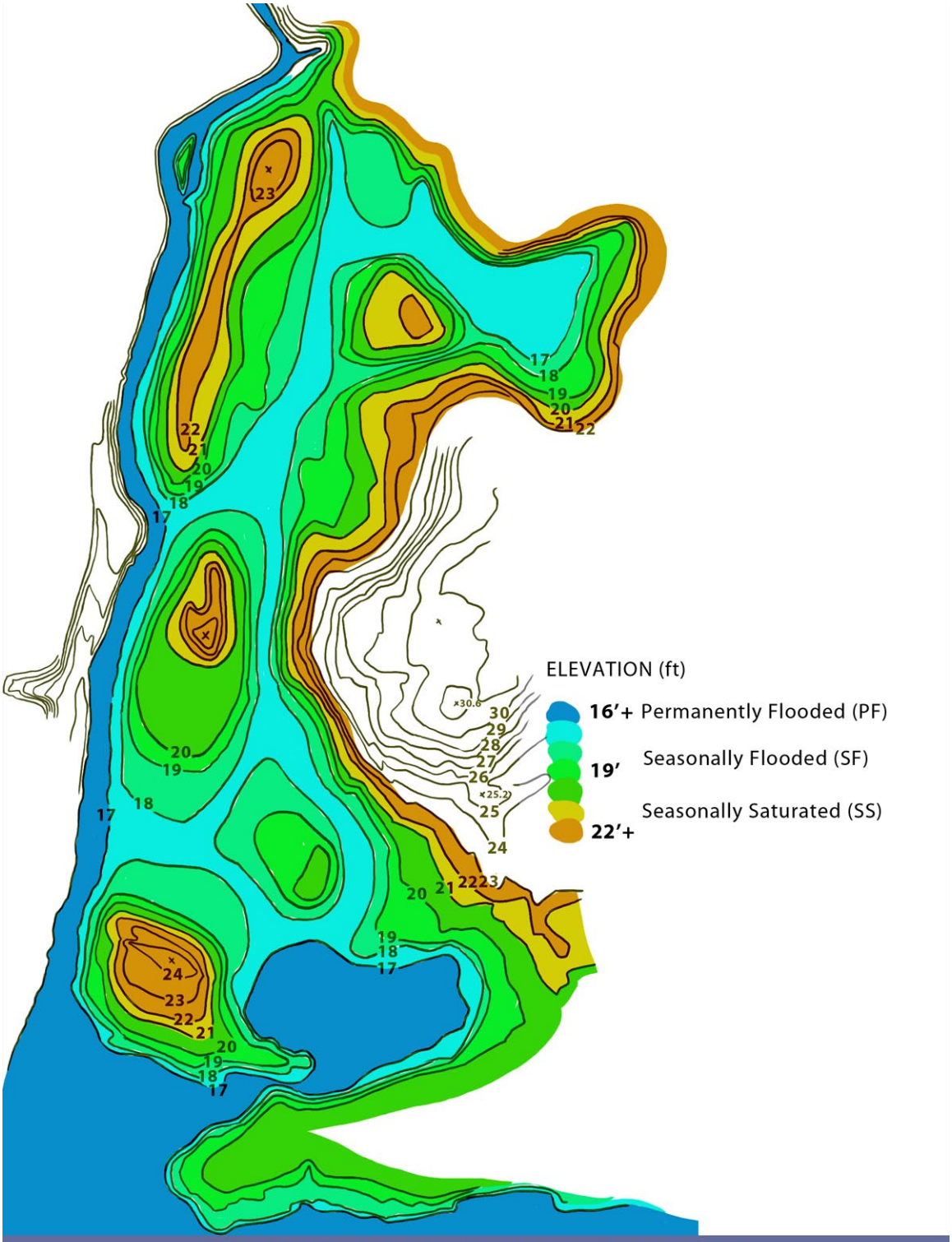
Wetland delineation activities conducted by the U.S. Army Corps of Engineers need to be taken into account. By establishing and reconnecting hydrology, having wetland plants and soils, and enabling access to the area, delineators can provide critical feedback to assure that our area is classified as a wetland. Functions of the wetland can be assessed and the values calculated based on three aspects of each function: potential of the site to provide the function, potential of the landscape

to support the function, and the value of the function to society (Hruby, 2010). Appendix A of (Hruby, 2010) details the value given per ecological function, and informed the planning of our restoration strategy. The amount of wetland mitigation acquired will fulfill the mitigation credits that WSDOT will accumulate with the reconstruction of the SR-520. Establishment of the proper and efficient communication between these parties will help expedite the reconstruction of the 520 bridge, with the assurance that there will be wetland gains as a result. The other applicable appendixes of (Hruby, 2010) will be applied at each step of the way with the establishment of good relationships with the Washington State Department of Ecology, WSDOT and U.S. Army Corps of Engineers.

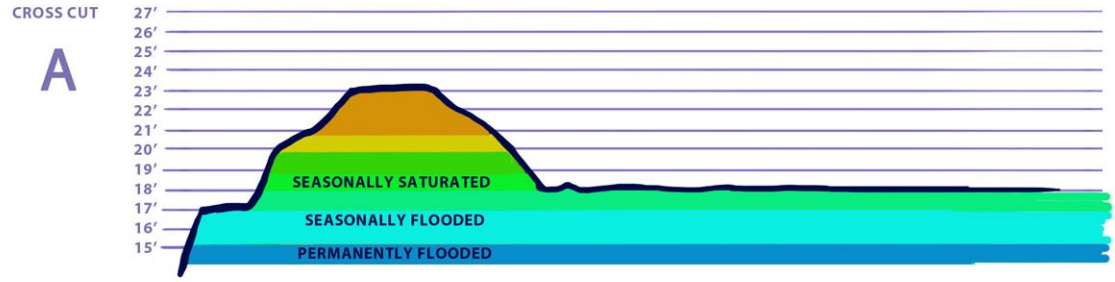
SITE DESIGN ELEMENTS

- Take out Douglas Rd.
- Put in a berm to block water that flows north.
- Create a channel in the north end to connect upper wetlands.
- The slough will remain separate from the wetland.
- Direct water during the winter time to flow out to the wetland
- Design areas low enough so that during the summer there will be year-round coverage
- Keep the north end seasonally flooded.
- Have some elevations lower than 16.5 so as to stay flooded.
- Install bat/bird boxes, perches, snags, snags.
- Build a bridge from UBNA to the soccer fields.

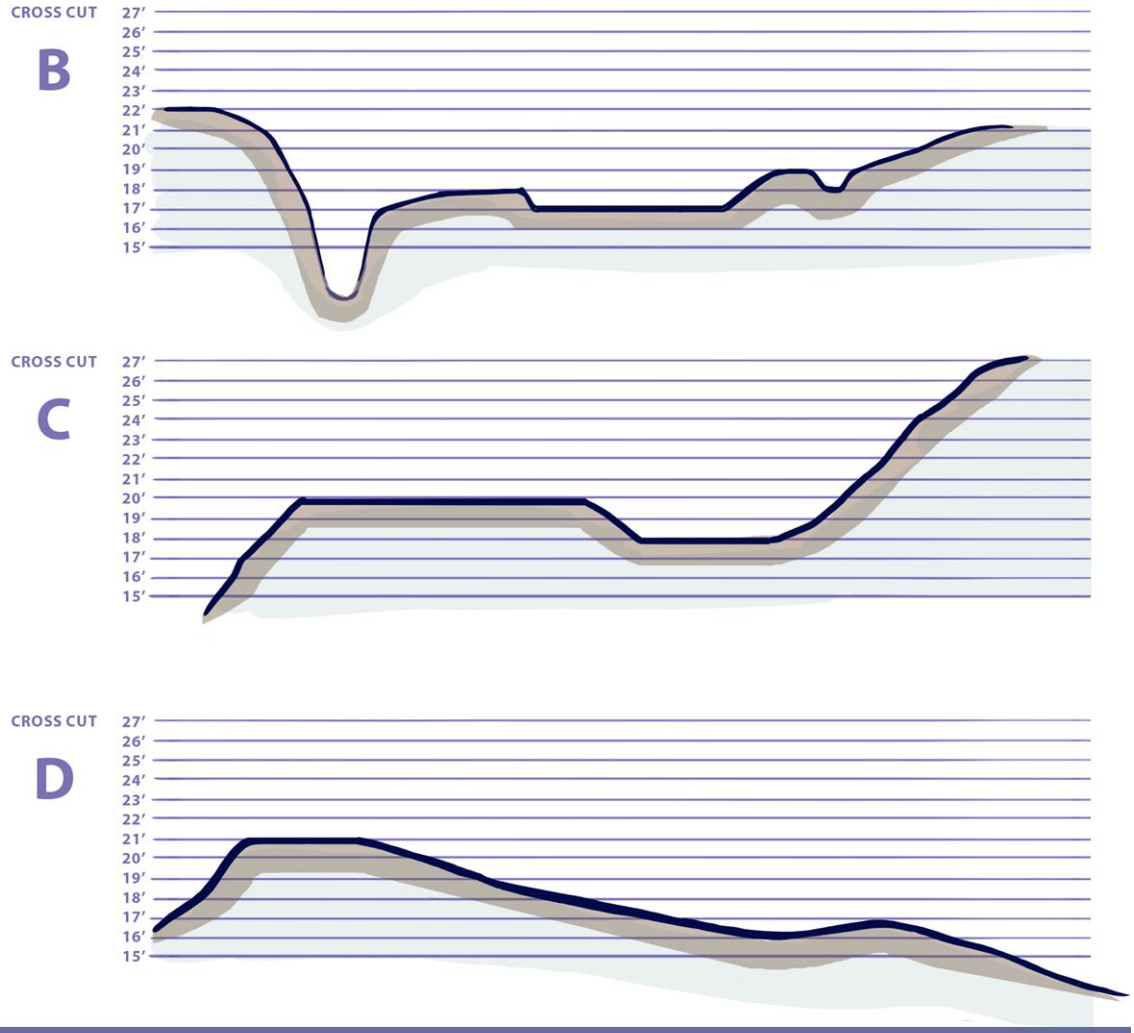
DESIGN



FLOODING ELEVATIONS / PLANTING ZONES



CROSS CUT: FLOODING ELEVATIONS / PLANTING ZONES



CROSS-CUT SECTIONS

DESIGN

DESIGNING FOR WETLAND CONDITIONS (SEE MAP 5)

Building an infrastructure that utilizes the hydrology of Lake Washington and the University Slough will enable the wetland conditions to be sustainable. Wetland areas that are Permanently Flooded (PF), Seasonally Flooded (SF), Permanently Saturated (PS), and Seasonally Saturated (SS) will be created. Planting native species that are specifically adapted to the various wetland conditions of this site will create species richness and diversity. These plantings will also crowd out any invasive species intrusion.

The red alder is specifically selected as a wetland restoration tree for its ability to enhance the Nitrogen content of the soil. It does this both through its roots and from the detritus of its decomposing leaves. It is also fast growing, and along with Oregon ash and Pacific willow, can help to shade out invasive species such as Phalaris arundinacea (canary reed grass).

The western red cedar survives well on winter flooded land. Sitka spruce can live in standing water. All these trees have shallow root systems so as to not break through the clay cap and into the fill. The swamp rose is a shrub to be used as a successional planting. Its fast growing thicket forming characteristics may out-compete invasive species until the cottonwoods, willows and alders become established. The swamp rose is shade intolerant and will then die back and leave space for shade loving wetland plants.

These species along with other native trees and shrubs will be used throughout the site as a way to begin the generative process of growing a northwest wetland habitat that is healthy diverse and abundant.

PLANT LIST

SHALLOW FRESHWATER MARSH PLANTS

- Schoenoplectus acutus(hard stem bulrush))(PF)
- Eleocharis palustris (creeping spikerush)(PF)
- Carex stipata (sawbeak sedge)(PF)
- C.obnupta (slough sedge)(PF)

TREES

- Fraxinus latifolia (Oregon ash)(SF,PS,SS) * major restoration plants
- Salix lasiandra (Pacific willow)(SF,PS,SS) *
- Picea sitchensis (Sitka spruce)(PF,SF,PS,SS)
- Thuja plicata (western red cedar) (SF,PS,SS)

SHRUBS

- Cornus sericea (red-osier dogwood)(SF,PS,SS)
- Lonicera involucrata (black twinberry)(PS,SS)
- Malus fusca (western crabapple)(PS,SS)or tree
- Rubus spectabilis (salmonberry)(PS,SS)
- Myrica gale (sweet gale)
- Rosa pisocarpa (swamp rose)

PLANTS THAT NEED/LIKE SHADE

- Lysichitum americanum (skunk cabbage)(PF,SF,SS)
- Oplopanax horridus (devil's club)
- Adiantum pedatum (maidenhair fern)
- Blechnum spicant (deer fern)
- Athyrium filix-femina (lady fern)

(Stevens et al.; Churney et al.; Mountaineers, 1996; Pojar et al., 2004)

PROJECT MANAGEMENT AND SEQUENCING

During the beginning phase of the project, a thorough research on ecological function loss of the disturbed wetland in Union Bay will be performed. According to the results of the research study and compared with the wetland ecosystems at University of Washington Bothell and Magnuson Park, our restoration design plan aims to mitigate for this loss of wetland function. This plan will increase and diversify habitat, improve water quality and increase hydrological functions. The soil excavation, grading, and drainage will be carefully calculated. Specific invasive species like Himalayan Blackberry will be removed with the excavation of the E5 parking lot and the removal of Douglas Rd.

Selected native plants (See Plant List) will immediately be planted in order to prevent negative competition with the invasive species. With the exception of plants that require a shaded environment for growth, like skunk cabbage, all plants will be planted at the same time. Plants will be planted according to their preferred water regime and planting condition. If the project is conducted during winter, water brought by sufficient rain will be able to support the growth of plants. If the project is conducted during summer, water condition will be strictly monitored in order to maintain at least an 80% survival rate of all plants. 18 different kinds of plants in total are chosen to be planted. The high biodiversity is expected to promote autogenic recovery, to reconnect the fragmented areas, to attract other native plant species, and to promote ecological succession.

Though boardwalks will be built for making the area more accessible for future research and teaching activities, it is recommended that access to the public be strictly prevented during the incipient stages of the project. This is to prevent any invasive species being tracked on to site, and damage to sensitive plantings.

In the long-term, the succession of plants and wildlife species diversity will be monitored and the maintenance plan adjusted accordingly. Biodiversity and numbers of wildlife will be used as an index to test the quality of this restoration project.

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MARCELLUS SHRUB-STEPPE PRESERVE

VERNAL POOL RESTORATION

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Image source: http://www.blm.gov/or/resources/recreation/tablerock/table-rock-plants-vernal-pools.php

INTRODUCTION

COLUMBIA BASIN PLATEAU SITE HISTORY

Crab Creek Subbasin is located within the Columbia Plateau Province in central Washington State. The subbasin's wide basalt terraces and steeply-walled landscape were sculpted 12,000 to 15,000 years ago by floods and contain many small bodies of water and shallow ponds. Most soils in the region are closely related to or influenced by historical volcanic activity, glaciation, rainwater runoff, and flooding effects. The Columbia River is the main water source of the subbasin, which is managed by the Columbia Basin Irrigation Project (Quinn, 2001).

Currently co-owned by The Nature Conservancy (TNC) and the Washington State Department of Natural Resources (DNR), the Marcellus Shrub-Steppe Preserve is divided into two parcels by a gravel road. The east side of the preserve belongs to TNC and has been fenced since 1986; therefore, the disturbance of grazing to the site has been very light. Alternatively, the west side is owned by the DNR, and is grazed every summer and spring. The presence of grazing activity has led to the degradation of both the shrub-steppe and the vernal pool ecosystems by invasive non-native weedy species, and fewer rare and endangered species have been documented (Class hand out). Two different kinds of sagebrush communities exist in the area: the Artemisia tridentata and Artemisia tripartita as well as vernal pools that are scattered throughout the site.

SHRUB-STEPPE

HABITAT DESCRIPTION

Sagebrush and shrub-steppe communities generally occur in areas of low precipitation, and are found on dry flats and plains, rolling hills, rocky hill slopes, saddles and ridges. This ecosystem type is characterized by an open shrub layer and a dominant grass and forbs layer, and have historically been maintained by natural fire regimes that create dispersed patches of shrubs and predominance of grasses ("Strategy Habitat", 2006).

In the Columbia Plateau, shrub-steppe lands are characterized by a microbiotic or cryptogamic crust, which is composed of lichens, mosses, fungi, and bacteria. This soil crust reduces soil erosion and moisture loss ("Strategy Habitat", 2006). Currently, the Marcellus Shrub-Steppe Preserve is dominated by Artemisia tridentata (big sagebrush) / Festuca idahoensis sagebrush and Artemisia tripartita (three-tip sagebrush) / Festuca idahoensis sagebrush plant communities.

Occurring on deep soils, big sagebrush habitat provides high structural diversity, which allows for burrowing, foraging, protection, and nest-building. The number of bird species positively correlates with the height of sagebrush ("Strategy Habitat", 2006). Big sagebrush communities have suffered the greatest loss amongst shrub-steppe communities. Much of the land that supported big sagebrush communities have been converted for agricultural development.

SHRUB-STEPPE

SITE ANALYSIS

The degradation and decline of shrub-steppe is a serious issue throughout eastern Washington, but is in a state of dramatic decline, from 97.7% to 30.2% (Quinn, 2003) in the Crab Creek Subbasin. This dramatic decline in the quantity of shrub-steppe has resulted in the corresponding decline of species that are highly dependent on the habitat that the shrub-steppe provides. Many of these obligate species are listed as "endangered", "threatened", or "species of concern" by the state of Washington. The greater sage-grouse, ferruginous hawk, loggerhead shrike, sage sparrow, Brewer's sparrow, sagebrush lizard, Washington ground squirrel, pygmy rabbits, black-throated sparrow, sage thrasher, sagebrush vole, and pronghorn are a few wildlife species that have declined along with the loss of shrub-steppe habitat ("Strategy Habitat", 2006).

Loss of habitat connectivity and fragmentation are serious issues as well. Small sizes and poor connectivity limits dispersal for vegetative and animal species for which shrub-steppe is valuable habitat. To approach these issues, connectivity should be improved when possible. On the Marcellus Shrub-Steppe Preserve, the land is crossed by a ballast embankment from where a railroad track used to be. Performing some restoration efforts on this area could potentially allow for greater connectivity within the site.

Unfortunately, most of the Columbia Plateau eco-region is privately owned, so complete elimination of grazing practices would be impossible. Annually, the DNR-managed western side is grazed, which has led to the loss of biodiversity and ecological disturbance, while the eastern side is fenced and has had relatively low levels of disturbance. We do not foresee the permanent removal of grazing activity on the site.

GOALS/OBJECTIVES

According to the agreement between DNR and TNC, TNC will take over management work of both sides of land. The restoration plan is focused on protecting and enhancing the native and threatened species in the entire combined area. Both vernal pool and sagebrush ecosystems need to be restored by creating separate restoration plans and providing sustained habitats that will benefit shrub-steppe wildlife obligates in the long term. At the same time, the political needs for grazing should also be met through detailed evaluation and strict regulation.

Management, restoration, and conservation efforts will address the habitat conversion, degradation, fragmentation, and loss of native species diversity in shrub-steppe ecosystems. Efforts will be made to seed the area with native herbaceous vegetation, monitor or remove grazing in the area, protect and maintain the existing habitat, control introduced vegetation and invasive weedy species, and reduce habitat fragmentation. Perimeter fences will be maintained, and decadent dense sagebrush stands should be thinned (Quinn, 2003).

FUNCTIONAL REQUIREMENTS

Non-native weedy species invasion is a great limiting factor to the ecological health of shrub-steppe communities. Sagebrush communities are degraded by invasive plants like the yellow-star thistle, knapweeds, rush skeleton weed, spikeweed, leafy spurge, and perennial pepperweed. To control and prevent the growth of invasive species, a few approaches can be taken ("Strategy Habitat", 2006):

- Management plans should place emphasis on prevention, risk assessment, early detection, and quick suppression in order to prevent the mature and full establishment of new invasive species.
- For effective management, prioritization of control methods should be

SHRUB-STEPPE

established, and site-appropriate methods should be used to control the newly established invasive species.

- Native shrubs, grasses, and forbs should be re-introduced through seeding and/or planting, and must be monitored and controlled to ensure successful establishment.
- Cooperation and positive relationships with stakeholders and partners through habitat programs and County Weed Boards should be maintained.

The **CRYPTOGAMIC CRUST** that occurs in the Marcellus Shrub-Steppe Preserve is a vital component of the site ecology. The loss of the microbiotic soil crust would lead to soil erosion, changes in plant species composition and structure, decline in biodiversity, and degradation by invasive plants ("Strategy Habitat", 2006). Unmanaged grazing leads to the disruption of these soil crusts. However, various measures can be taken:

- To ensure the management of grazing activity, cooperation and a positive working relationship with the DNR and surrounding private landowners should be maintained.
- Financial incentives, technical assistance, regulatory assurance agreements, and conservation easements would be essential to achieve restoration goals ("Strategy Habitat", 2006).
- Foster stewardship and voluntary cooperation with private landowners around the preserve.
- Determine grazing regimes that are compatible with restoration efforts and conservation goals.

STAKEHOLDERS

- The Nature Conservancy
- WA State Department of Resources (DNR)
- Cattle Ranchers
- Community Groups protecting endangered and threatened plant and animal species
- State and Federal Fish and Wildlife Agencies
- United States Environmental Protection Agency
- Surrounding Community Members
- Recreational users such as hikers, hunters and wildlife watchers
- Tax payers
- United States Government

(Further information about grazing management options will be discussed in the "Grazing" section.)

VERNAL POOLS

HABITAT DESCRIPTION

The Columbia Plateau Vernal Pool system has isolated shallow ephemeral ponds that are commonly small (3 sq m or 32 sq ft) and rarely large (260 ha or 1 sq mi). These ponds are located atop massive basalt flows and fill with rainwater in the winter and are usually dry again within 9 months.

Inundation is highly irregular and sometimes does not occur for years. Because of this irregularity of water the vernal pool plant community is quite unique, often rare (Myosurus minimus), and sometimes listed as at risk (Myosurus sessilis) (NatureServe, 2012).

When full, the pool's water column and saturated substrates support assemblages of macroinvertebrates as well as habitat for mobile invertebrates adapted to ephemeral wetlands. Fairy shrimp (Anostraca) are found in vernal pools along with birds and amphibians (Environmental Science Associates 2007).

A unique characteristic of vernal pools is that they are organized into distinct zones of vegetation with species such as Myosurus minimus and Psilocarphus oregonus growing in the wettest part of the pool, Eleocharis palustris and Deschampsia danthonioides in the middle zone and Lomatium grayi and Polygonum polygaloides growing around the margins.

The composition of species growing in vernal pools also changes through time as the pools begin to dry or evapotranspire with various annuals and perennials beginning to emerge such as Veronica peregrina, Eleocharis palustris, the endan-

gered Callitriche palustris (plants/usda.gov) and the threatened Pilularia americana (www1.dnr.gov). Plants grow especially well during the aquatic phase when the pool is saturated with water and drying phase when soil is completely exposed (Brown, 1999).

VERNAL POOL SITE ANALYSIS

Because a large number of vernal pools on both sides of the Marcellus Shrub-Steppe Preserve provide essential habitat for many rare species or highly threatened species like Callitriche palustris and Pilularia americana which are dependent on the unique conditions that vernal pools provide (Brown, 1999) the area has been classified as a "2" protection status by the Washington Natural Heritage Program (Quinn, 2001, Class hand out).

All of the pools have invasive species. Some of the pools have been further degraded from grazing, which leads to the compaction of soil and breaking of the cryptogamic crust. Some of the pools are in good condition, while others have been quite degraded.

We will be using the WA Department of Ecology's Methods for Assessing Wetland Functions – Volume II Depressional Wetlands in the Columbia Basin of Eastern Washington, Parts 1 and 2 to accurately and uniformly assess the level of restoration necessary for the vernal pools. (http://www.ecy.wa.gov/programs/sea/wetlands/wfap/pdfs/update2001.pdf)

GOALS

Our goal is to develop and increase the diversity and amount of native plant species in all vernal pools, both grazed and ungrazed, and reduce the occurrence and quantity of invasive species.

VERNAL POOLS

FUNCTIONAL REQUIREMENTS

In order to meet our goals for vernal pool restoration buffers will be created and maintained to help protect the functional requirements that are needed for a healthy vernal pool ecosystem. Other functional requirement goals include:

- Maintaining water storage capacity
- Protection of the cryptogamic soil crust
- Prevention from soil compaction and maintenance of proper soil structure with soil litter present
- Prevention from disturbance during the wet season and growing season, which occurs from mid Oct through the summer.
- Monitoring the presence of indicator species- Anostraca (fairy shrimp) and characteristic species Alopecurus saccatus and Eleocharis macrostachya.

GRAZING

GRAZING ISSUES

Grazing degrades the landscape by harming important plant and animal habitats and spoiling water quality. The smell is also offensive to many and negatively affects air quality. Grazing activities depletes the resources in the area at the ecosystem's expense.

According to the 2005 study from the Government Accountability Office, the United States spent over 144 million dollars each year managing private livestock grazing operations on public land, but collects only $21 million in grazing fees—for a net loss of at least $123 million per year. This amount spent does not take into account what state and city agencies spend or what the environmental cost is. It also costs tax payers thousands of dollars per year (KS Wild, 2012). Lastly, unsustainable grazing methods are economically unfeasible for land managers and cattle ranchers.

In the Marcellus Shrub-Steppe Preserve, grazing in vernal pools has produced both positive and negative effects. Three primary negative effects from grazing in these pools include: vegetation removal, trampling and soil disturbance, and excess nutrient input from fecal defecation and urination. High levels of grazing can be detrimental to the vernal pool wildlife and vegetation, but managed grazing could benefit the health of the shrub-steppe ecosystem.

Although studies have been done to show one way or the other, results are mixed and poorly understood. However, it is certain that grazing activity must be actively managed (Robins, 2002). Other means of producing the same positive effects of grazing, while avoiding the negative effects should be investigated and implemented. Examples of such activities include suppression of invasive species with controlled burning and the use of herbicides that target the invasive species.

GRAZING

MITIGATION OPTIONS

A number of options exist for minimizing the impact of cattle grazing in these pools during the spring and summer months. Barriers to entry can be created so the cattle cannot get into the site. This can be accomplished by planting native woody shrub species around the pools so the cattle cannot get through to the pools. Fencing around the pools can be a much more restrictive option, and can be done using wood from snags, large woody debris and assorted vegetation that can also serve as wildlife habitat.

Cattle ranchers can be paid off and moved to other areas that are removed by a substantial distance from sensitive ecosystems. The amount used to pay these ranchers offsets beyond the amounts spent on mitigation. These are the best options for improving ecological function of the pools and the surrounding areas. Since the pools are sensitive systems, this option is the best method of minimizing disturbance.

Cooperation with cattle owners will be essential. Their expertise with cattle will prove to be useful in any strategy we employ. Their livelihood is involved as well, so our options need to take this into account. Alternative grazing areas need to be available. These areas need to service the same amount of cattle and not cut the cattle ranchers' revenues or increase expenses. Perhaps a subsidy representing the amounts of revenue lost can be presented to compensate them for moving cattle to other areas. These areas can be in between pools and buffer areas, which would be planted with hardy native species that flourish with grazing activities. The buffer areas will help mitigate the water quality and other damage that cattle create before any runoff into the pool areas before they refill. Management will be essential, and monitoring will be necessary to make sure that grazing activity remains diverted away from vernal pools.

In the areas that are set aside for grazing, careful selection of diet is needed. Cow methane emissions are damaging to air quality. By feeding the cattle a selected

vegetative species and having a proper waste treatment system, the effects of these pollutants can be minimized so as not to affect the surrounding areas. The grazing area and production of the cows will be improved as a result of better quality feed (US EPA, 2012) Profits to the cattle ranchers will be the result. This increased profit will help mitigate for the cost of moving the cattle, and minimize the negative effects on the ecosystem as a whole.

Improvement of the feed quality should be implemented for any of the alternatives discussed. Long term effects will be less governmental costs and taxpayer costs. Wildlife and habitat can be preserved both on the site and the sites nearby.

A certain amount of grazing can be beneficial. Invasive species can be targeted in grazing areas, and the native plants can be in areas farther away from the cattle. Grazing can also keep the vegetation at a low enough growth, so as to minimize fire danger, increase the density of re-growth, and minimize intrusion of invasive species.

Timed grazing is another similar option. When the amount grazed is at a maximal level, the cattle can be moved to other locations. This can be done daily, or weekly, or any other interval that is manageable but also effective. However, these options may increase expense to the cattle ranchers as it involves more management and monitoring activities, and increases the amount of disturbance. Since vernal pools are very sensitive systems, this option could prove to be too management intensive for all concerned, and may not be successful.

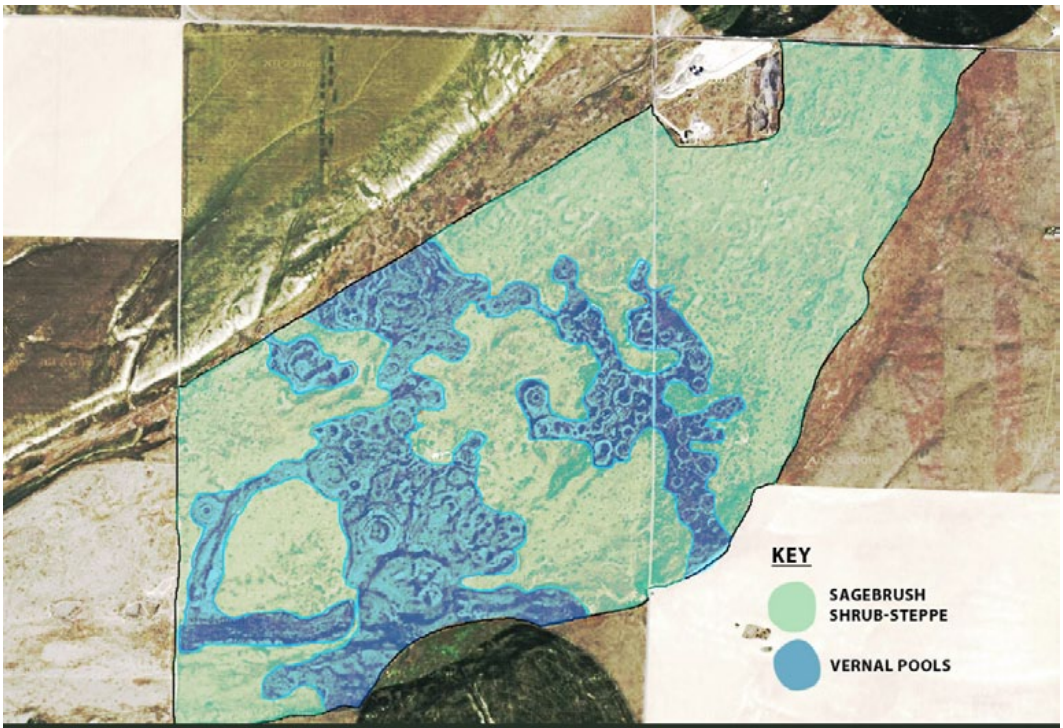
Running just north of the preserve, the Crab Creek Subbasin will be positively influenced by our restoration efforts and supports a diverse plant and animal community as well. State and Federal agencies are vested in that area and working with them will improve ecological function and autogenic recovery of both. The cattle grazing buffer areas need to be developed to account for both systems. The selection of appropriate plants in the grazing area, as discussed earlier, will help mitigate the damage caused by the cattle.

DESIGN

RS/WS = RAW Score/ Weighted Score

Options	WF	Timed Grazing	Fencing/ Shrub Barriers	Diversion of cattles to improved or less sensitive area	Peripheral grazing	Rotating grazing
Criteria		RS/WS	RS/WS	RS/WS	RS/WS	RS/WS
Protection of endangered and threatened species	20	2/40	5/100	4/80	3/60	3/60
Conservation & restoration of vernal pool ecosystem	25	2/50	4/100	5/125	3/75	3/75
Conservation & restoration of sagebrush ecosystem	25	2/50	4/100	5/125	3/75	2/50
Grazing needs	20	3/60	1/20	4/80	3/60	4/80
Long-term monitoring	10	2/20	3/30	1/10	1/10	2/20
TOTAL	100	220	350	420	280	285

DECISION MATRIX



HABITAT TYPES

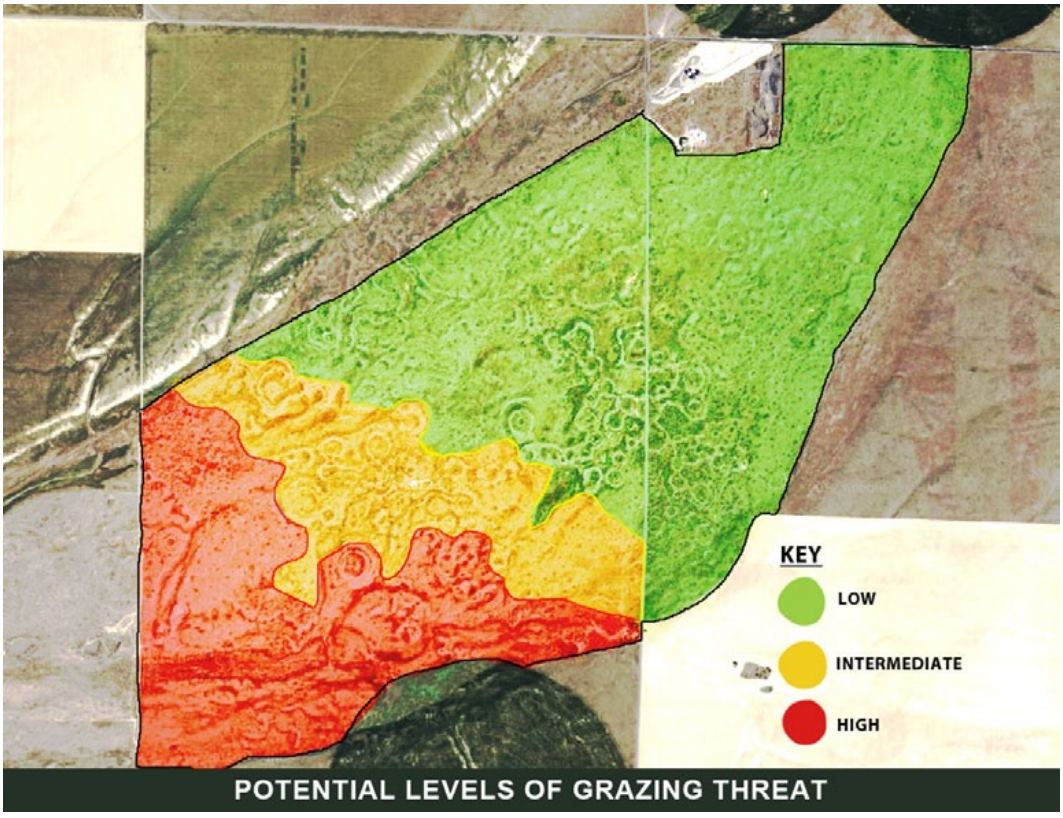
SAGEBRUSH - VERNAL POOL DELINEATIONS

The Sagebrush - Vernal Pool Delineation Map provided above creates a black boundary around the DNR and Nature Conservancy land ownership parcels as part of the Marcellus Shrub-Steppe Preserve. This area was determined to the best of our knowledge using Google Maps and the handouts provided.

The blue areas show vernal pool sites, while the area not within blue borders is considered to be sagebrush steppe community. We determined the delineations by examining the area in Google Earth and figured out where the vernal pools were. After that, we determined where possible river/stream systems were, and included them with the vernal pools.

The rest of the area within the Marcellus Shrub-Steppe Preserve was determined to be shrub-steppe community. Our only source was Google Earth for the site design portion, so we were constrained by how closely we could zoom in to examine the area and using our knowledge of what vernal pools normally look like and what shrub-steppe communities normally look like, we created the delineations seen above.

DESIGN



POTENTIAL LEVELS OF GRAZING THREAT

POTENTIAL GRAZING THREAT

The Potential Grazing Threat Map shown above creates a black boundary around the DNR and Nature Conservancy land ownership parcels as part of the Marcellus Shrub-Steppe Preserve. We delineated the Marcellus Shrub-Steppe Preserve into three classifications of grazing susceptibility by cows: the area in green shows land at a zero to low risk of grazing, the area in yellow shows land at a moderate risk of grazing, and the area in red shows land at a high risk of grazing.

We made these determinations through a few different criteria. First, the area east of Suko Road within the preserve is and has been fenced since 1986. The fencing around this area precludes cows from entering, thus observed grazing in this area is essentially nil. The area in green to the west of Suko Road has been determined to be at a low risk for grazing because the only access point for cattle

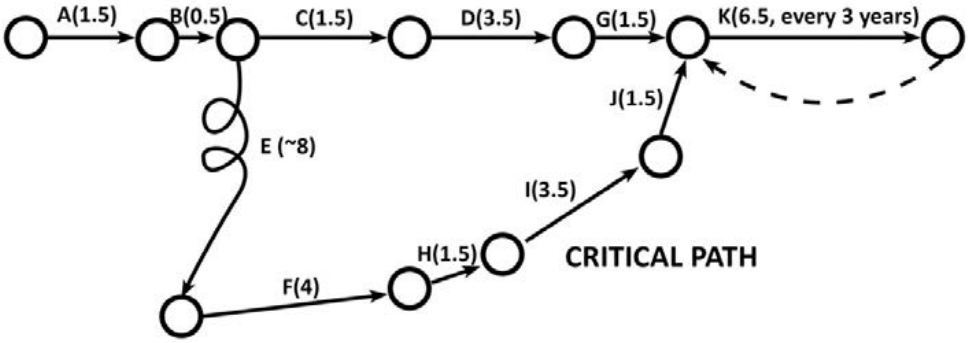
is the southwestern edge of the preserve. We have decided that cattle are not going to cross the abandoned railroad line that creates the northwestern edge of the preserve. They would have to cross what looks like a small ravine then cross the (most likely) raised abandoned railroad line to reach this area of the preserve, and we feel that is unlikely. We also determined that there are no cattle present in the southeastern field that is lighter than the surrounding area because that is likely a rotated crop field that cattle do not inhabit.

The area of land in yellow was determined to be at an intermediate threat of grazing because it is at a moderate distance from where cattle are expected to live, but still within a range attainable by cattle if they choose to roam that far to graze. The vernal pools and shrub-steppe communities within this area of land would entice cattle if sources closer to their home have been overgrazed or depleted.

The red shaded area of land was determined to be at a high risk of grazing because it is in close proximity to cattle's expected home range. If the area outside of the preserve becomes overgrazed, the cattle will move into this area and use the shrub-steppe and vernal pool communities' vegetation for grazing.

There are not many vernal pool communities in this area of the preserve, but the ones that are within the preserve are at a high risk to grazing activities. This high risk area will be the focus of grazing mitigation techniques such as rotating/peripheral grazing and other farmer best management techniques described in sections below.

SEQUENCING



TASKS

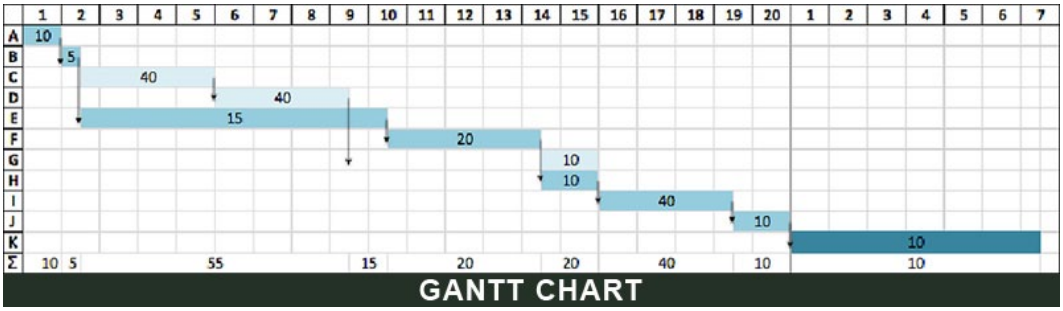
A: Vegetation and species inventory, site analysis and assessment of conditions
B: Quantify
C: EARLY RESTORATION TRACK - map out areas of invasive weed populations and areas of degradation
- **D**: Removal of invasives
- **G**: Begin seeding natives - sagebrush, idaho fescue, etc

E: GRAZING MANAGEMENT TRACK - Begin negotiations with DNR, private landowners, and private cattle owners around the preserve
- **F**: Establish shrub hedges and fences
- **H**: Map out areas of degradation and invasive weed species
- **I**: removal of invasives
- **J**: seed native species

K: ADAPTIVE MANAGEMENT/MONITORING

TASK	Duration (wk)	Workers
A	1.5	10
B	0.5	5
C	1.5	10
D	3.5	40
E	8	15
F	4	20
G	1.5	10
H	1.5	10
I	3.5	40
J	1.5	10
K	6.5, every 3 yrs	10

TASK FLOW DIAGRAM



GANTT CHART

MONITORING

Due to the widespread degradation of shrub-steppe habitat, the endangered status of the vernal pool ecosystem, and the lack of extensive research into the protection of vernal pools, adaptive management techniques will be utilized to measure the success of restoration and conservation efforts of both ecosystems and assess whether or not the goals and objectives for the site are being met. These management measures will begin after the first year of restoration efforts.

Monitoring will allow restoration teams to identify problems like invasive weed species early, so changes in management can be made when necessary. Adapting the habitat evaluation process recommended by Ralph Tiner in his paper, "Geographically Isolated Wetlands of the United States" (2003), vegetation monitoring will involve the evaluation of the Marcellus Shrub-Steppe habitat every three years to monitor habitat trends. Invasive weed areas will be mapped and monitored every two years, and periodic photographs will be taken at monitored sites.

Consistency in monitoring is essential, so time frame, location, baseline transects, and documentation should be the same in each evaluation. The monitored areas will be selected based on management history, and current management and restoration protocols. Wildlife species that will be monitored are primary species that are shrub-steppe obligates and species of concern, candidates, threatened, or endangered.

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VERNAL POOL IMAGES

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SAGEBRUSH SHRUB-STEPPE IMAGES

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PADILLA BAY

PADILLA BAY

AGRICULTURE AND SALTWATER MARSH RESTORATION

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Image from: http://imageshack.us/photo/my-images/685/dsc0895x.jpg/sr=1

INTRODUCTION

SITE ANALYSIS

Padilla Bay is an estuarine system which is part of the larger Skagit River delta, located at the margins of the fertile Puget Sound lowlands, approximately 60 miles north of Seattle, WA. The majority of the Bay is intertidal and subtidal mudflats covered with extensive meadows of eelgrass, providing habitat for important species such as the Dungeness crab, juvenile salmon, and hundreds of thousands of waterfowl and marine birds. Because of the extensive eelgrass beds in 1980 Padilla Bay was designated as a National Estuary Research Reserve (NERR), dedicated to the study and protection of vital coastal and estuarine resources.

This restoration site is 340 acres situated along the southern part of the 13,550 acres of the PBNERRS. Within this area are parts of Big Indian Slough, Little Indian Slough and No Name Slough. The sloughs are contained within levees with little to no native vegetation along their banks. The surrounding region is part of the Skagit Valley agricultural complex, one of the most fertile regions in the world.

Because of the diking of land for agriculture, many environmental problems exist within the slough and within the entire restoration site. Lack of water storage capacity results in frequent annual flooding of the surrounding land and disconnection of the slough from wetlands and nearshore habitat. It also causes poor riparian conditions, instable water temperature, dissolved oxygen violations and wet season turbidity. Invasive species such as cordgrass (Spartina alterniflora and S. angelica) and the Purple varnish clam (Nuttallia obscurata) also exist throughout the site (padillabay.gov). In 1983 No Name Slough was identified as a water body that, without control of non-point source pollution, cannot attain the State of Washington Water Quality Criteria for temperature and fecal coliform bacteria. (WDOE, 1998).

Also within the site is the Breazeale-Padilla Bay Interpretive Center, residential research quarters, laboratory space and a group meeting area. An observation

deck with interpretive signs and a stairway to the public beach is located next to the Interpretive Center. There is a 2.25 mile trail along the dike with interpretive signs. Because the area is research designated, various groups and organizations use the site for research, education and community outreach. The area is also home to many recreational users such as bird watchers, nature walkers and waterfowl hunters.

SITE HISTORY

The establishment of NERR could be traced as early as the1970s when the state and federal agencies were looking for estuarine reserves under the provision of Coastal Zone Management Act (CZMA). The Padilla Bay was listed as one of around 40 potential sites by the WDOE and was eventually selected for its unique eelgrass resource. In 1980, a thorough research on the boundaries, possible environmental effects, and multiple uses of the newly designated reserve area was performed by NOAA according to governor's request. In two decades from the 1980's to 2000, about 1200 acres of farmlands, 300 acres of residential areas, and over 10,000 acres of tideland were added to the reservation area through private donations and purchasing from willing sellers. By 2008, about 490 acres of tidelands within NERR boundary were privately owned. This number is growing each year, and adding to the NERR system.

For the sake of increasing public accessibility, in 1989 a 2.25 mile trail was constructed in south of Padilla Bay with cooperation of various departments, including WDOE. More trails have been created and opened in order to benefit recreational and educational use of the area. The education and coastal training program has taken place in NERR for more than two decades. It has provided individual research, training courses and coastal decision making opportunities for nearly 300,000 students and teachers. Hundreds of academic participants dedicate their efforts to the coastal management. The program also engages a large number of volunteers assisting in the monitoring of the Skagit River Data.

INTRODUCTION

WATERSHED BOUNDARIES

GOALS AND OBJECTIVES

Three major goals for Padilla Bay were outlined in the 2005-2010 Strategic Plan to address and guide the estuarine reserve's management, programs, and implementation. These three major goals are:

1. Protect and improve habitat and biological diversity within the Reserve and Puget Sound biogeographic region;
2. Utilize and increase the use of Reserve science and stewardship to address priority coastal management issues; and
3. Enhance people's ability and willingness to make informed decisions and take responsible actions that affect coastal communities and ecosystems. (Padilla Bay Management Plan, 2008)

Objectives for this restoration project include:

1. Decreasing peak storm water runoff flows;
2. Preserving and enhancing existing forests and wetlands;
3. Increasing hydraulic connectivity between slough and wetland and nearshore habitat areas;
4. Improving the habitat value of riparian vegetation increasing the storage capacity of No-Name slough for floodwater;
5. Consistently complying with the Washington Water Quality Criterion for dissolved oxygen, fecal coliform organisms, temperature, and turbidity.

PLANNING

FUNCTIONAL REQUIREMENTS

Areas of consideration in the project planning process included:

- Ecological restoration of the wetlands and surrounding watershed
- Flood protection
- Agriculture
- Waterfowl habitat
- Juvenile salmon habitat
- Educational opportunities
- Recreational opportunities

Ecological restoration activities in the Padilla Bay Area must address issues of flooding, water temperatures, inadequate levels of dissolved oxygen, turbidity levels due to sedimentation. Storage in existing slough and ditch channels must be increased by widening the channels to allow for more “live” water storage (“Feasibility Study of No-Name Slough Watershed”, 2005). The way that our site will influence surrounding watersheds and how those areas influence our site needs to be evaluated.

Spoils from removed levees and dredging can be utilized to form low berms to protect farmland. Native wetland shrub and tree species should be planted in degraded wetland areas, and riparian vegetation buffers should be expanded and improved to provide shading, stabilization, filtration, bioremediation of runoff, and habitat for waterfowl, other birds, and small mammals. Large woody debris can be placed across channels to encourage habitat complexity, the formation of side channels, and provide cover and protection for juvenile salmon.

Restoration efforts that are up wind will cause seed dispersal downwind to disturbed areas. Restoration of an area that is at least close to the beginning of the stream, or water channel will provide the most efficient restoration and help mitigate for flooding downstream in the low lying areas. Processes set into motion upstream will flow to surrounding areas, having an effect on those areas.

These strategic location factors will provide some element of passive restoration throughout Padilla Bay.

Other factors involved in restoration planning are educational and recreational uses of the area. Having trails going through the site will enable site maintenance, recreational observation, walking, and educational activities.

Other ideas for recreational use could involve activities such as picnic and recreational/ sporting areas, or benefit the public as open green spaces. These types of areas could provide revenue for our efforts and for stakeholder groups as well. Controlled fishing and hunting can be allowed for additional revenue sources. Having a site with these potential activities along with restoration will provide for the most efficient land use and ecological function. Farming activity needs to be taken into account as well, and the farmers in the area need to be consulted. With the cooperation with farmers and other interest groups, agricultural practices can be maximized along with restoration and ecological function.

The most ecologically efficient restoration site will provide the best financial gain and be the least costly to implement. Improved health and quantity of wildlife and improved ecological functions will benefit farmers and ownership in the long-term with increased revenue. The main restoration site will allow for passive restoration, autogenic recovery and ecological succession throughout the site.

PLANNING

CONSTRAINTS

In the No-Name Slough, freshwater upland tributaries drain into the saltwater bay, which creates a gradient from freshwater to brackish and/or salt water. The water quality of surface water bodies in the state of Washington are regulated by Washington Water Quality Standards. Moreover, the geography of juvenile salmon and wildlife habitat is also important consideration. The current habitats need to be improved and protected, expecting to increase after the restoration project.

Criteria	Class A Freshwater	Class A Marine
Fecal coliform organisms	Not to exceed a geometric mean of 100 colonies per 100/ml; no more than 10 percent of samples may exceed 200 colonies per 100/ml	Not to exceed a geometric mean of 14 colonies per 100/ml; no more than 10 percent of samples may exceed 43 colonies per 100/ml
Dissolved oxygen	Shall exceed 8.0 mg/l	Shall exceed 6.0 mg/l
Temperature	Shall not exceed 18.0°C due to human activities	Shall not exceed 16.0°C due to human activities
Turbidity	Shall not exceed 10% over natural background turbidity	Shall not exceed 10% over natural background turbidity.

Table 1. Selected Washington Class A Water Quality Criteria (“Feasibility Study of No-Name Slough Watershed”, 2005).

STAKEHOLDERS

Currently, the NERR is jointly managed by WDOE and NOAA. Our proposed restoration site is located along Padilla Bay, which falls within NERR system. Most of the land is owned by WDFW and 90 acres are owned by WDOE. These three stakeholders, WDFW, WDOE and NERR, are expecting to maximize the ecological function and wildlife habitat in the area.

Recreational and educational uses of the area will also be an important consideration. Trails that allow public access is one of the most important factors that attract people to the site. Hunting and fishing are popular activities and bring in revenue. Our restoration efforts should enhance this activity. Strict supervision and monitoring are essential in order to preserve and protect wildlife populations. The trails also provide access for educational programs. Information learned and observed can be used to benefit other areas.

Since the reserve has been converted from private as well as agricultural land, long term relationship with local residents and farmers should be taken seriously. Working with these groups and gaining community support and trust will give us the best chance of achieving long term success in our restoration efforts.

PLANNING

DECISION MATRIX

Since the restoration of any area involves many factors and considerations, and is generally limited in size and scope, not everything can be restored. Decisions need to be made that accomplish certain goals, while minimizing conflict. One method of deciding on a restoration site is the use of a decision matrix. This method is designed to take into account restoration options, functions and other design criteria and compare them. The results of this comparison yield the best restoration alternative. We used the following decision matrix to help us determine the best restoration option.

There were several restoration options available and criteria to take into account when making our final decision. In table 2-1, various restoration criteria were given a weighting factor of importance, and each was rated on a 1 to 5 scale for that particular restoration option: A score of 1 being not a factor or positive consequence at all, and 5 being the most critical factor and most positive consequence for that restoration option. These values were summed up and compared to each other.

The restoration option with the highest score was the one that achieved the most favorable results overall. Tables 2-2 through 2-11 are statistical models that we used to assess any possible errors in our estimates. These techniques were chosen in order to provide us with statistical certainty that the results from table 2.1 can be relied on for our restoration decision. The restoration options shown below will be discussed in greater detail at the end of this section.

Options	Weighting Factor	Tidal March	Farming/ Flooding	Hybrid	No Action
Criteria		Raw Score	Raw Score	Raw Score	Raw Score
Implementation Cost	10	3	2	3	5
Maintenance Cost	10	4	1	4	5
Stakeholder Acceptance	15	1	3	4	1
Restoration of Site	15	5	2	4	1
Agriculture	10	1	4	3	5
Waterfowl Habitat	10	5	3	4	1
Education	5	1	2	4	1
Recreation	5	1	2	4	1
Flood Protection	10	3	3	3	3
Juvenile Salmon Habitat	10	5	3	4	1
Scale: 1-5	100	310	255	370	240

Table 2-1. General Decision Matrix.

Best Case (a)	Tidal Marsh	Farming/Flooding	Hybrid	No Action
Implementation Cost	4	2	3.5	5
Maintenance Cost	4.5	1.5	4.5	5
Stakeholder Acceptance	2	4	5	1.25
Restoration of Site	5	2.5	5	1.25
Agriculture	1.25	4.5	3	5
Waterfowl Habitat	5	3.5	4.5	1.25
Education	2	3	4.5	1.25
Recreation	1.25	2	5	1.25
Flood Protection	4	3	4	3
Juvenile Salmon Habitat	5	1.25	4.5	1.25
Sum	340	272.5	435	255

Table 2-2. Decision Matrix: Best Case Scenario (a)

Worst Case (b)	Tidal Marsh	Farming/Flooding	Hybrid	No Action
Implementation Cost	2	1.5	2.5	4.75
Maintenance Cost	3	1	3.5	4.75
Stakeholder Acceptance	1	3.5	3	1
Restoration of Site	4.5	1.5	3.5	1
Agriculture	1	4	2	4.75
Waterfowl Habitat	4.5	2.5	3.5	1
Education	1	1	3.5	1
Recreation	1	1	3	1
Flood Protection	2	2.5	3	2
Juvenile Salmon Habitat	4.75	1	3	1
	247.5	195	305	222.5

Table 2-3. Decision Matrix: Worst Case (b)

C-values	Tidal Marsh	Farming/Flooding	Hybrid	No Action
Implementation Cost	6	6	6	7.5
Maintenance Cost	7.5	6	6	7.5
Stakeholder Acceptance	6	6	7.5	7.5
Restoration of Site	6	6	7.5	7.5
Agriculture	6	6	6	7.5
Waterfowl Habitat	7.5	6	6	7.5
Education	6	6	6	7.5
Recreation	7.5	6	7.5	7.5
Flood Protection	6	6	6	7.5
Juvenile Salmon Habitat	7.5	7.5	6	7.5

Table 2-4. Decision Matrix: C-Values

M-values	Tidal Marsh	Farming/Flooding	Hybrid	No Action
Implementation Cost	3	2	3	5
Maintenance Cost	4	1	4	5
Stakeholder Acceptance	1	3	4	1
Restoration of Site	5	2	4	1
Agriculture	1	4	3	5
Waterfowl Habitat	5	3	4	1
Education	1	2	4	1
Recreation	1	2	4	1
Flood Protection	3	3	3	3
Juvenile Salmon Habitat	5	1	4	1

Table 2-5. Decision Matrix: K-Values

PLANNING

K-values	Tidal Marsh	Farming/Flooding	Hybrid	No Action
Implementation Cost	5	5	5	6
Maintenance Cost	6	5	5	6
Stakeholder Acceptance	5	5	6	6
Restoration of Site	5	5	6	6
Agriculture	6	5	5	6
Waterfowl Habitat	6	5	5	6
Education	5	5	5	6
Recreation	6	5	6	6
Flood Protection	5	5	5	6
Juvenile Salmon Habitat	6	6	5	6

Table 2-6. Decision Matrix: M-Values

Means of Weighted Values	eqn: μ= W*(a+b+(k *m))/(k+2)	Tidal	Farming/Flooding	Hybrid	No Action
Implementation Cost		30.000	19.286	30.000	49.688
Maintenance Cost		39.375	10.714	40.000	49.688
Stakeholder Acceptance		17.143	48.214	60.000	15.469
Restoration of Site		73.929	30.000	60.938	15.469
Agriculture		10.313	40.714	28.571	49.688
Waterfowl Habitat		49.375	30.000	40.000	10.313
Education		5.714	10.000	20.000	5.156
Recreation		5.156	9.286	20.000	5.156
Flood Protection		30.000	29.286	31.429	28.750
Juvenile Salmon Habitat		49.688	10.313	39.286	10.313
Sum		310.692	237.813	370.223	239.688

Table 2-7. Decision Matrix: Means of Weighted Values

Std Dev of Weighted Values	W*|(b - a)|/c	Tidal	Farming/Floodi	Hybrid	No Action
Implementation Cost		3.333	0.833	1.667	0.333
Maintenance Cost		2.000	0.833	1.667	0.333
Stakeholder Acceptance		2.500	1.250	4.000	0.500
Restoration of Site		1.250	2.500	3.000	0.500
Agriculture		0.417	0.833	1.667	0.333
Waterfowl Habitat		0.667	1.667	1.667	0.333
Education		0.833	1.667	0.833	0.167
Recreation		0.167	0.833	1.333	0.167
Flood Protection		3.333	0.833	1.667	1.333
Juvenile Salmon Habitat		0.333	0.333	2.500	0.333
Sum		14.833	11.583	20.000	4.333

Table 2-8. Decision Matrix: Standard Deviation of Two Weighted Variables

Difference of Two Weighted Variable's Means	eqn: μx-y = μx - μy	Tidal - Farming/Flood	Tidal - Hybrid	Tidal - No Action	Farming/Flood - Hybrid	Farming/Flood - No Action	Hybrid - No Action
Implementation Cost		10.714	0.000	-19.688	-10.714	-30.402	-19.688
Maintenance Cost		28.661	-0.625	-10.313	-29.286	-38.973	-9.688
Stakeholder Acceptance		-31.071	-42.857	1.674	-11.786	32.746	44.531
Restoration of Site		43.929	12.991	58.460	-30.938	14.531	45.469
Agriculture		-30.402	-18.259	-39.375	12.143	-8.973	-21.116
Waterfowl Habitat		19.375	9.375	39.063	-10.000	19.688	29.688
Education		-4.286	-14.286	0.558	-10.000	4.844	14.844
Recreation		-4.129	-14.844	0.000	-10.714	4.129	14.844
Flood Protection		0.714	-1.429	1.250	-2.143	0.536	2.679
Juvenile Salmon Habitat		39.375	10.402	39.375	-28.973	0.000	28.973
Sum		72.879	-59.531	71.004	-132.411	-1.875	130.536

Table 2-9. Decision Matrix: Difference of Two Weighted Variable Means

Difference of Two Weighted Variable's Std Dev	eqn: σx-y = sqrt(σ^2x + σ^2y)	Tidal - Farming/Flood	Tidal - Hybrid	Tidal - No Action	Farming/Flood - Hybrid	Farming/Flood - No Action	Hybrid - No Action
Implementation Cost		3.436	3.727	3.350	1.863	0.898	1.700
Maintenance Cost		2.167	2.603	2.028	1.863	0.898	1.700
Stakeholder Acceptance		2.795	4.717	2.550	4.191	1.346	4.031
Restoration of Site		2.795	3.250	1.346	3.905	2.550	3.041
Agriculture		0.932	1.718	0.534	1.863	0.898	1.700
Waterfowl Habitat		1.795	1.795	0.745	2.357	1.700	1.700
Education		1.863	1.179	0.850	1.863	1.675	0.850
Recreation		0.850	1.344	0.236	1.572	0.850	1.344
Flood Protection		3.436	3.727	3.590	1.863	1.572	2.134
Juvenile Salmon Habitat		0.471	2.522	0.471	2.522	0.471	2.522
Sum		20.540	26.581	15.699	23.864	12.857	20.721

Table 2-10. Decision Matrix: Difference of Two Weighted Variable's Standard Deviations

Probability of Rank Reversal	Tidal - Farming/Flood	Tidal - Hybrid	Tidal - No Action	Farming/Flood - Hybrid	Farming/Flood - No Action	Hybrid - No Action
	0.00	0.99	0.00	1.00	0.56	0.00

Table 2-11. Decision Matrix: Probability of Alternative Switching Ranks with Another

PLANNING

NO ACTION OPTION:

While doing nothing would be the least expensive option, at least for the short-term, it is not an appropriate solution in that the area will remain degraded and the No Name Slough will not be able to obtain the State of Washington Water Quality Criteria, invasive species will continue to flourish and the land purchased for restoration will lay fallow and unused. This was shown with the lowest score in our decision matrix. Doing nothing is not a viable solution.

FARMING/FLOODING OPTION:

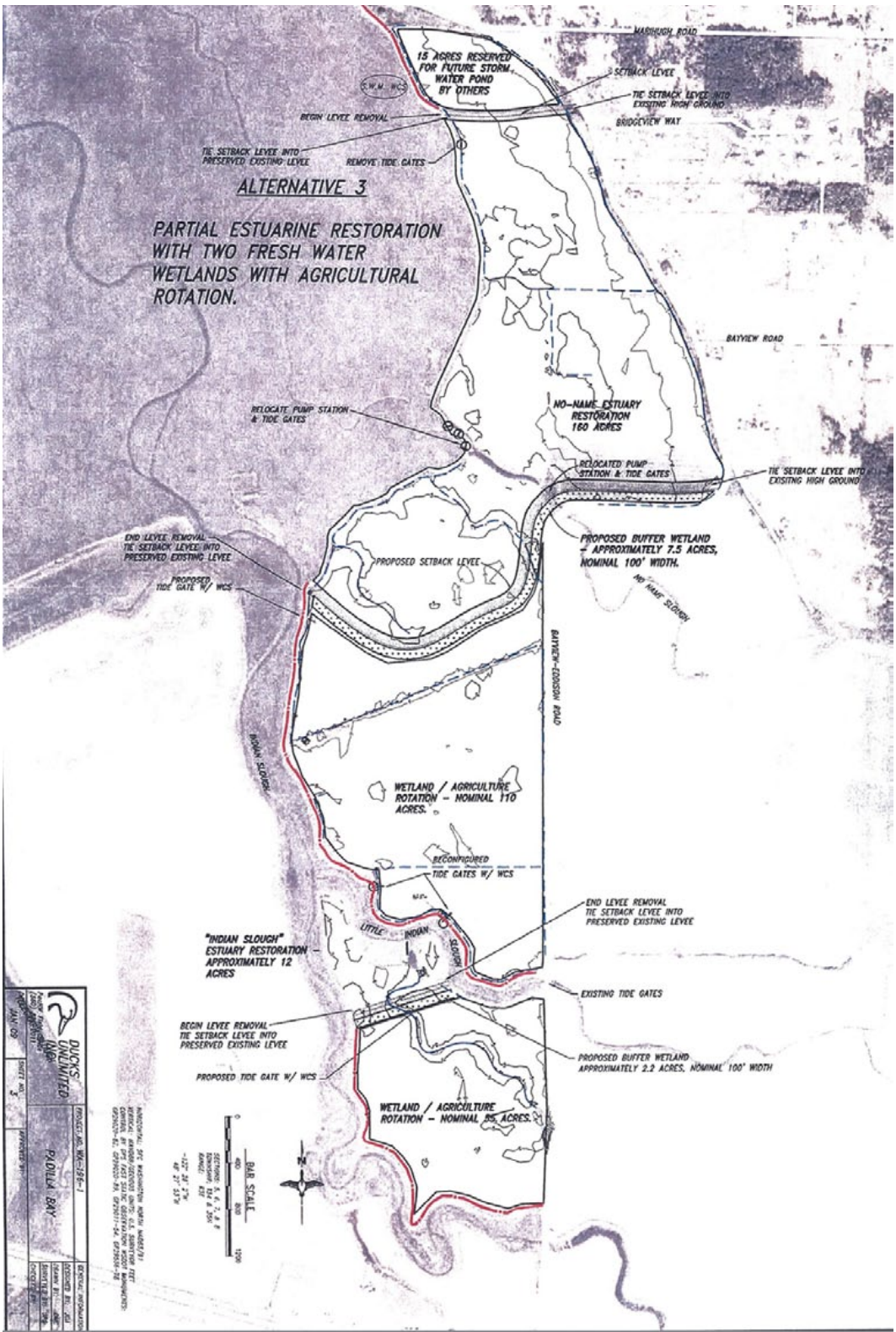
This option involves rotating farming and freshwater marshes in five cells along the margins of Padilla Bay. While this option would be beneficial to farmers it would not address the extensive habitat loss of the juvenile Chinook salmon. The Skagit River contains the largest tidal delta in the Puget Sound and has lost 80-90% of Chinook aquatic habitat. This option is not a viable solution.

TIDAL MARSH OPTION:

This option would maximize estuary and create the most habitat for the juvenile salmon. But it would exclude and alienate many stakeholders. So while it is imperative that salmon habitat be restored, being sensitive to the multiple stakeholders is also paramount. This solution is not ideal.

THE HYBRID OPTION:

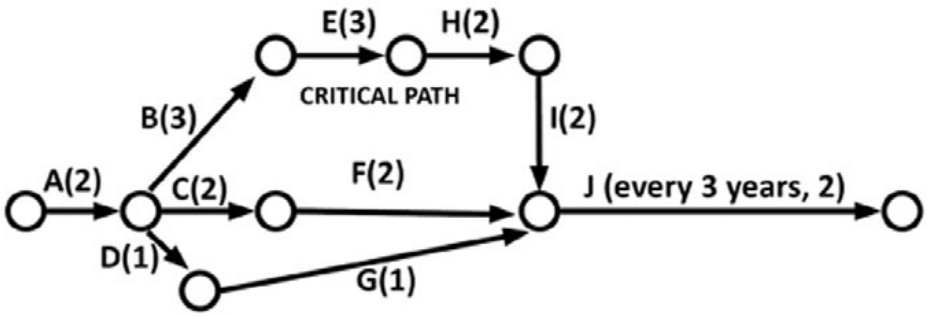
This option is a hybrid of the Farming Solution and the Estuary Restoration Solution. This is the option that not only creates salmon habitat but also takes into consideration all needs of the various stakeholders. While we acknowledge that all needs of all stakeholders will not/cannot be met, this solution attempts to address and satisfy as many of the various needs as possible and scored the highest in our decision. It allows us to meet goals and objectives of passive restoration, autogenic recovery and ecological succession. It could provide the most efficient long-term restoration of the area and have the greatest influence on surrounding areas, with the least amount of conflict.



ALTERNATIVE 3: HYBRID SOLUTION

DESIGN

PHASE 1: NO-NAME SLOUGH ESTUARINE RESTORATION



TASKS

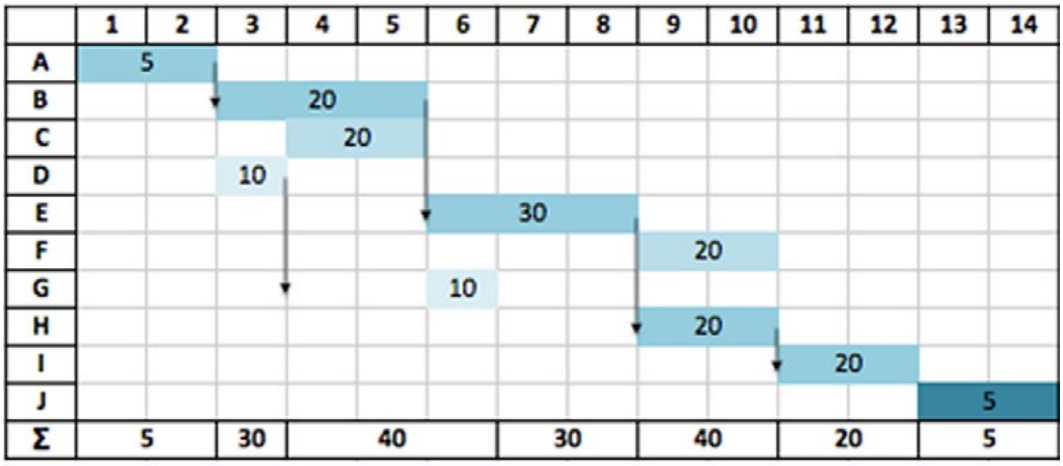
A. Assessment of conditions

B. Remove levees
E. Construct setback levees about 50 ft or more from channels; Tie levee into existing high ground and preserved existing levee
H. Plant vegetation for erosion control
I. Use excavated soil to form low berms to protect adjacent farmland
C. Expand and enhance wetland buffer areas and intervening riparian areas between levee and channels - Remove invasive cordgrass
F. Plant native wetland shrub and tree species in degraded wetland areas, and eelgrass in meadow areas
D. Remove pump station and tide gates
G. Relocate pump station and tide gates to new configuration

J. Adaptive management and monitoring

TASK	TIME (wks)	# WORKERS
A	2 weeks	5
B	3 weeks	20
E	3 weeks	30
H	2 weeks	20
I	2 weeks	20
C	2 weeks	20
F	2 weeks	20
D	1 week	10
G	1 week	10
J	every 3 yrs	5

TASK FLOW DIAGRAM

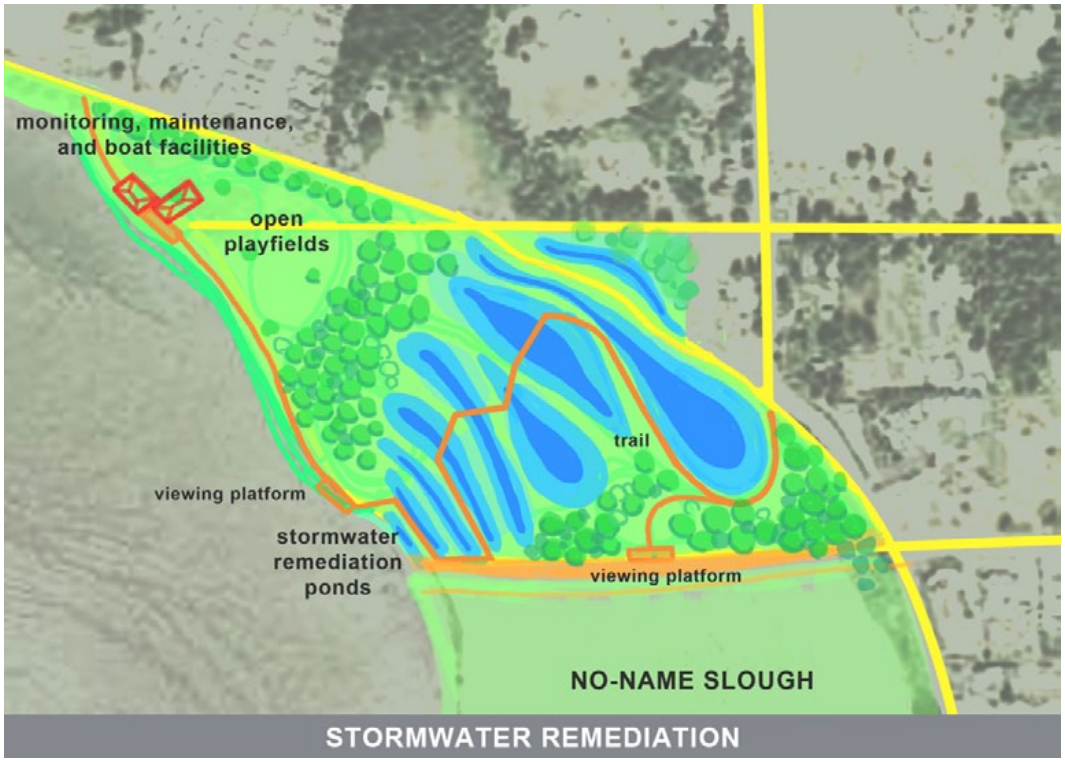


PROJECT SCHEDULE

DESIGN

PHASE 2: RECREATIONAL FACILITIES AND PUBLIC ACCESS

The northern 15 acres of land reserved for stormwater ponds will be developed for stormwater remediation as well as provide recreational parks trails, bird-watching platforms, and educational and maintenance facilities. The levees will be set back, and the pump station and tide gates will be relocated so as to allow greater connection between upper slough and existing wetlands.



PHASE 3: AGRICULTURAL LAND ROTATION

The southern end of the project site will be allocated for partial wetland and agricultural uses on a yearly or seasonal rotation. Care should be taken so that the agricultural practices do not damage the surrounding wetland areas. Negotiations and cooperation with farm owners will be essential. Actions, cost and timeframe will be determined after further study.

PLANTS

Padilla Bay's estuarine flora is mainly composed of eelgrasses Zostera marina and Z. japonica, which are flowering vascular marine grasses. Covering 7,500 acres of the bay, the eelgrass meadow is the largest contiguous expanse of eelgrass meadow in Washington. Eelgrass is a key component in the Padilla Bay ecological system, as it is eaten by the black brant sea goose and is used by small marine snails and other smaller organisms as habitat and food as well. Algae species found in the intertidal zone are sea lettuce (Ulva sp.) and Enteromorpha spp. Other algae genera include Laminaria, Ceramium, Gracilaria, and Fucus ("Padilla Bay Management Plan", 2008). These eelgrass meadows should be conserved and restored in areas where Spartina may have invaded and degraded.

A rich diversity of fauna thrive in the Padilla Bay area, and protection of these birds, mammals, and fish is important. The bald eagle (Haliaeetus leucocephalus) feeds on small mammals and dead fish and otzher organisms in the bay. The bay also supports one of the largest known populations of peregine falcons in North America, and the endangered anatum subspecies has been found in Padilla Bay. Other raptor species found include the merlin (Falco columbarius) and snowy owl (Nyctea scandiaca). 26 species of an average of 50,000 ducks live in the bay. Two great blue heron (Ardea herodias) rookeries are north and southwest of the bay. More than 240 species of birds are found at Padilla Bay, making it a prime bird-watching area in the state ("Padilla Bay Management Plan", 2008).

Mammals include the harbor seal (Phoca vitulina) and river otter (Lutra canadensis). Pods of killer whales have spotted right outside of the bay, and porpoises are found in deeper waters. Fish species include the herring (Clupea harengus), smelt (Hypomesus pretiosus), sole, starry flounder, juvenile chinook, coho, pink, and chum salmon. Padilla Bay is especially important as rearing areas for pink and chum salmon. Marine invertebrates are abundant in the mud and sand in Padilla Bay ("Padilla Bay Management Plan", 2008).

DESIGN

ADAPTIVE MANAGEMENT

The management plan will be developed with the feasibility study as the project progresses. Monitoring will involve the evaluation of the No-Name Slough channels, wetlands, and riparian forested areas every three years. Degraded areas with invasive weeds such as cordgrass will be mapped and monitored consistently. Monitored areas will be selected based on management history, current management, and restoration protocols. Raptor species and fish species that are species of concern, candidates, threatened, or endangered will be monitored.

MONITORING PLAN

Monitoring efforts focus on the success of the restoration in terms of habitat restoration, water quality, sediment load and wildlife usage. Monitoring will be ongoing and continuous. Management groups will periodically evaluate the cumulative effects of development and land use actions in terms of impacts to: instream flow, basin hydrology, water and sediment quality, stream channel complexity, riparian and wetland areas, and fish passage.

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NISQUALLY GRAVEL PIT

NISQUALLY GRAVEL PIT

MINING RESTORATION

Jake Dawe
Rob Edsforth
Gar-Yun Ho
Autumn Nettey
Chuhan Zheng

Image from class lecture powerpoint on the Nisqually gravel pit

INTRODUCTION

SITE ANALYSIS

The project site is an inactive five-acre open gravel pit on the south side of the Nisqually River in Pierce County, directly south of Ashford, Washington. Upstream of the Alder Reservoir and downstream of the headwaters in the Mt. Rainier National Park, the area was industrial forest prior to acquisition by Tacoma Power. Surrounding the gravel pit area is a Pseudotsuga menziesii (Douglas-fir) stand that is about 20 years old.

Excavated to a depth of up to 15 meters on the eastern edge, this pit contains residual gravel and sand that was not mined out. The original gravel deposits were created as the Nisqually River moved across the valley bottom, leaving coarse-graded depositional material in a complex pattern. This makes the site very quick draining.

However, in the northeast side of the gravel pit, a small basin that is poorly drained due to a high compacted soil layer under the gravel exists. The compact soil layer allows for higher levels of moisture retention year round, which has allowed for a small community of native and nonnative forbs, graminoids, young tree starts, and shrubs to thrive (UWREN, 2003).

The site is currently too high to be flooded by the river in any predictable manner. As the land sits now, the only plants that will grow there are species that are adapted to very dry droughty conditions. Currently, the site has been seeded with a non-native sterile annual Triticale grass to prevent erosion.

PROJECT SITE

INTRODUCTION

GOALS AND OBJECTIVES

In this project, we aim to recover the environmental functions lost in the mining of the gravel pit area located on the south side of the Nisqually River.

It is our objective to

- Recreate soils that will support diverse native flora
- Reduce habitat fragmentation
- Expand and diversify wildlife habitat and native foraging material
- Reduce runoff, ground water pollution and sediment loading into the Nisqually river
- Reduce and/or eliminate all off road vehicle usage in this area

In order to obtain these objectives, the site will be restored into four different ecosystems, a meadow, wetlands, forested wetlands and coniferous forest. Species of plants will be specified according to the different ecosystems and salvage availability from neighboring sites. An irrigation system will be installed and water will be artificially pumped in order to meet watering needs for plants on site. Tagro, wood chips, and sod from nearby places will be used to remediate the poor soil conditions. Pollutants will be prevented from water sources for protecting health of wildlife especially salmon.

Recreational activities will be discouraged from the site by planting denser vegetation along the road and installing both natural large woody debris and a temporary fence, which will be removed when the soil has been cut and filled, and plantings have stabilized.

A long-term monitoring and adaptive management plan will be applied to ensure proper autogenic recovery processes on the site, and will be updated every five years according to the local monitor.

CONSTRAINTS AND FUNCTIONAL REQUIREMENTS

SOILS

The pit area was once strip-mined and abandoned when projects were completed. Since the original topsoil is gone, the soil quality is poor. It has no water holding capacity, and is low in nutrients and organic matter. Any restoration on this site will require bringing in soil in order to provide adequate soil conditions and set into motion the redevelopment of organic matter and nutrients (Ewing, 2008).

Tagro biosolid, which is a mixture of 50% digested biosolid cake, 25% sawdust, and 25% sand (UWREN, 2003), will be distributed around the site at a minimum depth of four inches within the basin and less than one inch along the side slopes. An issue with using Tagro is that there are undesirable compounds in the biosolid mix. Although the concentrations of trace metals in Tagro are significantly lower than the maximum allowable concentrations established by the U.S. Environmental Protection Agency, care must be taken so that these compounds will not leave the site and potentially degrade water quality and nearby vital salmonid habitat.

WETLANDS

Potential for wetland habitat will first be assessed in the site. Wetland habitat will be constructed and artificially irrigated until vegetation has established and stabilized. To improve water retention and decrease the water permeability, clay soil taken from the site will be compressed along with overturned sod to create a layer with increased impermeability. The wetland areas will allow for increased wildlife habitat complexity and species diversity. A large backhoe from Tacoma Power will be used to excavate the soils, which will be used to fill the southeastern side of the site.

Wetlands must be maintained for the purpose of cleansing water of pollutants, and providing wildlife habitat. The areas surrounding the constructed wetlands will be

CONSTRAINTS AND FUNCTIONAL REQUIREMENTS

planted with trees and shrubs like Alnus rubra (Red alder), Carex spp. (sedges), and Cornus sericea (Red-osier dogwood). Areas with invasive species will be mapped, managed, and monitored.

WILDLIFE HABITAT

To protect and enhance nearby fish habitat within the Nisqually basin, water quality must be monitored and managed. An open meadow and native shrub-dominated plant community with high forage value will be created to support elk and other wildlife. Transplants will be taken from wetland environments within nearby elk forage habitat and other wetland locations in the vicinity. “Feathering” the edge between the native coniferous forest and the wetland/meadow area by creating a buffer wetland forest area will allow for greater habitat complexity.

STAKEHOLDERS

TACOMA POWER– This group is the owner of the Nisqually River Project. This project provides power to 43,000 northwest homes. Responsibilities of this ownership are to provide fisheries and wildlife habitat programs while providing recreational opportunities. Tacoma Power also operates the hydroelectric power generation dams and is required to provide ecological functions as part of the continued licensing of the Nisqually River Projects.

This project was licensed in 1997 between WDFW, USFW, National Marine Services and the Nisqually Tribe (Tacoma Power, 2012). They are motivated to restore the area and can provide salvageable plants, resources and financing. Communication with this group and coordinating our restoration efforts will complement other restoration and construction work being conducted as part of the Nisqually River Project.

CITY OF TACOMA – The city of Tacoma owns the land that the gravel pit is on. Constraints of land uses, treatments used, and equipment used will need to be requested and approved by the City in advance. Another constraint is that restoration efforts on the city land may affect the Nisqually River Project. Any liability issues and other legal constraints should be addressed in advance.

Approval of budgets, tracking progress, and percentage completion information needs to be communicated to the city. Following city procedures will minimize delays, and help mitigate for any changes in financial, equipment and labor needs as unforeseen events arise.

WASHINGTON DEPARTMENT OF FISH & WILDLIFE – Since the site is on the south side of the Nisqually River, any restoration efforts need to take into account salmon and other wildlife habitat. This group has strict rules and regulations about work done on or near rivers and streams. Any re-contouring activities and soil amendments need to be done so as not to create runoff into the river. Working with WDFW will enable us to create areas for habitat and protect existing ones.

STAKEHOLDERS

U.S. FISH & WILDLIFE SERVICE – The Nisqually National Wildlife Refuge belongs to the National Wildlife Refuge System, which is managed by the USFWS. This agency also regulates partial sources in the area. Currently it is taking charge of the comprehensive conservation planning of Greys Harbor NWR and the Black River Unit of Nisqually NWR. (USFWS, 2011) Thus any actions that involving wildlife habitats use should be permitted by this agency first.

NATIONAL MARINE FISHERIES SERVICE – This agency is managing salmon conservation and restoration project in Washington region. Any disturbance to salmon habitats needed to be reported and agreed by this agency.

NISQUALLY RIVER COUNCIL – The Nisqually River Council was formed in 1987 as a non-regulatory cooperative group. It is a broad-based organization comprised of public agencies, businesses, local governments and private citizens who are committed to the protection and enhancement of the Nisqually River and its basin.

NISQUALLY INDIAN TRIBE – These people are very protective of the river and the surrounding environment. They are "People of the River, People of the Grass". Their history and ways of life have surrounded the river for thousands of years. They were ordered off some of their land in 1917 by the US Army, who used 3,353 acres of this land to construct the Fort Lewis Army Base. Any work done should keep the tribe in mind.

Positive and negative effects of modifying landscape can impact this group directly. They have a strong presence in Thurston County and are an influential group that is part of the Nisqually River Project (Dory, 2010). Re –establishing trust with this group will help make this restoration effort successful. Recruiting members of this group to help in restoration efforts would add considerable value for improving salmon habitat and other restoration activities along or influencing the river.

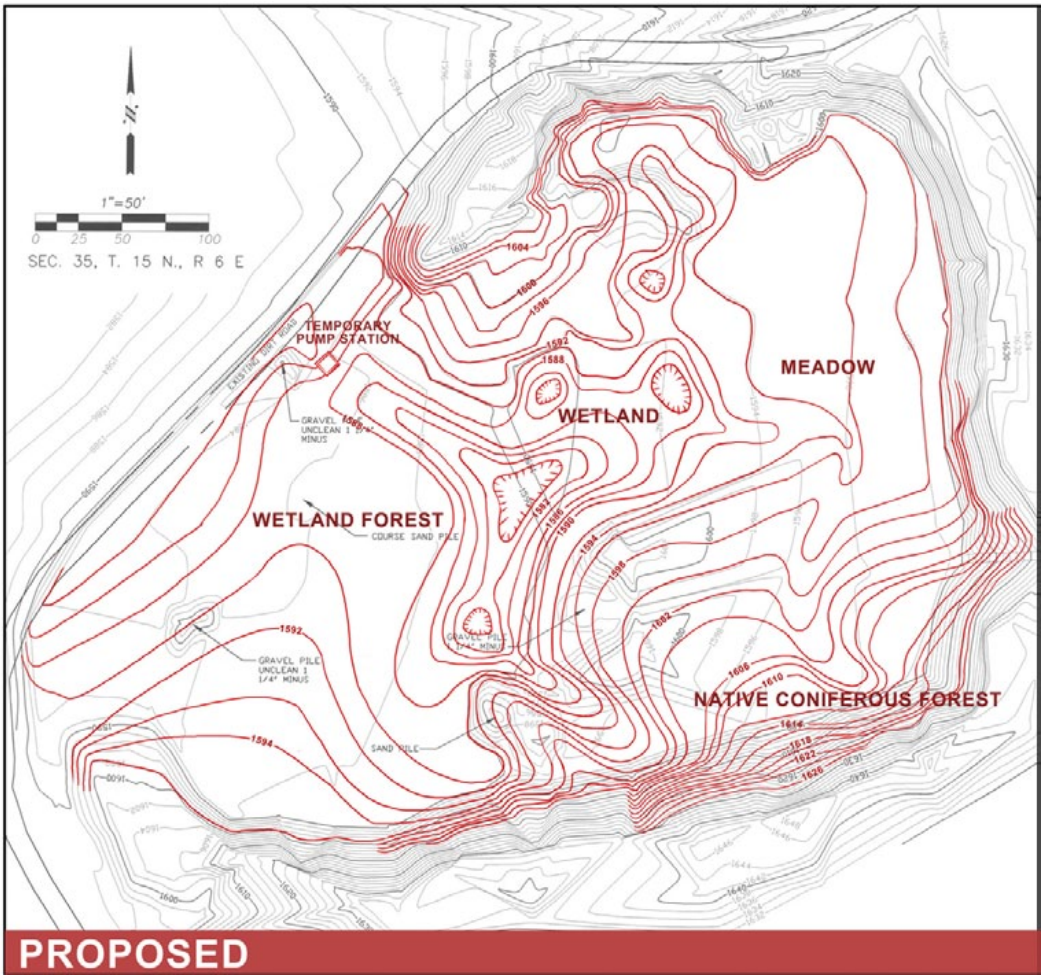
LOCAL BUSINESS – This group also includes the Nisqually Indian tribe, as they are one of the largest employers in Thurston County. Constraints and opportunities with this group have already been discussed. Other business constraints would come from local business that depends on the area for economic benefit. Our proposed restoration site activities and boundaries need to be carefully considered so as not to encroach on the running of local business.

DESIGN

With the shaping of the earth we will create various ecosystems within our five acres site including wetlands with a wetland forest consisting of hardwoods and coniferous tree species, a native coniferous forest and a native grass meadow. Tacoma power is backing this project and will provide the funding, manpower and over site to accomplish what is set forth in this plan.

This being a gravel pit, all nutrients, topsoil, seed banks and biomass had been stripped away. The soil is sandy and porous with low nutrient levels. Our design takes this into consideration with the use of sod from salvage, the addition of Tagro, native plants salvaged from nearby sites, and the installation of an irrigation system of PVC pipe in which a water truck can be hooked up to for watering needs.

If, in the unlikely event plants aren't available from salvage they will be purchased bare root and in containers from a local nursery. Watering will be kept at a minimum but will be relied upon for successful plant establishment. Because of the degradation of the soil we feel this will be a necessity for the first couple of years, until plants become well established.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TEMPORARY PUMP STATION
GRAVEL UNCLEAN 1 1/4" MINUS
WETLAND
MEADOW
WETLAND FOREST
COURSE SAND PILE
GRAVEL PILE UNCLEAN 1 1/4" MINUS
SAND PILE
NATIVE CONIFEROUS FOREST
PROPOSED

DESIGN

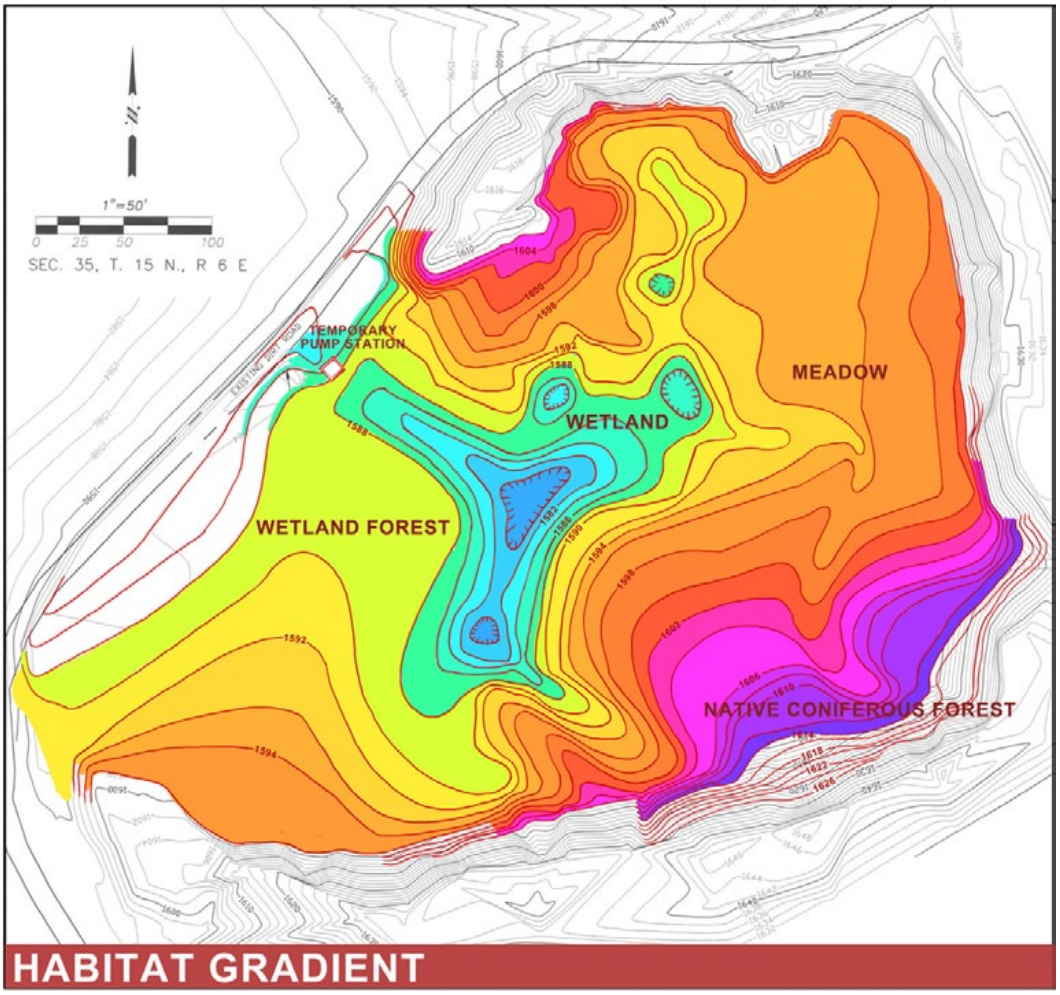
PLANTING

The **WETLAND FOREST** will be planted with Alnus rubra (red alder), Acer macrophyllum (bigleaf maple), A. circinatum (vine maple), Thuja plicata (western red cedar), Cornus sericea (Red-osier dogwood) and Lonicera nvolucrate (black twinberry).

The **WETLANDS** will be planted with Carex spp. (sedges), Camassia quamash (common camas), Eleocharis palustris (creeping spikerush), Red-osier dogwood and Betula glandulosa (resin birch).

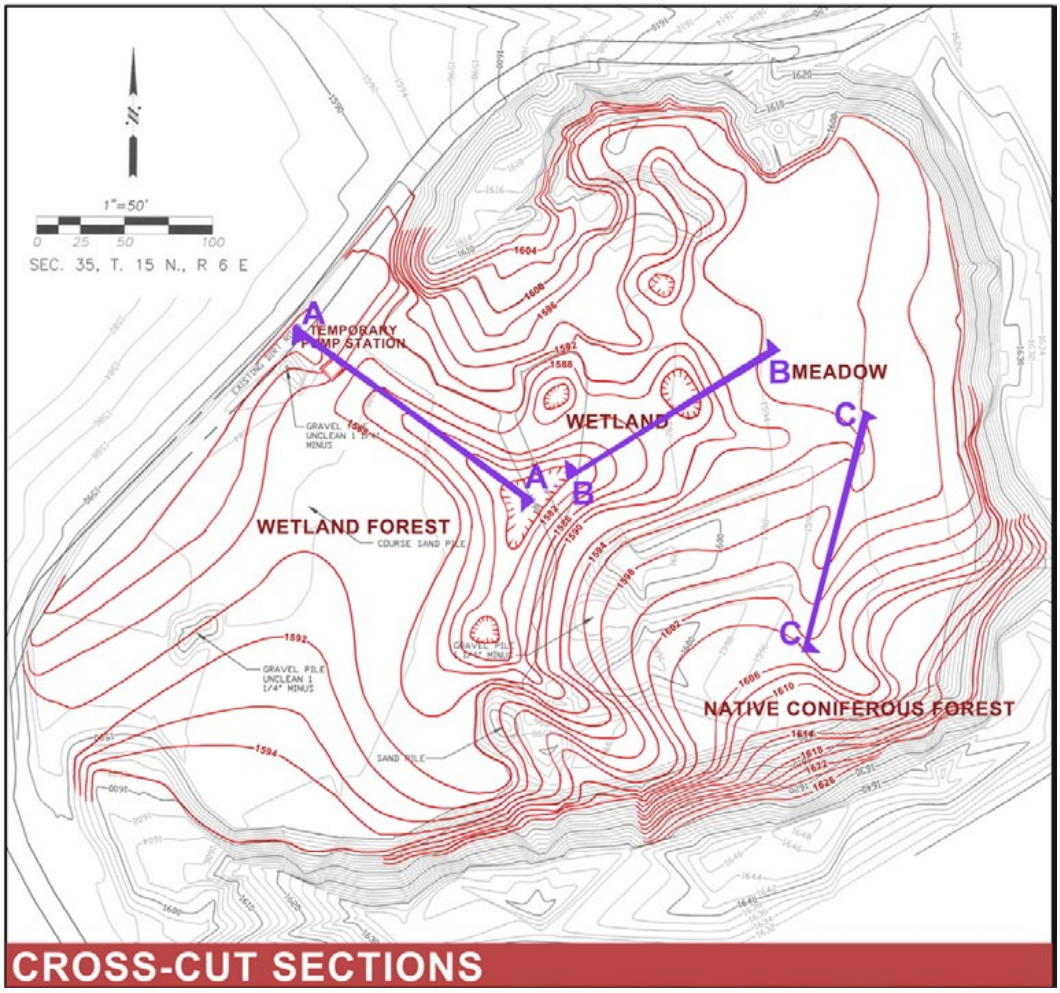
The **MEADOW** will be planted with Fragaria virginiana (wild strawberry), Petasites palmatus sweet coltsfoot) seeded with a mixture of Elymus glaucus (Buckley blue wildrye), Poa annua (annual bluegrass) and Festuca occidentalis (Idaho fescue). Five Quercus garryana will be also be planted.

The **CONIFEROUS FOREST** will be planted with Tsuga heterophylla (western hemlock), Pseudotsuga menziesii (douglas fir), Abies grandis (grand fir) and Pinus monticola (western white pine)



HABITAT GRADIENT

DESIGN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SEC. 35, T. 15 N., R 6 E
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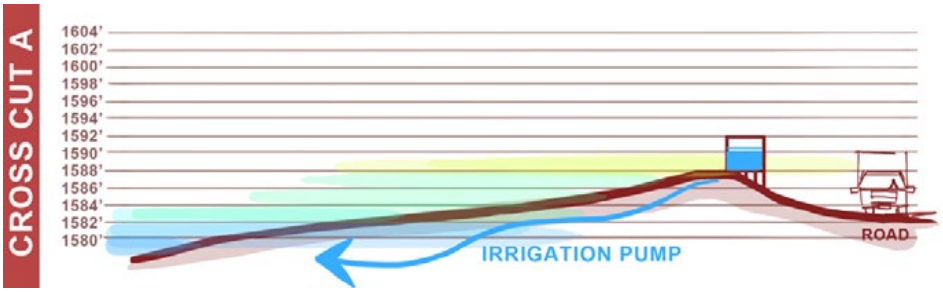
TEMPORARY PUMP STATION
B MEADOW
WETLAND
C
A
B
WETLAND FOREST
COURSE SAND PILE
GRAVEL PILE UNCLEAN 1 1/4" MINUS
C
NATIVE CONIFEROUS FOREST
SAND PILE
CROSS-CUT SECTIONS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IRRIGATION PUMP
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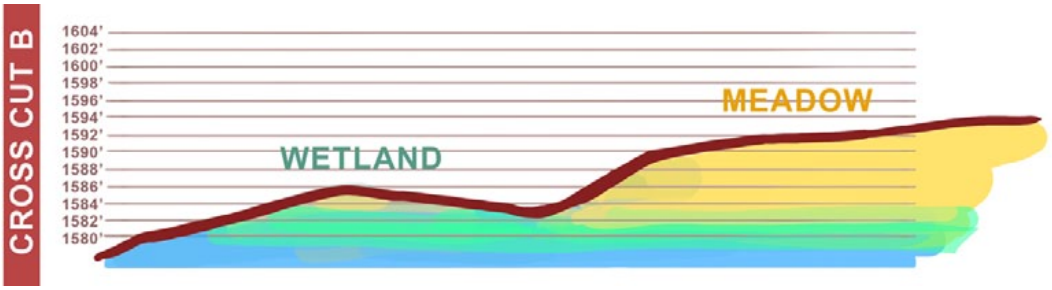
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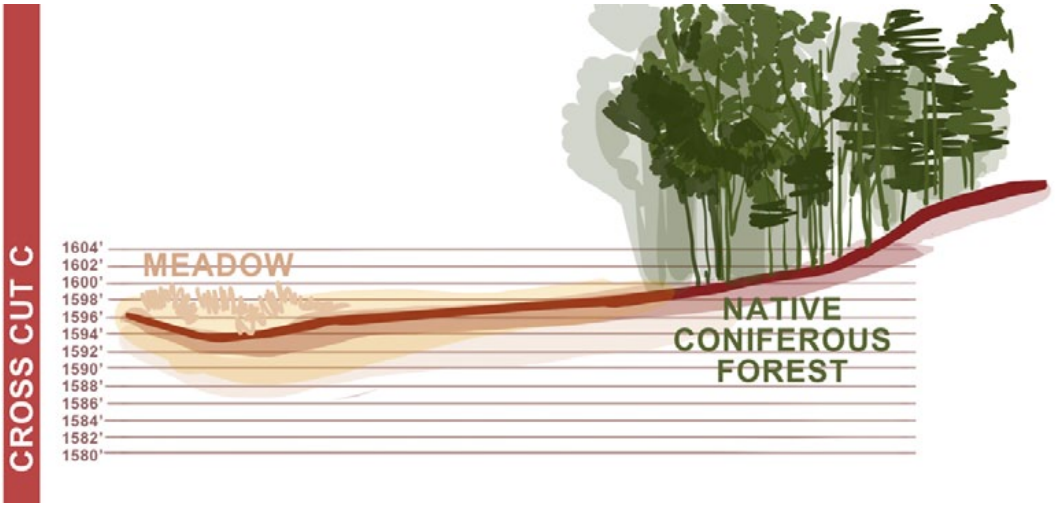
MEADOW
WETLAND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1580'
MEADOW
NATIVE
CONIFEROUS
FOREST

IMPLEMENTATION AND MANAGEMENT

TAGRO

After the earthwork has been completed the irrigation piping system will be installed. All sprinkler heads will have a protective cover so as not to get clogged with Tagro.

AMOUNT OF TAGRO NEEDED:

- The whole area as a rectangle:
  600 ft × 400 ft = 240,000 sq ft

- Area of Northwestern portion that is not actually part of the gravel pit:
  (300 ft × 300 ft)/2 = 45,000 sq ft

- Subtract the Northwestern portion from whole area and get estimated area of the gravel pit site restoration:
  240,000 sq ft – 45,000 sq ft = 195,000 sq ft

- According to calculation, in order to grow anything of note over this soil type, we would need to cover all the ground with 3 inches of Tagro.

- Volume of Tagro: 195,000 sq ft ×0.25 ft = 40,750 cu ft

SOD

Sod that is available from surrounding clear cut will be collected and used to help the gravel pit ecological functions start recovering again. The sod will be flipped upside down on top of the gravel soil and Tagro will then be spread on top. This will help new plants by providing a nutritious decaying soil layer and will also provide an impermeable layer between the plants and the soil, which largely helps to collect and store floodwater. This also helps to prevent extreme episodes of drought. Since a large amount of sod is needed, and the local availability of sod

is unknown until further exploration, this sod treatment will be applied to the wetland forest area first as a trial experiment.

Monitoring is needed in order to test the usefulness of sod in re-growing soils and making adjustment on treatment methods before large scale application. Moreover, an irrigation system will also be placed under the sod and Tagro layer which allows manually adding water by water truck if plants are starting to dry.

AMOUNT OF SOD NEEDED:

- 100 ft × 100 ft = 10,000 sq ft

- In order to cover the entire site by using sod, 100 ft × 100 ft = 10,000 sq ft sod is needed.

- Volume of Sod: 10,000 sq ft × 0.25 ft = 2,500 cu ft

LABOR NEEDED FOR SOIL AND SOD TRANSPORTATION AND DISTRIBUTION:

- Assuming 100sq of sod could be collected per hour per person. Thus 100 man hours are needed to collect the sod.

- Transportation:
    - Assuming a larger end dump truck can hold 10 cubic yards of material. So (18,750 cu ft + 2,500 cu ft) / 270 cu ft ≈ 190 dump truck loads to bring all the needed Tagro from Tacoma.
    - According to google map calculation, about 2 hours and 7 minutes is needed to drive from the Tacoma Tagro facilities to the Gravel Pit. Including dump off, 4 hours and 30 minutes is needed for a round-way.
    - Assuming 5 dump trucks are available for this project, it would take 150/5 = 30 round-way convoy trips to deliver the needed Tagro.
    - Assuming one person per dump truck, and 4.5 hour trips per

dump truck, it would take 30 × 4.5 hrs × 5 = 855 hrs to deliver all of the Tagro needed from Tacoma.

- Two options are available for distributing Tagro across the site:
  - Wheelbarrows
    - » Assuming standard wheelbarrow can carry 6 cu ft of material, it would take 48,750 cu ft / 6 cu ft = 8,125 wheelbarrow trips to empty the pile of Tagro.
    - » The Tagro must be spread furthest away from the entrance first, otherwise Tagro will be compacted and wasted in the process. Assuming pushing a wheelbarrow the 400 ft and then spreading the Tagro 3 ft deep would take 5 minutes when full and 3 minutes when empty, it takes 8 minutes in total for round-trip. Being high estimate, that gives us a man hour total of (8,125 × 8 mins)/60 mins/hr = 1,084 hrs, or 27 weeks/1 person; 9 weeks/3 workers; 4.5 weeks/6 workers to spread the Tagro.
  - ATV trailer
    - » Assuming standard ATV trailer can carry10 cu ft of material, it would take 48,750 cu ft / 10 cu ft =4,875 ATV trips to empty the pile of Tagro.
    - » Assuming pushing an ATV trailer the 400 ft and then spreading the Tagro 3 ft deep and make the return trip would take 3 minutes as high estimate, that gives us (4,875 × 3 mins) /60mins/hr ≈ 244, or 9 weeks / 1 person; 3 weeks/ 3 workers; 1.5 weeks / 6 workers to spread the Tagro.

- Two options are available for distributing sod across the site:
  - Wheelbarrows
    - » Using same standard from above, and assuming the sod

is 3 inch thick, it would take 2,500 cu ft / 6 cu ft ≈ 417 trips to lay out the sod in the wetland forest area.

- » As high estimate, it would take (417 × 8 mins)/60 mins/hr ≈ 56 hrs, or 2 days / 6 workers to spread the sod, to spread the sod.

◦ ATV trailer

- » Using same standard from above, and assuming the sod is 3 inch thick, it would take 2500 cu ft / 10 cu ft = 250 trips to lay out the sod in the wetland forest area.
- » Using same standard from above, as high estimate it would take (250 × 3 minx) /60 mins/hr≈13 hrs, or 2 days/1 worker to spread the sod.

• Summing the total man hours needed for this whole process both for sod and Tagro, we get: **1,185 hours using ATVs, and 2,068 hours** using wheelbarrows. Thus, using ATVs to help spread the Tagro is believed to be a much more efficient idea than wheelbarrows, and it would require much less physical effort by the volunteers or paid employees spreading the soil.

IRRIGATION

The irrigation system will be a system of plastic PVC tubes that can be laid on the gravel before the sod and Tagro is applied. We would need roughly 4300ft of PVC if we spaced the pipes 50 feet from each other. A person could put together 250 feet of PVC together in an hour, so that would take 18 man hours to put together.

The PVC could be transported with the Tagro as it is lightweight and can be spread over 180 truckloads.

IMPLEMENTATION AND MANAGEMENT

PLANTS

The amount of plant material required for a restoration of this size will require forethought, organization and detailed planning. Throughout the summer teams of 4 will go to salvage sites to tag, record and map plant species. We calculate that 4 people can scout and map one acre per hour and that approximately 50 plants per acre will be tagged. The labels will be color coordinated with our habitat gradient map for ease of identification and distribution.

Our site requires over 190,000 or so plant species to be salvaged for transplant. The search for and documentation of these plants will take 8 teams of 4 people approximately 4 weeks. Six hours a day will be spent surveying and two will be commuting. Plant surveying will begin in mid May and continue into mid June.

The digging and transporting of material is a significant endeavor and will require the organization of over 150 workers for the digging up of plants alone. This work will begin in August and will continue for approximately the next 12 weeks. Plants will be safely stored onsite until planting begins a week later. As the plants are beginning to be salvaged a crew will come in and contour the land to specifications.

The irrigation pipes will be laid and the sod and Tagro will then be applied. We estimate that 6 people can lay pipes, sod and Tagro in two weeks. Immediately after the Tagro application plants will be distributed and crews will begin the planting, mulching and watering of all plants. The meadow will be seeded at this time as well.

For planting, the site will be divided into four pie or wedge shaped sections radiating out from the pump station. In order to minimize soil compaction an ATV will be loaded with enough plants for one day of planting in one section and then distribute at specific locations within that section. Planting will take a crew of sixty approximately 8 weeks to plant all species.

We will be planting heavily to help inhibit the establishment of invasives such as Scotch broom (Cytisus scoparius), Japanese knotweed (Polygonum cuspidatum), reed canary grass (Phalarisarundinacea), and Himalayan and evergreen blackberry (Rubus discolor and R. laciniatus).

MANAGEMENT

Tacoma Power will coordinate and manage all aspects of the restoration with the guidance of the design team. We will assist the plant survey crews in plant identification, mapping and proper labeling. We will also oversee all aspects of plant removal, storage and installation.

The planting teams will be instructed how to plant using the "Horticultural techniques for successful plant establishment" from WSU Puyallup Research and Extension Center. (WSU, 2009) The site will be monitored annually for invasive species, as well as plant growth and survival. The management plan will be adjusted every three years according to the long term monitoring.

	May		June				July				August				September				October						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
A	32																								
B					6																				
C							6																		
D								6																	
E										150															
F														60											
G														2											
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Σ	32				6					150				212			210					6	3		

GANTT CHART

IMPLEMENTATION AND MANAGEMENT

Task	Time(wks)	Workers	Estimated time of the year
A: Research of local salvageable plants, tags and maps	4	32	Mid-May
B: Change topography, incldiuing cuting and filling land, constructing wetland and move away earth	2	6	Mid-June
C: Build temperary fence and construct pump pad for water truck	1	6	
D: Lay Tagro, sod and irrigation pipes	2	6	
E: Dig salvaged plants from surround areas	12	150	Early-July
F: Plant on gravel pit site	8	60	
G: Short-term monitor and site assessment , adjust proposal and work plan	2	2	
H: Install signage and block motorized vehicle access road	1	6	Mid-October
I: Long-term maintenance and monitoring plan	3	3	

TASK AND LABOR SEQUENCE

REFERENCES

Ritchie, Anna; Hall, Jason; Moore, Jessica; Sandvik, Patti; Baker, Sarah; and Osenga, Wynnae. "Nisqually Gravel Pit Reclamation Project Proposal." Tacoma Power: Nisqually Wildlife Project.
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Dory, (2010) Nisqually Indian Tribe, Squally – Absch People of the river people of the grass, (http://www.nisqually-nsn.gov/, accessed 17 May 2012)

Ewing, K, Restoration Design, (2008) (http://courses.washington.edu/esrm479/2008%20Studios/ESRM%20479%202008%20Wk7%20Studio%20Strip%20Mine%20Reclamation.pdf, accessed 17 May 2012)

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U.S. Fish & Wildlife Service, (2011), Nisqually National Wildlife Refuge (http://www.fws.gov/nisqually/management.html, accessed on 2 June 2012)

Washington State University, (2009), Puyalup research and Extension Center (http://www.puyallup.wsu.edu/~Linda%20Chalker-Scott/FactSheets/Planting%20fact%20sheet.pdf, accessed on 2 June 2012)

CASCADE PASS

THE CASCADE PASS

RECREATION DISTURBANCE RESTORATION

Jake Dawe
Rob Edsforth
Gar-Yun Ho
Autumn Nettey
Chuhan Zheng

Image source: class slides on the Cascade Pass

INTRODUCTION

The North Cascade Pass, located in the upper part of the Skagit River Watershed in the North Cascades, is considered by Washington Trails Association to be one of the most scenic and crowded high country hikes in the North Cascades (Romano, 2009). In 1974 it was declared a high visitation and high impact area in need of protection. The 1988 Washington Wilderness Parks Act formally incorporated Cascade Pass into the national wilderness preserve system.

The subalpine vegetation zone near Doubtful Lake in the North Cascades National Park often exceeds 100 inches or more of precipitation and is typically dry during the summer. Dominant vegetative species in the coniferous tree and heather meadow communities include Tsuga mertensiana, Abies lasiocarpa, Abies amabilis, Phyllodoce empetriformis, Vaccinium deliciosum, Vaccinium membranaceum, Cassiope mertensiana, and various sedges and rushes near the lake (de Gouvenain, 1995).

Within the site vicinity, human activities began impacting and disturbing the ecological systems in 1886, when a saw mill was constructed alongside the Doubtful Lake (de Gouvenain, 1995). Camping and recreational activities have had a long history at the site, but many measures have been taken to restrict camping at the Doubtful Lake and along the Cascade Pass Trail. The impacts of extensive recreational use have caused long lasting damage to these vegetation communities, associated soils and the surrounding subalpine ecosystem.

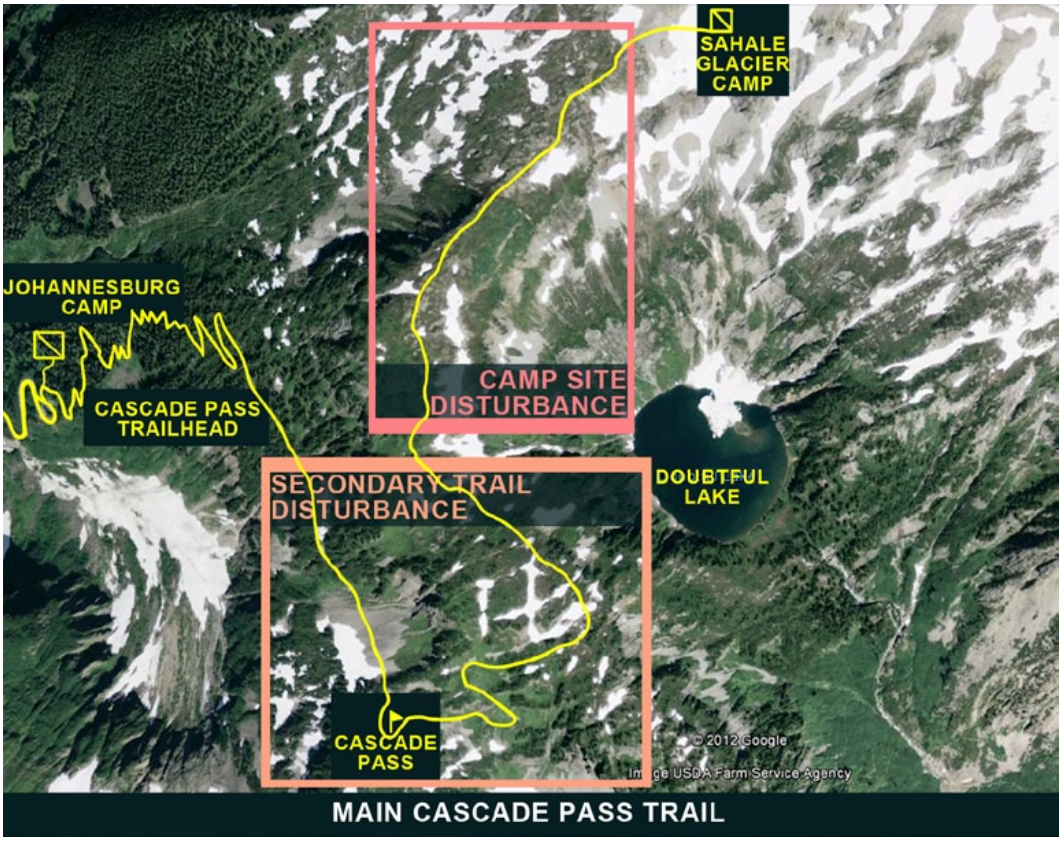
Restoration has been slow and extended due to the extremely slow growth rate of subalpine plant species. Short growing seasons and harsh conditions constitute to the fragility of subalpine ecosystems, and impede recovery from disturbance. Bald spots and scars on the landscape exist still, even though overnight camping has been prohibited for almost forty years now.

Trampling is the main disturbance that has impacted the ecology alongside the Cascade Pass Trail. The effects of trampling are three-fold: the direct effect being the mechanical damage to all or parts of the plants, and the indirect effects on

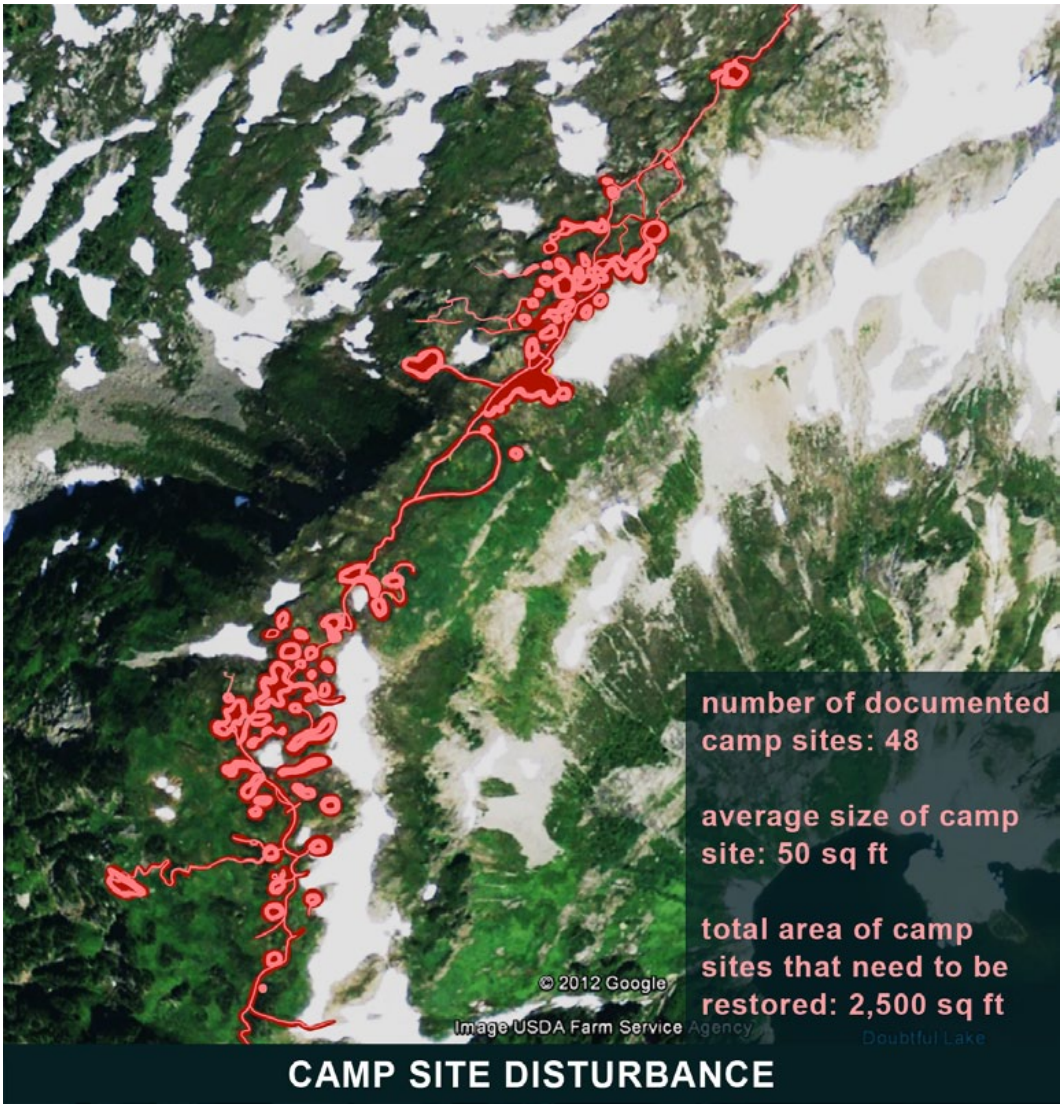
the physical and/or chemical characteristics of the soil as well as future plant development (de Gouvenain, 1995). Trampling is a form of compaction, which reduces soil volume and the air porosity of soil, and increases the bulk density. The lack of air porosity can lead to periods of deficient soil and root aeration, since compaction and higher densities affect the mobility and availability of inorganic ions. Nitrogen mineralization and nitrification can be reduced with only a slight amount of compaction (de Gouvenain, 1995). These changes in the physical and chemical properties of the soil negatively impact plant development.

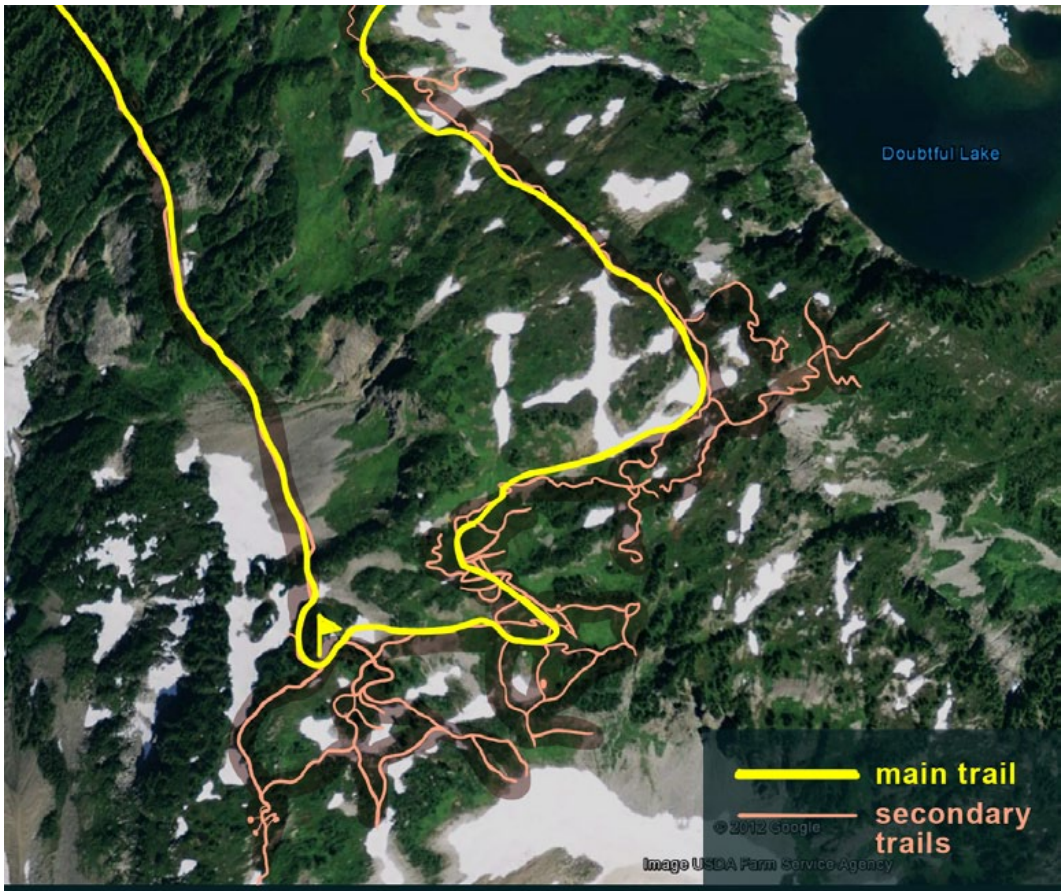
GOAL

Our goal is to restore the natural beauty and ecological functions of the subalpine ecosystem at Cascade Pass.



PLANNING


number of documented camp sites: 48
average size of camp site: 50 sq ft
total area of camp sites that need to be restored: 2,500 sq ft
© 2012 Google
Image USDA Farm Service Agency
Doubtful Lake
CAMP SITE DISTURBANCE



TRAIL DISTURBANCE

PLANNING

FUNCTIONAL REQUIREMENTS

In order for the subalpine ecosystem to regain proper ecological functions, certain requirements for the restoration of the ecosystem must be met:

- Proper soil composition
- Balanced soil nutrient content
- Subalpine native plant species
- Mulch and plants must remain in place during high winds
- Initial watering requirements
- Protection from herbivory for vegetation
- Control and mitigation of erosion
- Minimization of disturbance

CONSTRAINTS

Restoring a subalpine area comes with uncertainties and multiple constraints. We are limited to five employees that must not only coordinate volunteer efforts but to collect seeds, propagate plants, gather materials, organize supplies and implement the design plan. Other important elements to consider are:

- Site access - hike in only, elevation gains, potential for inclement weather to postpone and delay restoration efforts
- Difficulties in transporting materials to site
- Weather - potential for sudden and extreme temperature changes
- Rules and regulations of The Wilderness Act
- The fragile nature of the subalpine ecosystem and how difficult it is for the ecosystem to recover and regenerate after a disturbance
- The fitness level, health and experience of volunteers
- Limited growing season of 10 - 12 weeks
- Budget

PLANNING

The **DECISION MATRIX** and **ADDITIONAL STATISTICS** provide a quantitative approach toward choosing an alternative objectively, avoiding all possible human bias. All criteria are considered to be independent of one another, as well as any numbers that were generated for this report. Our criteria were considered to be the most important and all-encompassing factors in deciding between alternatives, and then weighted based on importance to the successful completion of the project.

IMPLEMENTATION COST is the criterion that represents the budget, and the highest weight on the project. While we have a Congressional funding available, we do not have a large budget and that has to be factored into this project. **IMPACT ON SITE** is how much potential damage the alternative could do to the site during restoration. This is another major factor in our project, because the more impact the alternative has on the site, the less our restoration project actually accomplishes. **RESTORATION OF SITE** shows how successful each alternative is in restoring Cascade Pass, ignoring all potential damage to the site while restoring. **VOLUNTEERS NEEDED** shows how many volunteers would be needed to carry out this project. Most likely, all three alternatives would need similar amounts of volunteer hours. Lastly, **LENGTH OF RESTORATION** simply represents how long we expect each project to take. It is not necessarily a bad thing that projects take a long time, but all else being equal it would be better to finish sooner rather than later.

Transportation and Management of Supplies Decision Matrix

Alternatives		Helicopter	Pack Animals	Backpacks
Criteria	Weighting Factor	Raw Score (x)	Raw Score (x)	Raw Score (x)
Implementation Cost	35	1	2	4
Impact on site	25	4	1	4
Restoration of Site	20	5	3	5
Volunteers needed	10	3	3	3
Length of Restoration	10	4	3	1
Scale: 1-5	100	305	215	380

Transportation and Management of Supplies Decision Matrix

Best Case (a)	Helicopter	Pack Animals	Backpacks
Implementation Cost	1.05	3	4.5
Impact on site	5	2	4.5
Restoration of Site	5	4	5
Volunteers needed	3.5	3.5	3.5
Length of Restoration	4	3	1.5
Weighted Sum	336.75	300	420

Transportation and Management of Supplies Decision Matrix

Worst Case (b)	Helicopter	Pack Animals	Backpacks
Implementation Cost	1	1.5	3.5
Impact on site	3.5	1	3.5
Restoration of Site	4.5	2.5	4.5
Volunteers needed	3	2.5	2.5
Length of Restoration	3	2	1
Weighted Sum	272.5	172.5	335

Transportation and Management of Supplies Decision Matrix

K-Values	Helicopter	Pack Animals	Backpacks
Implementation Cost	6	4	5
Impact on site	4	5	5
Restoration of Site	6	6	6
Volunteers needed	4	4	5
Length of Restoration	4	4	4

Transportation and Management of Supplies Decision Matrix

C-Values	Helicopter	Pack Animals	Backpacks
Implementation Cost	7	5	6
Impact on site	5	6	6
Restoration of Site	7	7	7
Volunteers needed	5	5	6
Length of Restoration	5	5	5

Transportation and Management of Supplies Decision Matrix

Means of Weighted Values	eqn: μ= W*(a+b+(k*x))/(k+2)	Helicopter	Pack Animals	Backpacks
Implementation Cost		8.97	26.25	40.00
Impact on site		35.42	10.71	28.57
Restoration of Site		23.75	16.25	23.75
Volunteers needed		10.83	10.00	8.57
Length of Restoration		11.67	8.33	4.17
Sum		90.64	71.55	105.06

Transportation and Management of Supplies Decision Matrix

Std Dev of Weighted Values	eqn: $\sigma = W^*\|(b - a)\|/c$	Helicopter	Pack Animals	Backpacks
Implementation Cost		0.25	10.50	5.83
Impact on site		7.50	4.17	4.17
Restoration of Site		1.43	4.29	1.43
Volunteers needed		1.00	2.00	1.67
Length of Restoration		2.00	2.00	1.00
Sum		12.18	22.95	14.10

Transportation and Management of Supplies Decision Matrix

Z-Score of Unweighted Variables	eqn: $Z = \|(x - \mu)\| / \sigma$	Helicopter	Pack Animals	Backpacks
Implementation Cost		-31.88	-2.31	-6.17
Impact on site		-4.19	-2.33	-5.90
Restoration of Site		-13.13	-3.09	-13.13
Volunteers needed		-7.83	-3.50	-3.34
Length of Restoration		-3.83	-2.67	-3.17

Transportation and Management of Supplies Decision Matrix

Difference of Two Weighted Variable's Means	eqn: $\mu x-y = \mu x - \mu y$	Backpacks - Helicopter	Backpacks - Pack Animals	Pack Animals - Helicopter
Implementation Cost		31.03	13.75	17.28
Impact on site		-6.85	17.86	-24.70
Restoration of Site		0.00	7.50	-7.50
Volunteers needed		-2.26	-1.43	-0.83
Length of Restoration		-7.50	-4.17	-3.33
Sum		14.42	33.51	-19.09

Transportation and Management of Supplies Decision Matrix

Difference of Two Weighted Variable's Std Dev	eqn: $\sigma x-y = \sqrt{(\sigma^2 x + \sigma^2 y)}$	Backpacks - Helicopter	Backpacks - Pack Animals	Pack Animals - Helicopter
Implementation Cost		5.84	12.01	10.50
Impact on site		8.58	5.89	8.58
Restoration of Site		2.02	4.52	4.52
Volunteers needed		1.94	2.60	2.24
Length of Restoration		2.24	2.24	2.83
Sum		20.62	27.26	28.66

Transportation and Management of Supplies Decision Matrix

Probability of Rank Reversal	Backpacks - Helicopter	Backpacks - Pack Animals	Pack Animals - Helicopter
	0.24	0.11	0.75

DISCUSSION OF ALTERNATIVES

There are a few different options available to us in dealing with the transportation and management of supplies used throughout the restoration process. To implement this project, we will need to get tools, Excelsior mulch, and plant plugs up to Cascade Pass. Three options were considered: Backpacking in all gear and supplies, helicoptering in all gear and supplies, or using pack animals to help mitigate the weight of gear and supplies.

BACKPACKING

This was found to be our best alternative. While strenuous and the most time consuming, it provides the cheapest way to transport all materials to the top of Cascade Pass. Backpacking and using only human power also ensures that our current restoration efforts do not harm other areas at the site. The subalpine ecosystem at Cascade Pass is very fragile and using anything but human power all but guarantees further damage to the site. Further, this alternative provides a learning experience for volunteers through a college summer credit program, where students can learn more about restoration in a subalpine environment.

HELICOPTERING

Using a helicopter to bring up all the Excelsior mulch, tools and plant plugs is problematic for several reasons. While the ideal solution in a cost-free world, using a helicopter is too cost prohibitive to really consider for an organization such as the North Cascades National Park. There is Congressional funding available, but budgets are tight and likely could not fund a helicopter at this time. It would also be frowned upon by many naturalists, as helicopters are loud and will disrupt wildlife and may potentially knock down fragile trees.

PACK ANIMALS

Using pack animals would help the employees and volunteers transport the Excelsior mulch up to Cascade Pass greatly. The main problem with this alternative, however, is the boarding of the pack animals. The pack animals would destroy the fragile landscape at Cascade Pass, and would negate restoration efforts made throughout this project. The benefit of using pack animals to help carry materials does not outweigh the risk of further disturbance to the restoration site.

DESIGN

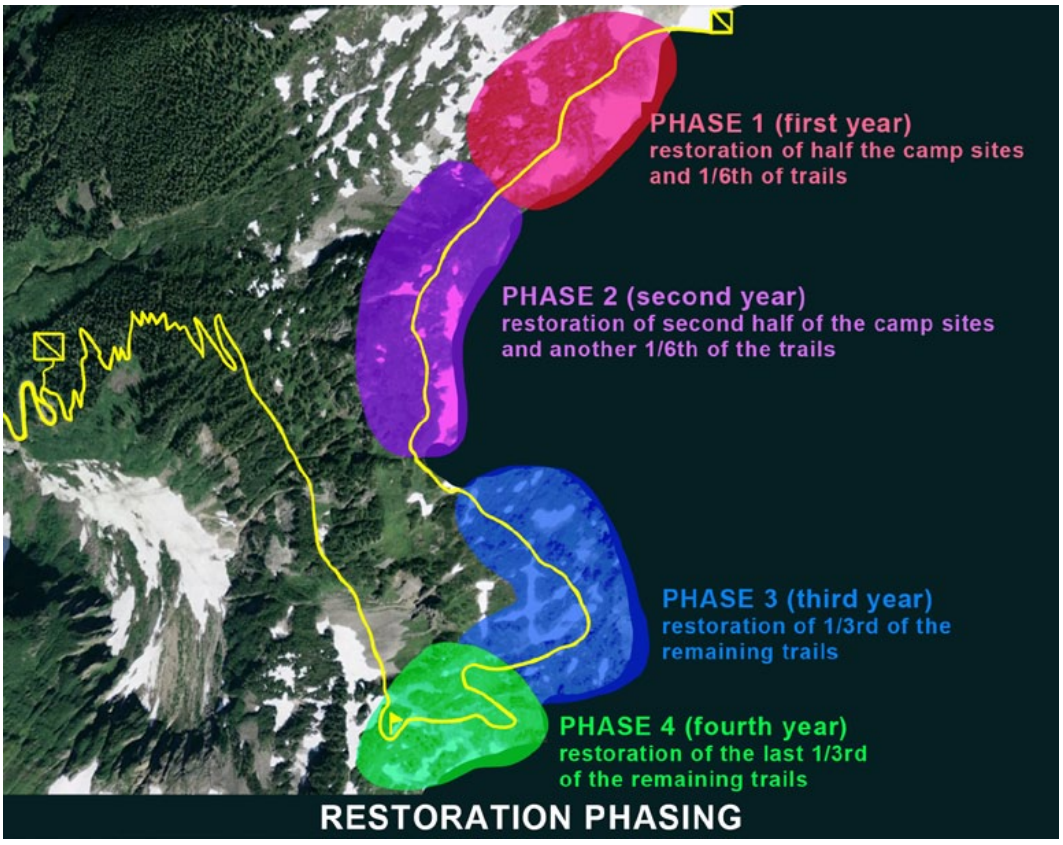
The restoration area has a heavy snowpack most of the year, with a growing season of 10 to 12 weeks. The weather can change quickly, and can vary from year to year. We, therefore, decided on a 6 weeks per year restoration work schedule. This will minimize the potential for weather delays and unsafe working conditions and it will give our plants a chance to take hold before the end of the growing season. This schedule will also allow us some flexibility as the work progresses.

The entire restoration will take 4 years in total. For the first two years, we plan on having the 5 employees working on site restoration and the 7 interns working on trail restoration. Three volunteer events will be held every year at the end of second, fourth and sixth week of work. 24 volunteers will be recruited and will be divided into two groups, 12 volunteers each working in separate areas to help prevent additional damage to the land.

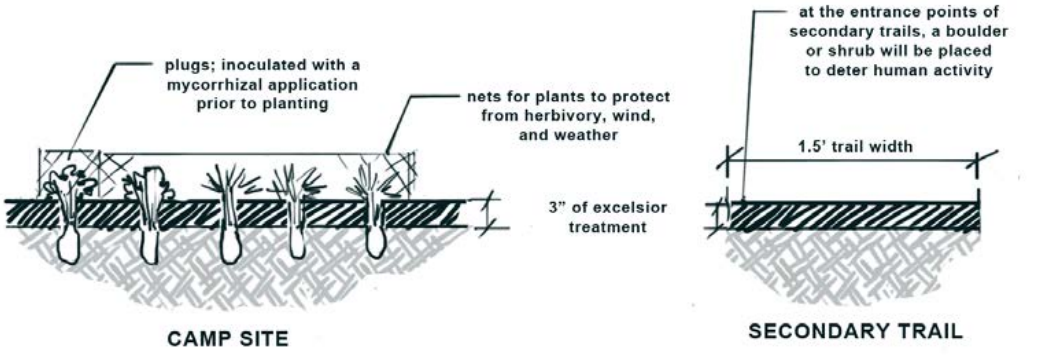
There are regulations regarding the number of people that can be working in the area at a time. Because the restoration sites are within the Stephen Mather Wilderness Area, we are allowed only 5 total employees on the site. We need to get approval for the 7 interns and for each volunteer restoration event for the 6 week period. (Ewing, 2012) This needs to be done in advance.

Communicating our objectives to the appropriate agencies and following the provisions of the Wilderness act, along with outlining our strict employment precautions, will increase our likelihood of obtaining approval for the extra workers and the three volunteer events.

DESIGN



RESTORATION PHASING



TREATMENTS

PLANTS

All plant plugs will have been previously propagated from local seed sources and germinated in the Marblemount Greenhouse. Prior to planting, the plugs will be inoculated with a Mycorrhizal application. (Lee, J, et al, 2012) Plants to be used are:

- Phyllodoce empetriformis (pink mountain heath)
- Vaccinium deliciosum (Cascade Bilberry)
- V. membranaceum (thinleaf huckleberry)
- Deschampsia atropurpurea (mountain hairgrass)
- Cassiope mertensiana (western moss heather)
- Carex nigricans (black alpine sedge)
- C. spectabilis (showy sedge)

EQUIPMENT AND TOOLS:

- Storage container w/ lock
- Pickaxes, trowels, and rakes
- Gloves
- Backpacks
- Watering cans
- Rope
- Tarps and netting
- Two way radios
- Laminated information sheet to keep w/ on-site supplies
- Compass

SUPPLIES:

- Snacks
- Water
- Black garbage bags (to fill with snow)
- Bug spray
- First aid kit, matches, and flares

DESIGN

FACTS FOR CALCULATION:

- 2 miles of trails
- 5 ft x 10 ft in average per site
- 48 sites needed to be restored
- 3 inch deep of Excelsior
- 7000 cu inch amount of Excelsior that one person could carry every time
- 4 days a week, 6 weeks which is 24 days of working per year
- 7 internships and 5 paid employees in first two years on both sites and trails restoration; 11 internships and 1 paid employees in the other two years on trails restoration
- 3 volunteer events per year, 24 volunteers every event divided into two groups, 4 years in total

SITE CALCULATION:

- Site area: 5 ft x 10 ft = 50 sq ft = 7200 sq in
- Amount of Excelsior needed per site:
  7200 sq in x 3 in = 21600 cu in
- People needed to care enough Excelsior for one site:
  21600 cu in / 7000 cu in = 3.1

TRAIL CALCULATION:

- 2 miles = 10560 ft
- Surface area of all trails:
  10560 ft x 1.5 ft = 15840 sq ft = 2280960 sq in
- Amount of Excelsior needed for all trails:
  2280960 sq in x 3 in = 6842880 cu in

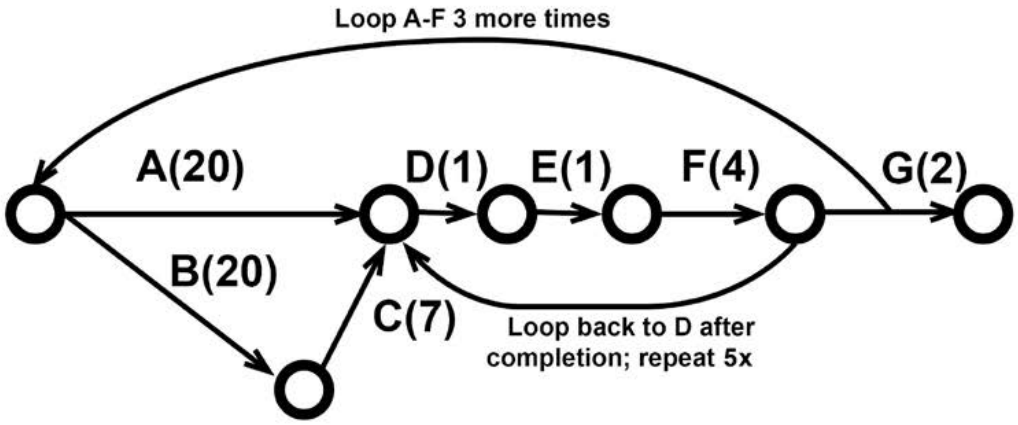
VOLUNTEER EVENT CALCULATION:

- Amount of Excelsior that volunteers can bring to site in the four year period: 3 events x 4 yrs x 24 people x 7000 cu in = 2016000 cu in

FOR INTERNS:

- Amount of Excelsior that interns need in order to work on trails: 6842880 cu in - 2016000 cu in = 4826880 cu in
- Amount of Excelsior that 7 interns could bring in the first two years: 7000 cu in x 7 people x 24 days per year x 2 years = 2352000 cu in
- Amount of Excelsior that needs to have been applied after two years of restoration activity:
  4826880 cu in - 2352000 cu in = 2474880 cu in
- Amount of time it will take for 12 workers to restore the trails:
  2474880 cu in / 12 people / 7000 cu in/ 24 days per year = 1.2 years

SEQUENCING AND GANTT CHART



TASK	DURATION	NOTES
A	20 days	2 months before first day of restoration
B	20 days	
C	7 days	2-3 days before event
D	1 day	In the morning, on the way to work
E	1 day	
F	4 days	Loop back to Task D after completion
(Loop A-F until the fourth year)		
G	2 days	Every 2 years

TASKS

A. Recruit and interview interns

B. Plan and prepare for volunteer events;
Advertise and recruit for volunteers

C. Volunteer orientation

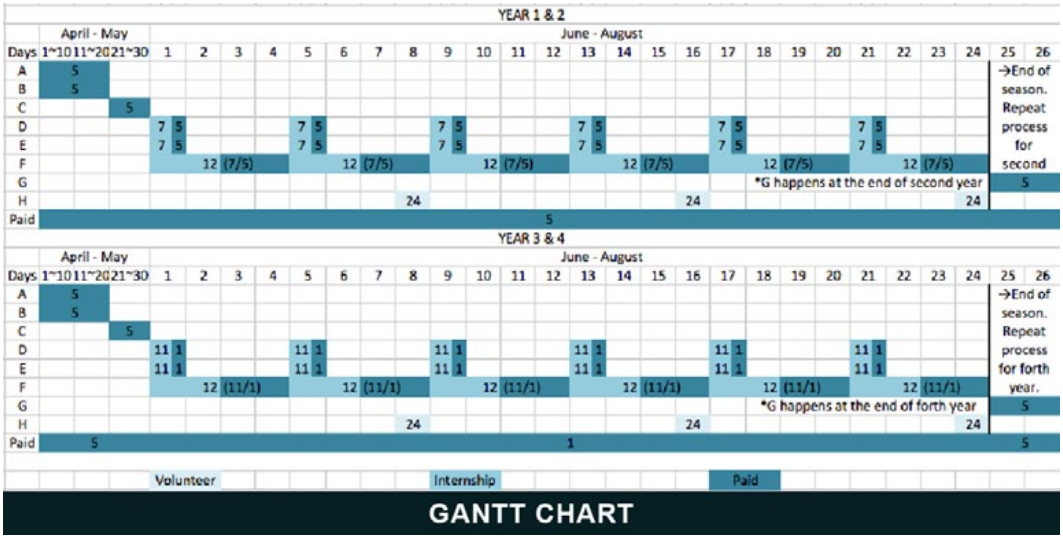
D. Assemble all tools and supplies necessary (see list below), store in lock box at head of trail inoculate seedlings prior to transport for planting; transport one week of plugs to trailhead

E. Relocate pickaxes, rakes, nets, tarp, watering cans and laminate info sheet to restoration site

F. Pack backpacks w/ necessary supplies (see list) hike in to site; scarify ground; lay mulch and plant one campsite plus assigned trails; return

G. Maintenance and Monitoring

SEQUENCE DIAGRAM


YEAR 1 & 2
April - May
June - August
Days 1~10 11~20 21~30 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
A 5
B 5
C 5
D 7 5
E 7 5
F 12 (7/5)
G
H 24
Paid 5
→End of season. Repeat process for second
*G happens at the end of second year
5
YEAR 3 & 4
April - May
June - August
Days 1~10 11~20 21~30 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
A 5
B 5
C 5
D 11 1
E 11 1
F 12 (11/1)
G
H 24
Paid 5 1 5
→End of season. Repeat process for forth year.
*G happens at the end of forth year
Volunteer
Internship
Paid
GANTT CHART

BUDGET

In order to be as fiscally efficient as possible, we will be recruiting qualified interns from Universities as unpaid interns and/or for course credit. Volunteers will be recruited from hiking and other wildlife organizations.

The cost of restoration will go down each year, as some of the supplies and equipment will last for the entire period, and site set up costs will not be incurred each year. There will be monitoring and maintenance activities at the beginning of each growing season, to assess how the restoration efforts have held up during the winter months. Congressional funding includes a provision for funding of the necessary monitoring, maintenance and project documentation.

The labor budget is based on 4 day work weeks of 10 hours per day with one additional day bi- weekly, as noted previously. It accounts for 6 hours of hiking time and 4 hours of restoration work daily. This is our highest expense, 68% of the total budget. Medical/ Life, other insurance, and legal fees are included. These figures are the second highest expense category at 19.96%. They represent increases in the respective expense categories due to the nature of this project and the additional liability of having volunteer labor. We do not anticipate any legal fees past the first year.

The supplies, equipment and materials represent the lowest percentage of the total budget. (American Excelsior Company, 2012), (Appalachian Trail, 2012) The highest amounts within these categories are the plants themselves and transportation. The plant category includes propagation, scarification and other steps in developing plants to ensure a high survival rate. (Lee, J, et al, 2012) We are also budgeting for more plants then needed to account for plant mortality.

The high transportation expense is due to insurance requirements and is discussed in the Volunteers and Internship Management section.

Fiscal Budget for first year of restoration					
Labor Expenses		Amounts	Totals		% of Total Budget
Labor - restoration planning		$ 5,000.00			7.98%
Labor - assembling tools, supplies, plant materials		$ 4,500.00			7.18%
Labor - restoration		$24,000.00			38.31%
Mktg Costs - finding intern candidates		$ 2,500.00			3.99%
Human Resourses - interviewing candidates to hire		$ 5,000.00			7.98%
Labor - training volunteers		$ 1,500.00			2.39%
Total Labor Expense			$42,500.00		67.85%
Medical/ Legal Expenses					
Medical/ Life Insurance - 12 week period		$ 5,000.00			7.98%
Legal Fees - compliance, liability, risk assessment		$ 5,000.00			7.98%
Key Man Insurance - for most experienced staff		$ 2,500.00			3.99%
Total Medical/ Legal Expenses			$12,500.00		19.96%
Project Equipment/ Supplies					
Storage Containers with Locks		$ 500.00			0.80%
Restoration tools (pick axes, shovels, rakes, etc)		$ 500.00			0.80%
Back packs, 7000 cubic inches, 12		$ 840.00			1.34%
clothing, gloves, rope, walkie talkies, tarps, compass		$ 600.00			0.96%
Food and water		$ 600.00			0.96%
Garbage bags, bug spray		$ 200.00			0.32%
Transportation - vehicles, gas		$ 1,000.00			1.60%
Safety Equipment/ Supplies - first aid kit, flares, lighter		$ 200.00			0.32%
Total Project Equipment/ Supplies Expenses			$ 4,440.00		7.09%
Planting Materials and Supplies					
Plants from propogation/ nurseries		$ 1,400.00			2.23%
Planting nets to protect from elements and herbivory		$ 500.00			0.80%
Stakes, signs, tape - for marking sites and restricting access		$ 500.00			0.80%
Soil ammendments/ treatments		$ 500.00			0.80%
Excelsior		$ 300.00			0.48%
Total Planting Material and Supplies Expense			$ 3,200.00		5.11%
Total First Year expenses				$62,640.00	

INTERNSHIP AND VOLUNTEER MANAGEMENT

Care must be taken when assembling our volunteer base. It can be a hazardous environment even in the most favorable weather conditions. It is a very sensitive environment that can be easily disturbed and takes a long time to recover.

Interviews will be conducted in order to get the most qualified interns ranging from PhD to bachelor degree candidates. Volunteers will be screened, asked to provide references and pass a health exam. All interns and volunteers will sign a liability waiver.

Our 5 staff members who will design and conduct the restoration have experience in subalpine environments. Our on staff attorney has reviewed our insurance policies and has prepared all necessary forms to ensure compliance with Stephen Mather Wilderness Area regulations and any liability issues for volunteers and staff members.

There will be 15 minute breaks every 2 hours, and a one hour lunch break. Workers will be bussed in and out daily in a company vehicle. These are standard practices and are a requirement of our insurance carrier. They are designed to promote safe employment practices in hazardous conditions.

There will be 7 internship positions filled every year for the first two years of the project and 72 volunteer positions for three volunteer events in four years. Recruitment will happen two months before the first day of restoration. Information regarding internship recruitment and volunteer opportunities will be advertised through internet, brochures, flyers and posters on university campus, with outdoor and wildlife organizations, and at related events.

Necessary training will be provided on site background, restoration process, methods and expectations.

MONITORING AND MAINTENANCE

There is congressional funding provided with a provision for ongoing monitoring and maintenance.

After installation, and for the duration of the summer, the employees and interns will visit the site biweekly for watering and site monitoring which includes canvassing the area for potential trespassing.

To evaluate whether functioning ecosystems have been established we will monitor plant survival and growth rate, soil erosion and soil composition. Plans and activites will be adjusted accordingly.

REFERENCES

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THORNTON CREEK

THORTON CREEK

URBAN CREEK RESTORATION

Jake Dawe
Rob Edsforth
Gar-Yun Ho
Autumn Nettey
Chuhan Zheng

image source: http://en.wikipedia.org/wiki/File:Thornton_Creek_Meadowbrook_Seattle2.JPG

INTRODUCTION

Located in northern Seattle and southern Shoreline, the Thornton Creek watershed is 11.6 square miles of land that drains into Lake Washington at Matthews Beach, and is Seattle's largest watershed. With 50% of the land covered with impervious surfaces and only about 0.5 square miles of parks and green spaces, the watershed has been negatively impacted by developments since the 1880s. Negative effects include habitat loss, channelization, pollution by pesticides, heavy metals, PCBs, and fecal coliforms, and loss of species availability and diversity (Thornton Creek Alliance, 2007).

This pattern of hydrological, physical, and biological conditions is described by Maceo Martinet as the "Urban Stream Syndrome" (Martinet, 2009). The primary causes of the USS (Urban Stream Syndrome) are stormwater runoff and wastewater treatment plant effluent. Urbanization comes second to agriculture as a major cause for the degradation of streams and the USS. Some characteristics of the USS include (Martinet, 2009):

- Higher frequency of overland and erosive flows as well as a greater magnitude in peak flows
- Increased "flashy" rising and falling limbs of storm hydrographs
- Erosion with more incision and channelization
- Less habitat diversity
- Disturbed macroinvertebrate and fish communities
- Larger loading rates of inorganic nitrogen and phosphorus, metals, and man-made chemicals like PCBs and pharmaceuticals
- Increased algal communities
- Reduced nutrient retention efficiency

After extensive logging, agriculture development, the expansion of the interurban Rail, the construction of Northgate Mall and I-5 and many other developments, the once-healthy salmon run in Thornton Creek suffered. However, recent restoration efforts by volunteers and restoration groups have been successful in bringing fish back into the creek.

State water quality standard revisions in 2003 placed Thornton Creek as a "Class AA" water body and under the categorization as "Core Salmon Migration and Rearing Habitat" (King County, 2009). Additionally, the creek was assigned for further "Supplemental Spawning and Incubation Protection", which meant that the creek temperatures must be no higher than 13 ºC. (King County, 2009)

Some restoration accomplishments include the de-channelization of tributaries for fish passage and the construction of a pond in Matthews Beach Park as rearing habitat for juvenile salmon (Thornton Creek Alliance, 2007). Currently, salmonid species in Thornton Creek include Chinook salmon, Coho salmon, coastal cutthroat trout, steelhead, and rainbow trout (King County, 2009).

INTRODUCTION

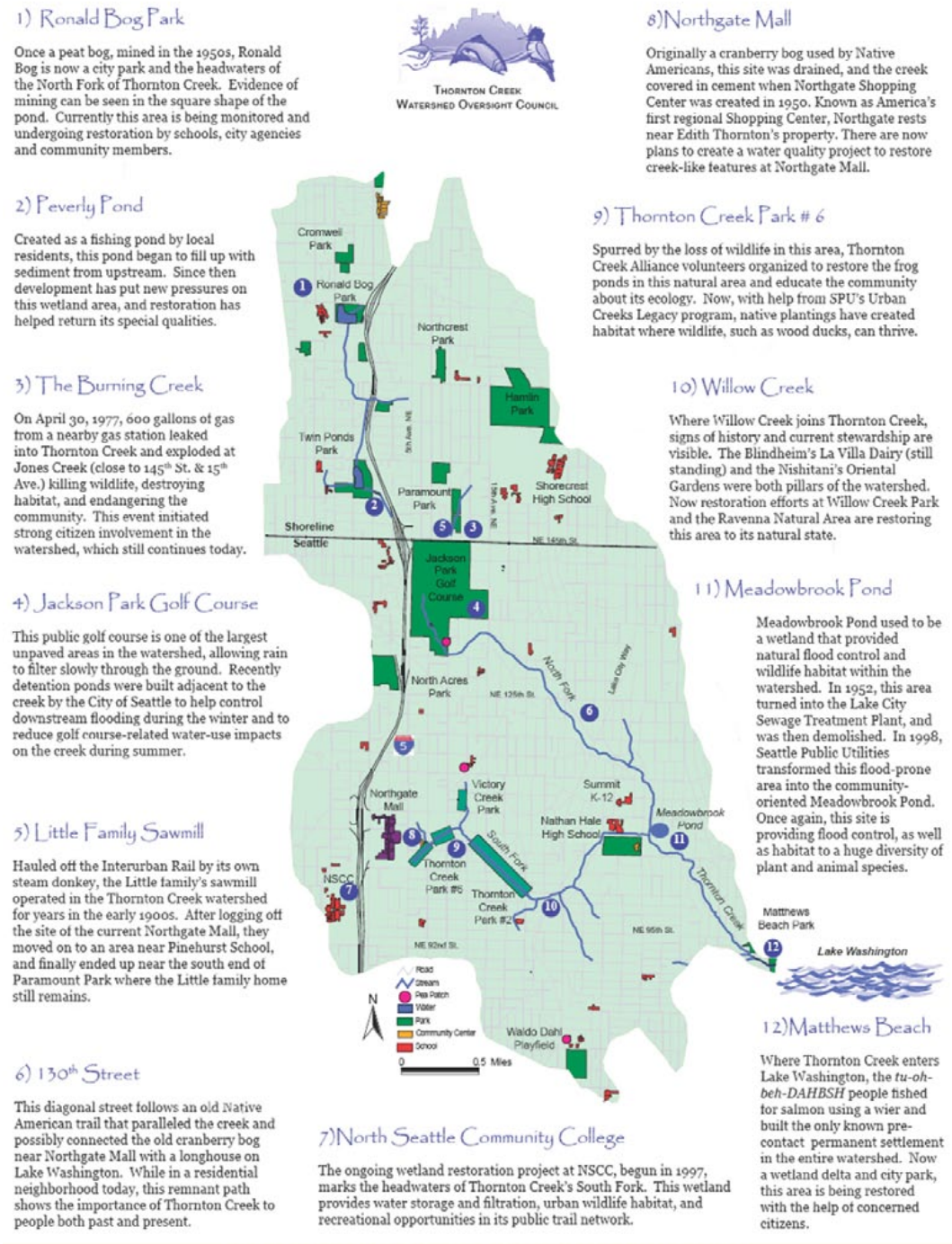

Figure 2. Restoration Sites along Thornton Creek

(http://islandwood.org/school_programs/homewaters/resources/thorntoncreek/brochure)

PROPOSAL FOR RESTORATION SITES

PARAMOUNT PARK

This is a wooded park containing pond and soft-surface trails. It is at NE 147th and 8th Ave NE. Most of the area along the trail is wet and has blackberry and other invasive species growing. There is one open space at the entrance of the park with nice a grassland area which makes it a good place for social events. All other areas are covered by tree canopies, creating an isolated and quiet atmosphere in the park.

The trail is about half mile long and unpaved, creating a more natural feel. (City of Shoreline, 2012) It offers local residents a good place for walking and running among trees. The interpretive and plant identification signs along the trail add recreational and educational factors to the park.

A series of wetland ponds were created by the Paramount Park Neighborhood Association under financial support from King Conservation District and City of Shoreline. This is good habitat for Pacific chorus frogs when they were introduced more than a decade ago. (Thornton Creek Alliance, 2007)

Due to the diverse ecosystems, more functions could be applied to the park: more wildlife habitats could be created through weeding and reforestation; more recreational uses could be brought through holding more social events; the fragmentation between neighborhoods could also be eliminated through planting. The slope stability of the trail should be improved. Taking these factors into consideration, and comparing this site to the other options, Paramount Park was our least favorable option.

PROPOSAL FOR RESTORATION SITES

JACKSON GOLF COURSE

Jackson golf course is a 130 acre park containing an 18-hole regulation length golf course, 9-hole par 3 course, practice green, clubhouse and adjoining cafes with supporting facilities. (Seattle Parks and Recreation, 2009) It is located at NE 145th and 5th Ave NE, right across from I-5.

This large area provides both ecological and recreational functions. Improvements could be made to make the most of both. Several more ponds could be created in the area. Underground culverts could be reconstructed and naturalized as creeks. More habitats for small creatures could be brought to this area. Fragments between the surrounding areas could be eliminated, and the large areas of grass minimized. For these reasons, and the variety of restoration options available, this was our best option.

ROSSI WETLANDS

This is a wetland area located at NE 100th and 20th Ave NE. Many houses have been bought back from retired folks from the 1950's and converted to wetland and habitat. More can be done to connect these areas. This would be a good choice, but due to the variety of opportunities for option 2, this is not the chosen option.

MEADOWBROOK WETLANDS

This used to be an empty baseball field that is being restored, and another great opportunity for restoring a large area recreational facility. There are still many fragmented areas where ecological value can be added. This site did not present as high of a level for potential restoration activities and habitat improvements, and thus was not the best option.

DECISION MATRIX

The following decision matrix compares four proposed restoration areas along Thornton Creek. Scores were given to several categories, and weighted for degree of importance. Additional statistical tests were conducted in order to measure the accuracy of the data.

Thorton Creek Restoration Decision Matrix

Alternatives		Paramount Park	Jackson Golf Course	Rossi Wetlands	Meadowbrook Wetlands
Criteria	Weighting Factor	Raw Score (x)	Raw Score (x)	Raw Score (x)	Raw Score (x)
Complexity of Project	10	4	2	3	3
Salmon/Wildlife Habitat	20	2	4	4	5
Environmental Value	20	3	5	3	2
Implementation Cost	20	4	4	3	2
Size of Restoration Site	15	3	4	3	5
Proximity to Other Restoration	15	2	4	5	4
Scale: 1-5	100	295	400	350	345

Table 1. Alternatives

PROPOSAL FOR RESTORATION SITES

Thorton Creek Restoration Decision Matrix

Best Case (a)	Paramount Park	Jackson Golf Course	Rossi Wetlands	Meadowbrook Wetlands
Complexity of Project	4.5	3	4	4
Salmon/Wildlife Habitat	3	5	4.5	5
Environmental Value	4	5	4	2.5
Implementation Cost	4.5	4.5	3.5	2.5
Size of Restoration Site	3.25	4.25	3.25	5
Proximity to Other Restoration	2.25	4.25	5	4.25
Weighted Sum	357.5	447.5	403.75	378.75

Table 2. Best Case (a)

Thorton Creek Restoration Decision Matrix

Worst Case (b)	Paramount Park	Jackson Golf Course	Rossi Wetlands	Meadowbrook Wetlands
Complexity of Project	3	1	2	2.5
Salmon/Wildlife Habitat	1	3	3	4.5
Environmental Value	2	4.5	2.5	1.5
Implementation Cost	3.5	3.5	2.5	1.5
Size of Restoration Site	2.75	3.75	2.75	4.75
Proximity to Other Restoration	1.75	3.75	4.75	3.75
Weighted Sum	227.5	342.5	292.5	302.5

Table 3. Worst Case (b)

Thorton Creek Restoration Decision Matrix

K-Values	Paramount Park	Jackson Golf Course	Rossi Wetlands	Meadowbrook Wetlands
Complexity of Project	5	5	5	5
Salmon/Wildlife Habitat	4	4	4	4
Environmental Value	5	5	5	5
Implementation Cost	4	4	4	4
Size of Restoration Site	6	6	6	6
Proximity to Other Restoration	6	6	6	6

Table 4. K-Values

Thorton Creek Restoration Decision Matrix

C-Values	Paramount Park	Jackson Golf Course	Rossi Wetlands	Meadowbrook Wetlands
Complexity of Project	6	6	6	6
Salmon/Wildlife Habitat	5	5	5	5
Environmental Value	6	6	6	6
Implementation Cost	5	5	5	5
Size of Restoration Site	7	7	7	7
Proximity to Other Restoration	7	7	7	7

Table 5. C-Values

PROPOSAL FOR RESTORATION SITES

Thorton Creek Restoration Decision Matrix

Means of Weighted Values	eqn: μ= W*(a+b+(k*x))/(k+2)	Paramount Park	Jackson Golf Course	Rossi Wetlands	Meadowbrook Wetlands
Complexity of Project		10.71	5.71	8.57	9.29
Salmon/Wildlife Habitat		13.33	26.67	25.00	31.67
Environmental Value		17.14	27.14	18.57	11.43
Implementation Cost		26.67	26.67	20.00	13.33
Size of Restoration Site		11.25	15.00	11.25	18.28
Proximity to Other Restoration		7.50	15.00	18.28	15.00
Sum		86.61	116.19	101.67	99.00

Table 6. Means of Weighted Values

Thorton Creek Restoration Decision Matrix

Std Dev of Weighted Values	eqn: σ = W*|(b - a)|/c	Paramount Park	Jackson Golf Course	Rossi Wetlands	Meadowbrook Wetlands
Complexity of Project		2.50	3.33	3.33	2.50
Salmon/Wildlife Habitat		8.00	8.00	6.00	2.00
Environmental Value		6.67	1.67	5.00	3.33
Implementation Cost		4.00	4.00	4.00	4.00
Size of Restoration Site		1.07	1.07	1.07	0.54
Proximity to Other Restoration		1.07	1.07	0.54	1.07
Sum		23.31	19.14	19.94	13.44

Table 7. Standard Deviation of Weighted Values

Thorton Creek Restoration Decision Matrix

Z-Score of Unweighted Variables	eqn: $Z = \|(x - \mu)\| / \sigma$	Paramount Park	Jackson Golf Course	Rossi Wetlands	Meadowbrook Wetlands
Complexity of Project		-2.69	-1.11	-1.67	-2.51
Salmon/Wildlife Habitat		-1.42	-2.83	-3.50	-13.33
Environmental Value		-2.12	-13.29	-3.11	-2.83
Implementation Cost		-5.67	-5.67	-4.25	-2.83
Size of Restoration Site		-7.70	-10.27	-7.70	-24.79
Proximity to Other Restoration		-5.13	-10.27	-24.79	-10.27

Table 8. Z-Score of Unweighted Variables

Thorton Creek Restoration Decision Matrix

Difference of Two Weighted Variable's Means	eqn: $\mu x\text{-}y = \mu x - \mu y$	Jackson Golf Course - Paramount Park	Jackson Golf Course - Rossi Wetlands	Jackson Golf Course - Meadowbrook Wetlands	Paramount Park - Rossi Wetlands	Paramount Park - Meadowbrook Wetlands	Rossi Wetlands - Meadowbrook Wetlands
Complexity of Project		-5.00	-2.86	-3.57	2.14	1.43	-0.71
Salmon/Wildlife Habitat		13.33	1.67	-5.00	-11.67	-18.33	-6.67
Environmental Value		10.00	8.57	15.71	-1.43	5.71	7.14
Implementation Cost		0.00	6.67	13.33	6.67	13.33	6.67
Size of Restoration Site		3.75	3.75	-3.28	0.00	-7.03	-7.03
Proximity to Other Restoration		7.50	-3.28	0.00	-10.78	-7.50	3.28
Sum		29.58	14.52	17.19	-15.07	-12.39	2.68

Table 9. Difference of Two Weighted Variables' Means

PROPOSAL FOR RESTORATION SITES

Thorton Creek Restoration Decision Matrix

Difference of Two Weighted Variable's Std Dev	eqn: σx-y = sqrt(σ^2x + σ^2y)	Jackson Golf Course - Paramount Park	Jackson Golf Course - Rossi Wetlands	Jackson Golf Course - Meadowbrook Wetlands	Paramount Park - Rossi Wetlands	Paramount Park - Meadowbrook Wetlands	Rossi Wetlands - Meadowbrook Wetlands
Complexity of Project		4.17	4.71	4.17	4.17	3.54	4.17
Salmon/Wildlife Habitat		11.31	10.00	8.25	10.00	8.25	6.32
Environmental Value		6.87	5.27	3.73	8.33	7.45	6.01
Implementation Cost		5.66	5.66	5.66	5.66	5.66	5.66
Size of Restoration Site		1.52	1.52	1.20	1.52	1.20	1.20
Proximity to Other Restoration		1.52	1.20	1.52	1.20	1.52	1.20
Sum		31.04	28.35	24.51	30.87	27.61	24.55

Table 10. Difference of Two Weighted Variables' Standard Deviation

Thorton Creek Restoration Decision Matrix

Probability of Rank Reversal	Jackson Golf Course - Paramount Park	Jackson Golf Course - Rossi Wetlands	Jackson Golf Course - Meadowbrook Wetlands	Paramount Park - Rossi Wetlands	Paramount Park - Meadowbrook Wetlands	Rossi Wetlands - Meadowbrook Wetlands
	0.17	0.30	0.24	0.69	0.67	0.46

Table 11. Probability of Rank Reversal

CRITERIA

When considering which area of Thornton Creek to restore many elements of design were used for our decision. We feel all of the below criteria must be allowed for in order for the restoration to be a success (Thornton Creek Alliance, 2007):

- Improvement of water quality to state mandated levels for temperature, pollution, sedimentation, fecal coliforms, and inorganic compounds
- Reduction of watershed imperviousness by imposing development limits
- Stabilization of water flow
- Protection of creek bank from erosion
- Prevention of floods
- Revegetation of native plant species
- Provision and placement of large woody debris and boulders to creek ecosystem
- Acquisition of open space - ability to provide social activity (community involvement)
- Enhancement of salmon/ wildlife habitat (salmon return)
- Protection of associated wetlands
- Maintenance of infiltration of rainfall and contribution to creek baseflow

CONSTRAINTS

When performing restoration in an urban area many factors must be taken into consideration including:

- Budget
- Private property owners
- Golf course requirements
- City codes and regulations
- Non point pollution
- Stream bank erosion
- Stream hydrology
- People
- Proximity to completed restoration projects
- Size of potential restoration site

SITE DESIGN

Jackson Golf Course presents the most potential for restoration within the Thornton Creek area. The area is over 200 acres and is the largest area of green space in northeast Seattle. It is almost entirely dedicated to one use, golf. The course is built around areas of vegetation and has wetlands on both sides. Many areas of hills and mounds are found throughout the course layout.

JACKSON PARK GOLF COURSE

(http://activerain.com/image_store/uploads/4/6/5/5/2/ar127472048025564.jpg)

SITE DESIGN

Starting in the summer of 2012, Jackson Park Golf Course will be building a driving range and practice facility (See Figure 3). As part of the approved Seattle Parks and Recreation Golf Master Plan dated May of 2009, it is scheduled to be completed by Winter 2013 (Seattle Parks and Recreation, 2012). This golf course design and site offers a high potential for creating a diverse ecological landscape. The golf course perimeter trail project was developed by Seattle Parks Foundation and Friends of Jackson Park. It is a 4 mile trail around the golf park (See Figure 4.) (Seattle Parks Foundation, 2012). This trail is part of the master plan and can be used to enhance our restoration efforts.

By making the most of the master plan, we can increase wildlife habitat, ecological function and autogenic recovery over a very large area. Restoring areas of the golf course that connect to the trail system will reconnect fragmented areas and increase wildlife habitat over a much larger area.

The optimal area for restoration and creek daylighting would be in the southwest area of the golf course, near holes 1, 2, and 8, where Thornton Creek actually runs through Jackson Park. Restoration work can be done in between golf holes by daylighting and adding vegetated areas across fairways to connect fragmented areas. Efforts should be coordinated with the City, Friends of Thornton Creek and Alliance of Thornton Creek.

(Top) Figure 4. Current proposed schematic design for changes to be made to Jackson Golf Course (http://www.seattle.gov/parks/projects/jackson_park/golf.htm)

(Bottom) Figure 5. Area of Restoration

CURRENT PROPOSED SCHEMATIC DESIGN

SITE MAP

STAKEHOLDERS

In order to give ourselves the best opportunity for success in this project, the following stakeholders/ key organizations need to be acknowledged and worked with. Our proposed restoration work could be a long term project from summer 2012 until winter of 2013, and is partially dependant on the various stages of the master plan. Public meeting have already been held, and most of the design is in process. Our desire to participate needs to be communicated quickly.

- **JACKSON PARK GOLF COURSE** – City of Seattle. Some of the restoration work we are proposing will be on golf course property. We need to share our restoration plan with this group and get the necessary approvals.
- **SEATTLE PARKS AND RECREATION** – This group developed the golf master plan. In order for our restoration ideas to be implemented, we need to present the benefits of implementing our ideas as the construction begins. Cost savings and ecological function can be attained with minimal added time to the endeavor. Resources and equipment of the city may be utilized as well, since it will be on site, if the restoration and construction efforts complement each other.
- **SEATTLE PARKS FOUNDATION** – This group, along with Friends of Jackson Park, put together the plan for the four mile perimeter trail. (Seattle Parks Foundation, 2012) Working with them as the construction occurs will complement both of our efforts. They need to be made aware that we all have the same goal. Adding connections from the golf course to the trail and connecting fragmented areas will go best and be most efficient, if done together.
- **FRIENDS OF JACKSON PARK TRAIL** – They are the group mentioned above that are partners with Seattle Parks Foundation. (Seattle Parks Foundation, 2012) Establishing a relationship early with this group is critical. The success of restoration projects has always been because of the Friends of group. They are the ones who organize the work parties for restoration efforts. Since they will be involved in the construction of the perimeter trail, we can utilize their resources to help each other attain the same goal.

- **THORNTON CREEK ALLIANCE** – This group has individuals responsible for each community around Thornton Creek, called Stream Care Groups. (Thornton Creek Alliance, 2012) The representative for Jackson Park needs to be contacted. This person will have information about parts of Thornton Creek that can be utilized in our restoration efforts. Work that we do will have implications for the creek, as will the construction. This is an all volunteer organization that is dedicated to the revitalization of Thornton Creek. One of their functions is organizing work parties for restoration efforts.
- **SEATTLE PUBLIC UTILITIES** - This group trains the volunteers for the Thornton Creek Alliance. Having their input will give us the best chance of acquiring trained volunteers
- **GOLFERS** – This group needs to be consulted in order to find out what they value. Connecting to perimeter paths and daylighting the creek between golf holes will have an impact on this group. Creating features in the right way will be accepted positively. Adding vegetation features along the perimeter trail will both protect trail walkers from golf balls, and give the golfers more privacy as they golf. Increased wildlife and the natural beauty created will be appreciated by golfers.
- **WALKERS ON THE PERIMETER TRAIL** – This group can add some good ideas for ways to compliment the trail system. Having features that connect to streams, reconnect fragmented areas and create habitat, will add value to this group's experience. Establishing vegetated areas between the trail and parts of the golf course will also protect walkers from golf balls.
- **GOLF COURSE ARCHITECTS** – Early communication of our plans and coordination of work along the way is essential to ecological improvements.

SITE DESIGN

Figure 6. Jackson Park Perimeter Trail
(http://www.seattle.gov/parks/projects/jackson_park/golf.htm)

This golf master plan is a unique opportunity to accomplish restoration on a large scale. It also provides an opportunity for diversity and variety, as there are many potential areas and options for restoration. Golf courses like Jackson Park that meander through wetland areas, in uplands, and in between forests are tremendous restoration opportunities for reconnecting fragmented landscapes. Restoration in these areas can initiate ecological succession, autogenic recovery and passive restoration to many surrounding areas just because of the enormity of a golf course area.

Figure 7. Restoration Proposal

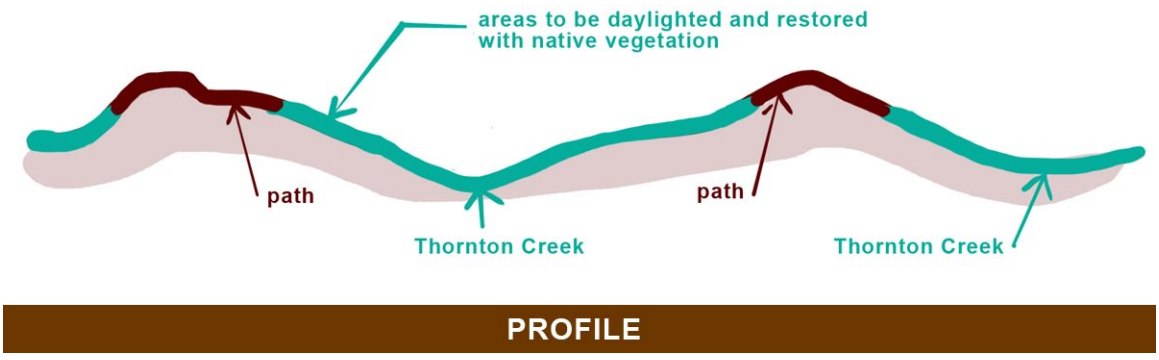

Figure 8. Profile of Restoration Proposal

SITE DESIGN

VEGETATION

After Thornton Creek has been daylighted we will be planting a variety of native plants. Due to height restrictions in the golf course, we will plant low growing shrubs.

For **BANK STABILIZATION**:

- Oemleria cerasiformis (Indian plum) shade intolerant
- Rubus spectabilis (salmonberry) part to full shade
- Berberis nervosa, B. aquifolium (Oregon grape) part to full shade
- Symphoricarpos albus (snowberry) full sun to full shade

THICKET forming plants:

- Amelanchier alnifolia (serviceberry) full sun to part shade
- Rosa pisocarpa (swamp rose) full sun to part shade

For **HABITAT DIVERSITY**:

- Cornus sericea (red-osier dogwood) full sun to full shade
- Lonicera involucrata (black twinberry) part shade
- Philadelphus lewisii (mock orange) full sun to part shade

Average Costs per Unit of Stream Restoration Work			
Practice	**Component**	**Units**	**Unit Average Cost**
Filter Strip	Site prep and seeding	Acre	$475.00
Riparian Forest Buffer	Site prep and seeding	Acre	$75.00
	Tree planting	Acre	$800.00
	Tree shelters	Each	$3.00
	Seeding	Acre	$400.00
Fish Habitat Improvement	Stream boulder placement	Each	$50.00
	Log/wood frames	Linear foot	$3.00
	Rock riprap	Cubic yard	$50.00
Streambank Stabilization	Brush Mattressing	Linear foot	$6.00
	Plant cuttings	Each	$0.50
	Fiber rolls	Linear foot	$12.00
	Live stakes	Each	$2.00
	Erosion control blanket	Square yard	$2.00
	Herbaceous plants	Each	$2.00

Table 11. Average Costs for Restoration (Kelly, 2001, p.8)

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City of Shoreline, 2012, Parks and facilities (http://www.shorelinewa.gov/index.aspx?page=135, accessed on 31 May 2012)

City of Corvalis Native Plant List
(http://www.ci.corvallis.or.us/downloads/pw/SWP_Riparian_Natives.pdf, accessed on 31 May 2012)

Thornton Creek Watershed, culvert map
(http://wa.water.usgs.gov/projects/linkingsources/data/5_stormwater_system_thornton_creek.pdf)

IN CONCLUSION

We have presented within this book a total of 8 restoration design projects. Each of these projects presented our team with a different landscape disturbance to work with. The 8 projects, listed in the order presented, were Salt Marsh Restoration, Transportation Corridor Restoration, Wetland Restoration, Overgrazed Landscape Restoration, Agricultural Land Restoration, Mining Damaged Site Restoration, Recreational Site Restoration, and Urban Creek Restoration. We had one week to analyze, coordinate and complete these reports. Our team and the other three teams were assembled by the professor team of Kern Ewing, Jim Fridley and teaching assistant Andrew Fraser. They put careful thought into the backgrounds of each student so that the teams were relatively equal, and had the resources to produce high quality reports.

As part of this class, we also had weekly assignments due on Wednesdays. These assignments related to the weekly reports, and educated us on restoration techniques, general site conditions and other challenges for each week's eco system project. Class lectures were interactive, and we worked in groups to solve real world issues. The weekly reports are responses to actual events, conditions and challenges. Class time was also used to present our studies, discuss strengths and weaknesses, and brainstorm ideas.

When looking back on these studies during the quarter, several common themes stick out. Every project involved stakeholders and other groups that had major influences on the success of the projects. These were discussed in each report. Our research findings emphasized the importance of communication throughout any project, and the importance placed on the multiple uses of the land. Without support and involvement from the public and private sectors, none of these projects have a chance of long term success. To achieve our goals, many individuals and organizations need to work together over a long period of time. It was also apparent that political and trust issues need to be remedied if long term success is to be attained. Other common threads throughout these reports are the need for being organized, detailed and thorough. These projects are not quick fixes. Our proposed solutions are designed to start the process of autogenic recovery, passive restoration and ecological succession. They are projects that

will evolve over time, and the intended outcome may not be seen in our life time. Monitoring and maintenance activities are critical to the long term success of all restoration projects. In these reports we are trying to restore ecological function, not to a particular point in time. Another common theme in these reports is the creation of wildlife habitat. Most restoration is driven by the loss, or potential loss of critical wildlife species. The restoration needs to be designed in such a way as to both create ecological function and wildlife sustainability. A recreational component to each study emerged as well. All of the studies involved the creation or recognition of areas for wildlife observations, hunting, fishing and other income generating activities throughout the sites. Budgets to complete these projects were a common constraint. In most of these studies, proper planning and coordination will enable the use of equipment, volunteers and other resources for a minimal cost if used at the right time and in cooperation with the entities involved.

Each individual group member developed strengths in particular areas that were applied over multiple studies. These strengths emerged quickly, as it was a very fast paced course. We worked well together and came up with very well thought out projects. Our discussions were productive, and all of the restoration design decisions were unanimous. Although we are all listed as doing separate parts for each project, we provided support to each other when needed. This was due to the fact that all phases of the project were in some way related to each other, and could not be analyzed individually. Much like our environment, nothing is stagnant. Changes in one area effect processes down the line, and even the simplest sounding ideas had complications and ramifications. As mentioned above, setting in motion passive restoration, autogenic recovery and ecological succession are the ultimate goals.

EPILOGUE

Even though all of our restorations sites differ greatly from one another, rehabilitating recreational subalpine ecosystems due to recreation degradation, mitigating estuary loss from diking or the reclamation of a former open pit gravel mine, one of the main themes throughout these design projects is stakeholder and community involvement. Just as it 'takes a village to raise a child' it takes a community to reclaim and steward the land we are dependent upon for our survival. In all of our designs we strive to create a sense of community with each other and with the land we are nurturing back to health.

Restoration involves more than the physical act of earthwork, weeding and planting. Hard work and perseverance are required but the ability to see each situation through the eyes of another is also vital for success. It is a varied and complicated endeavor that has no hard and fast rules. Each challenge and opportunity is met with a multitude of responses and solutions.

Throughout all of our design projects we strove to balance the needs of stakeholders, the community at large and the needs of the land being reclaimed. Mostly it was our desire to involve as many people as possible in the restoration efforts because as Carl Sagan says

"Anything else you're interested in is not going to happen if you can't breathe the air and drink the water. Don't sit this one out. Do something." - Carl Sagan

ASSIGNMENT 1

Overview

The Skagit Wildlife Area (Washington Department of Fish and Wildlife) includes areas that are diked and areas that are open to tidal action and river flows. Diking of Skagit Bay began with the construction of levees on individual farm plots in the 1870's. Dikes eventually became almost continuous, and today there are diking districts which are responsible for the maintenance of the levees.

Wiley Slough is located in the Headquarters Unit of the Wildlife Area. The Headquarters unit was purchased in 1948 for pheasant hunting. Apparently, as part of the management of the unit, 150-200 additional acres were diked in the 1960's and were converted from tidal marsh to drained land suitable for growing cereal grains for wildlife.

Tribes on the Skagit had been in an adversarial relationship with both the Diking Districts and with the Washington State Department of Fish and Wildlife for some time because of obstruction of salmon runs and diminution of potential salmon habitat. WDFW has recently agreed to increase their emphasis on salmon habitat restoration, and funding has been made available by the Salmon Recovery Funding Board and by Seattle City Light. A design team made up of representatives of the tribes (Skagit River System Cooperative) and WDFW prepared the "Wiley Slough Estuarine Restoration Design Report".

The Wiley Slough project proposes to convert the land diked in the 1960's back to open tidal influence. To accomplish this, the existing levee will be breached and a new levee will be created at the upland edge of the area. Tidal gates that keep salt water out of Wiley Slough will be removed from their current location and new gates will be built upstream.

There has been a philosophical difference within the WDFW about converting waterfowl habitat to salmon habitat. The feeling is that ducks and geese are well-served by the existing configuration of the wildlife area, which serves waterfowl, hunters and recreational users. The manager feels that the Skagit Wildlife Area is operated as a classic wildlife management operation as proposed and articulated by Aldo Leopold. Leopold wrote the book "Game Management" (1933), and is also considered to be one of the founding fathers of ecological restoration. Converting from management for ducks to management for fish is causing a great deal of angst among the on-the-ground managers in WDFW.

Your Assignment

There is a plan for the conversion of the diked grain fields to estuarine marsh, open to tidal action. The outline of the plan is available online in the **"Wiley Slough Estuarine Restoration Design Report",** WDFW. A good summary of the proposed project is available in the "**Wiley Slough Restoration Project, Report to the 2008 Legislature**", which is available on your class Catalyst website in the section for Design Assignments.

For the purposes of this class exercise, assume that the project budget has been cut in half because of the State's current and anticipated budget shortfall. Because of certain un-

ASSIGNMENT 1

avoidable constant costs in the project, this means that of the originally proposed project only about one third of the amount of dike can be removed and/or built and only one third of the area can be restored at this time, with the State's ability to restore other parts to be reviewed at some time in the future.

Look at the resources made available to you in class, on the class website, and at the links mentioned in this assignment sheet. Find other sources of information if you can.

To help you evaluate alternatives, use the Design Element Checklist that has been handed out in class. You must **decide which part of the project should be done**. Support this decision with documentable reasons (cite materials presented in class, suggested below or discovered through your own literature research) why you have selected the area you have selected. Part of this documentation should be a **completed Design Element Checklist** for the area you have chosen.

A major part of this project is the removal and reinforcement of dikes. Material from removed dikes can be used to replace or reinforce other dikes on a 1:1 ratio. An exception is the east-west dike which runs from the new tide gate location to the western tip of the property. Because the current land is not diked, spoil material from removed dikes will need to be added to the new dike at this location in a 2:1 ratio (twenty linear feet of dike removed somewhere else can be used to build ten feet of dike here). Your rationale for the selection of the area to restore **must include an accounting of how you intend to balance out cut and fill of dike material.**

Be aware that WDFW has contracted with some farmers outside of the Skagit Wildlife Area to allow land to lie fallow during the winter to create forage for waterfowl. WDFW has also participated in the purchase of land near Padilla Bay to help mitigate for the loss of recreational opportunities that will no longer exist at the Headquarters Unit.

Your completed assignment must include a map of the site, showing the area to be restored, amenities to be preserved or created, dikes to be removed or added, and potential second and third stages of the restoration to be done later. You should also include a list of potential pitfalls and a discussion of how they should be avoided.

ASSIGNMENT 2

Overview

The Bonneville Power Administration proposed to build a transmission line project that would bring additional lines from the Grand Coulee Dam to a point near Kangley, Washington. All of the proposed alternatives would cross the Cedar River near an existing BPA right-of-way through the Cedar River Watershed. Some of the alternatives would have created new corridors, but the chosen route simply expands an existing corridor by 150 feet. "Clearing all of the tall-growing vegetation within the ROW will be required…" "Tall trees outside of the ROW that could fall and damage the line would be removed".

The route has been selected to 1) maintain environmental quality, 2) minimize impacts to the human environment, and 3) minimize costs to ratepayers. Five miles of the route will go through the Cedar River Watershed. In return for the use of the Watershed land, BPA will transfer ownership of 600 acres of land to the Watershed, protected under a conservation easement to improve water quality and habitat. An additional 500 acres of adjacent BPA land will be placed in a conservation easement. BPA has also agreed to no future expansions into the Watershed.

BPA has agreed to minimize disturbance during construction, eliminate clearing within the riparian corridor, use helicopters for tower construction (except for pieces which are too heavy), and use minimal clearing outside the ROW in the Watershed (taking only trees that can fall onto the lines). In the Watershed, logs will be removed by helicopter north of the Cedar River.

BPA will allow low to medium tall vegetation in the ROW. Tall vegetation will be removed on a rotation plan so that more tall trees stay in the corridor for a longer time. BPA will suppress non-native plants, plant native vegetation in areas disturbed for the new ROW, and herbicides will not be used in the Watershed. For habitat, Large Woody Debris (LWD) will be left and snags created. Remnant old growth trees, snags, and trees of 20" diameter or greater will be retained if they do not pose a safety hazard to the operation of the line. A minimum of two large downed logs per acre will be retained within the ROW. Seasonal wildlife use (fish, eagles) will be noted and accommodated. Wetlands will not be filled.

Your Assignment

The City of Seattle operates the Cedar River Watershed with a primary focus on the production of clean dependable drinking water for Seattle and other municipalities. The transmission corridor crosses the Watershed below the intake for municipal water; there is, however, a Habitat Conservation Plan that requires consideration of impacts on wildlife and fish (including salmon runs that have access to the reach where the transmission corridor crosses the Cedar River). There are also recreational and education uses of the Watershed. Logging has been carried on until very recently in the Watershed, especially at higher elevations. The City took ownership of Forest Service parcels in 1996 and in 2000 the HCP established the entire watershed as a no-logging reserve.

ASSIGNMENT 2

The City has called for proposals for the restoration of the newly disturbed transmission corridors by placing a Request for Proposals in the Seattle Daily Journal of Commerce (in the Construction section, under Bid Calls or RFP's). Your group answers this request; you must provide typical solutions for the restoration of the Right-of-Way. The ROW is five miles long through the Watershed, so you must provide text and illustrations that show the City what you propose to do in these kinds of locations:

In ROW, uplands

In ROW, wetlands

Snags, LWD, large trees

Riparian zone and river crossing

In order to organize your approach, you should run through a Design Elements Checklist (which we have given you) for the project in general, noting what applies to the project generally, and what applies specifically to each of the above four elements (if different).

This project has a continuing element. A transmission corridor must have vegetation that does not reach the powerlines, but trees grow persistently. Prepare a monitoring and maintenance schedule that prescribes actions that keep the trees lower than the conductors, while maintaining some of the mature growth characteristics that were incorporated in the original design. (This should include LWD, snags, habitat diversity, wildlife or legacy trees if possible).

ASSIGNMENT 3

Overview

The proposed reconstruction of the SR 520 Evergreen Point Floating Bridge will involve the destruction and disturbance of a number of acres of wetland including parts of Marsh Island and Foster Island in Union Bay. WashDOT is looking for sites near the route where compensatory mitigation can be performed, and where similar kinds of wetlands (freshwater, fringe lacustrine) can be created, restored or enhanced. A multiplier has been applied to the acreage that is to be lost, and WashDOT is proposing to use about 28 acres of the Union Bay Natural Area to obtain mitigation credits. In total they need to find 56 acres along the shore of Lake Washington for mitigation.

WashDOT requested UW Botanic Gardens to identify areas within the boundaries of UBNA where mitigation might be performed. Looking at areas either adjacent to the Lake or along University Slough where the creation of lakeside wetlands might be accomplished without damaging existing wetland or upland restoration projects, UWBG staff and WashDOT agreed on a general scheme for the restoration.

WashDOT has created a team to assess the potential for using UBNA for mitigation. To create wetlands on UBNA, there are two potential strategies: 1. with a large enough watershed, a depression or low dam would hold water seasonally, as occurs in Shovelers Pond, or, 2. excavation would have to occur to take the surface of the site down to lake level. The second alternative would be an expensive kind of restoration because UBNA is located atop the former Montlake Landfill, and to lower existing grades to an elevation where they would function as wetlands, both the landfill cap and some fill material potentially would have to be removed. Then a new cap would need to be installed, and contouring and vegetation installation would have to take place in that material. The excavated fill material would have to be taken to a hazardous waste disposal site, and the cost would be significant.

A possible way around excavating into actual landfill material is available because the landfill cap is exceptionally thick in several places. Parking lot E-5 is a gravel parking lot that has been maintained since 1970 by bringing in gravel to level it when it subsided. It is estimated that 10-20’ of gravel are under the surface of E-5. Canal road and University Slough are built atop a cap of rock, soil and construction debris. The cross-section of this fill is 200’ wide and from 15 to 40 feet deep. Excavation into either of these areas could be accomplished without encountering garbage or other wastes that would have to be taken to a special landfill.

A lakeside wetland would need to have areas of shallow standing water, and transitional zones where the land would be flooded part of the year and emergent part of the year. This would allow open water to enter the wetlands, and would provide a place for emergent wetland vegetation to be established in shallow water or in saturated soil. Adjacent to the emergent vegetation, slightly higher ground would support shrubs and small trees that are commonly found around the edge of and within a few feet of wetlands (*Lonicera involucrata, Rhamnus purshiana, Crataegus douglasii, Pyrus fusca*, etc.).

ASSIGNMENT 3

An additional restoration alternative, preferred by some birders, would be to create mudflats that would be able to support migratory shorebirds as they are on their summer migration (which actually starts here in early spring). Such mudflats would need to be out of the water but muddy during the right time of the year for bird use.

Designing fringing wetlands or mudflats at this site is complicated by the fact that the level of Lake Washington and Union Bay is artificially controlled by the dam at the Hiram Chittendon Locks in Ballard. In winter, the lake level is lowered to an elevation of about 20'. In summer it is raised to 22' ($\Delta = 2$') (http://www.nwd-wc.usace.army.mil/nws/hh/basins/lwscsh.html .) Locally this is described as "reverse hydrology", because wetlands and lakes in this region normally have more water in winter and less in summer. The current elevation may be found at (http://www.nwd-wc.usace.army.mil/nws/hh/basins/data.html?lkw+bths .) In addition, the University uses a different elevation datum, so the University digital maps will show the water fluctuating between an elevation of 16.5' and 18.5' ($\Delta = 2$').
($h_{army} = h_{uw} + 3.5$')

Union Bay Natural Area and Shoreline Management Guidelines, 2010

The management guidelines for the Union Bay Natural Area have been revised, and are available on the University of Washington Botanical Garden website http://depts.washington.edu/uwbg/research/ubna.shtml . The guidelines are intended to update a previous document, the "Management Plan for the Union Bay Shoreline and Natural Areas" published in 1994, and a second edition published without appendices in 1995 (known as the pink report). A copy of the 1995 document may be found on the Design Assignments page of the class workspace under "Pink Report".

Your Assignment

Develop a preliminary restoration design for creating new wetlands in UBNA. Be sure you understand the general problem or opportunity and can express the design problem using the idea/terminology of "Functional Requirements" and "Constraints". Identify at least five stakeholders or stakeholder groups.

The eight tasks below are intended to help you arrive at a recommended preliminary design that will meet the overall functional requirements and constraints that you have identified.

1. Outline the location of areas along Lake Washington or the University Slough where a thick cap would allow excavation that would not unearth garbage.

2. By looking at contours and drainage areas, suggest a site that would be a good location for an impoundment (in an excavation or behind a dike).

3. Keeping the two assignments above in mind, locate areas of UBNA (as shown on the WashDOT conceptual plan) that are suitable for conversion to lakeside wetland, sea-

ASSIGNMENT 3

sonal wetland or mudflat, and will not damage any of the existing restoration projects in UBNA.

4. Combine or connect the winter flooding of the upland wetlands with the summer flooding of the lakeside wetlands to maximize the annual area of flooding. (We suggest that you run water off of UBNA, into winter wetlands, and out into the Lake through the lower elevation summer wetlands.) You could use weirs, low dams, leaky berms, benches or other mechanisms to retain water draining off of the uplands, while spreading out the water to maximize the impact of either winter or summer flooding.

5. Using contour maps for the area, draw a profile view of a line that flows from the uplands, into the seasonal wetlands you design, into the summer wetlands you design, and then into the slough. The profile should show elevations before and after your modification of the site to create impoundments and channels.

6. Along this profile, draw cross-sections where it is important to show features that you want to incorporate into your design.

For your planting design:

7. On a plan view (this is a view from above) show general areas of vegetation (called polygons).

8. For each polygon list 4 to 5 plants you would like to establish there. Use the flooding preferences shown in the tables from Stevens and Vanbianchi's book on wetland restoration. You might have one polygon for a shrub buffer, another for emergent wetland plants, another for summer dry wetlands, etc.

Stevens and Vanbianchi: http://www.ecy.wa.gov/biblio/93017.html

ASSIGNMENT 4

Overview

The Nature Conservancy (http://www.nature.org/wherewework/northamerica/states/washington/) and the DNR both own land that is part of the Marcellus Shrub-Steppe Preserve (47□14'N, 118□24'W; T20N, R35E), about seven miles north of Ritzville, Washington. The DNR land is to the west of TNC land, separated by a gravel road. TNC land has been fenced since 1986 and degradation by grazing prior to fencing is not noticeable. The DNR land is currently grazed in spring and summer months. The dominant plant communities are *Artemisia tridentata/Festuca idahoensis* sagebrush and *Artemisia tripartita/ Festuca idahoensis* sagebrush. At the north end of the DNR parcel are large areas without sagebrush but with *Bromus mollis* and *B. tectorum*.

Vernal pools are scattered among both sites. The Washington Natural Heritage Program has designated them for Priority 2 Protection status, due to their having rare or highly threatened species or having intermediate rarity and threat but little representation in the DNR Natural Area Preserve system. Vernal pools have water in them only part of the year and so are characterized by perennials in the deeper parts and annuals in the shallow areas. There are aquatics and plants that flourish as the pools dry. Vernal pools have their share of rare species of vascular plants, but also have cyanobacteria, bryophytes, and lichens forming crusts. Vegetation zonation is common and often striking. The lower zones may have conditions that are more saline and alkaline.

The Nature Conservancy has developed guidelines for the management of vernal ponds. Studies have found that grazed ponds at the Marcellus preserve have more weeds, and may have fewer rare species than ungrazed ponds. Removal of grazing is an obvious first step in the management of such sites.

Your Assignment:

The DNR and TNC have reached an agreement on the management of the Marcellus site; TNC will manage it. The DNR portion now has more weedy species and fewer native species in both the sagebrush and vernal pool communities. Develop and propose a goal for the entire combined site.

There are biological reasons to restrict cattle from unique communities, wetlands, and sites that support endangered species of any kind. There are political reasons to allow the continued, if limited use of sites by cattle. Devise a way to evaluate the level of potential threat from grazing at this site. Delineate the site in terms of sensitivity and resilience to grazing pressure. Create a set of rules to govern grazing practice there.

Delineate the sagebrush communities and separate them from the vernal pool communities. Develop plans to manage the invasive species in both.

The *Artemisia tridentata* (big sagebrush)/fescue and *Artemisia tripartita* (three-tip sage-

ASSIGNMENT 4

brush) /fescue communities are both considered to be high quality examples of their type, even though the preserve is surrounded by wheat fields. The vernal pool communities, though they contain some weedy species, still have an excellent representation of vernal pool species. Develop separate vegetation management and development plans for the sagebrush and the pool communities. These plans should include your plans for augmenting or increasing the presence of native plants. Remember, the vernal pools have both annual species and perennial species, and these should be handled differently. How would you obtain plant material, increase it, plant it, and manage its growth?

There are 45 vernal pools on this site, combining the DNR and TNC land. Create a schedule on a calendar for the restoration of the pools. Which pools would you start with? When would you start? What would you have to accomplish first? What would be your first on-the-ground restoration steps? What would be your restoration activities in the first year in which you actually do site modification, conditioning or installation? We are currently approaching the first week of May 2012; be sure your calendar/schedule accurately and realistically reflects this. How much could you get done in a year? What resources would you require? How many people would you require, for how many days, and when? (This is asking for a pretty thorough discussion of what you will do the first year.)

ASSIGNMENT 5

Overview

When the Wiley Slough project in the Skagit Wildlife Area was about to be built, an interest group approached the legislature and got the funding blocked. Their argument was that because of the project there would be lost recreation opportunities, and the kind of habitat that was being lost could only be replaced by converting working agricultural land back to waterfowl habitat. The purchase of land to the north on Padilla Bay was thought to be a partial solution to mitigate this loss, and the Washington Department of Fish and Wildlife (WDFW) and the Washington Department of Ecology (WDOE) were able to negotiate purchases from private land owners sufficient to put together a 340 acre parcel. The agricultural community, however, again took exception to the idea of taking agricultural land and placing it in State ownership and restoring it. A summary report, outlining alternatives, was prepared with input from farming, hunting, diking and environmental interests.

The land in question is within dikes and lies along Padilla Bay. A popular recreational trail atop the dike attracts hikers, bikers and birders. The Washington Department of Fish and Wildlife (WDFW) owns most of the land, and the Washington Department of Ecology (WDOE) owns about 90 acres. All of Padilla Bay falls within the Padilla Bay National Estuarine Research Reserve System (NERRS), and is managed jointly by NOAA and by WDOE; the Reserve has a visitor's center located just north of the newly purchased land. In the early 1990's, the NERR purchased one hundred acres of farmland within the 340 acres currently being considered for restoration. They have operated part of it as a Demonstration farm and have done research on salinity and pesticide residuals on the farm. Apparently ownership of the land upon which the Padilla Demonstration Farm sits has passed to WDFW and WDOE, and it is now operated as the Washington Department of Ecology Demonstration Farm.

Parts of Big Indian Slough, Little Indian Slough and No Name Slough are within the 340 acres that were proposed for restoration. Indian Slough runs north from State Highway 20 to where it empties into Padilla Bay. Much of its course roughly parallels and is about 2000' west of Bayview-Edison Road. It has been cut off from most of its freshwater input, and so is quite salty (15-20 ppt) on the bay side of the tide gates where it crosses under Bayview-Edison Road and near State Highway 20. No Name Slough, on the other hand, drains a substantial watershed in the uplands to the east of the Padilla Bay flats.

Indian Slough and No Name Slough are contained within levees for most of their lower reaches. There is very little native vegetation along their banks, and tree cover is limited to some shrubby species growing along the drainage ditches outside the levees. Land along the sloughs is agricultural, and was formed by diking out Padilla Bay. There are areas where the agricultural land protected by the dikes is obviously lower than the adjacent slough and its floodplain outside of the dikes. If the dikes were breached, most of the current agricultural land would be too low to support emergent saltmarsh vegetation; a fringe of land along Bayview–Edison road would be high enough to support emergents.

ASSIGNMENT 5

Current vegetation in the Slough is characterized by *Salicornia* (pickleweed), *Distichlis* (saltgrass), *Atriplex* (shadscale) and other species tolerant of saline environments. Quite a bit of *Zostera* (eelgrass) wrack washes into the Slough from Padilla Bay. There is invasive *Spartina* (saltmarsh cordgrass) in Padilla Bay near the mouth of Indian Slough, but it has been subjected to a vigorous eradication program.

Your assignment:

A consortium of Federal and State agencies wants you to help them decide how to manage or restore 340 acres of diked farm land. You must make a decision about what mix of uses you will propose to WDOE, WDFW, and the Padilla Bay NERR, the **Problem Owners** for this project. **Stakeholders** have proposed that restoration, production agriculture, migratory waterfowl habitat, bird-watching, recreational walking, and education are uses that should be considered. In addition, the diking district must protect adjacent low-lying lands from flooding. Use the Design Element Checklist to evaluate ecosystem services when developing your proposal.

Three action alternatives have been proposed by the stakeholder committee. One alternative proposes that almost the entire site be converted to tidal marsh. A second alternative proposes that farming and flooding for freshwater wetland habitat be practiced in cells of 50+ acres each. A third alternative looks like a hybrid of the first two. In the end, any decision that allocates any uses to the 340 acres will result in some unhappy and vocal stakeholders. You should back up whatever you propose by showing why your chosen action alternative is superior to the other two and to the no-action alternative.

You must give your clients compelling reasons for accepting your proposal. Your solutions may be the best, or most economical, or provide the biggest bang for their buck. Areas proposed for restoration may be the most damaged and needing repair, or the key to the success of the greater project, or the first step, or whatever you think is a good argument to support your choice as to what they should spend their money on.

Three hundred forty acres is a large piece of land. How would you propose to phase the restoration or other management uses of your parcel or parcels? What would be the first step, what would be the second step, etc.? What is your timeline; how long would the total project take? How many individual restoration steps would it require? (A step might be all of the restoration that you think you could accomplish in one year.)

Take one project (that would be installed in a single growing season), and apply the design framework we have discussed. What kind of site modification and conditioning might be required? What plants would be specified and how would the installation be scripted? What management program should be put into effect?

What would be a reasonable goal (of the clients) for the project? How would you translate the goal as functional requirements? What constraints would you need to consider? What are some design parameters that might be developed in order to meet the functional

ASSIGNMENT 5

requirements of the project?

Some options (examples):

1. Connect headwaters of Little Indian Slough, Big Indian Slough or No Name Slough with the forested watershed to the east.
2. Breach a dike at lower end of Indian or No Name Slough and create a salt marsh.
3. Continue to operate the farmland, but as "green" farms.
4. Focus on riparian corridors.
5. Create saltwater excluders (weirs) in the upper reaches of the sloughs.
6. Expand on the proposals from the No Name Slough improvement study.

Specifically, you need to…

1. Consider all of the elements on your Design Element Checklist.
2. Clearly describe at least three alternatives (not including the "do nothing" alternative) for the entire 340 acre site.
3. Develop a decision making framework (we suggest using a decision matrix like we will discuss in class) and use it to recommend a preferred choice from among the alternatives you have described. You might have to anticipate results from research that is needed to fully implement your decision making scheme. Be very clear where you are anticipating research results – justify your estimations or predictions.
4. Very clearly (in detail) describe your recommended alternative.
    a. What the area will be like once it is restored.
    b. How you intend to restore / manage it.
5. Use Project Planning tools:
    a. Make a list of restoration tasks.
    b. Sequence them (which need to occur before subsequent tasks can be started).
    c. Estimate task durations.
    d. Draw a network diagram.
    e. Prepare a project schedule for the first year's activities.

ASSIGNMENT 6

ASSIGNMENT 6 – MINING DAMAGED SITE RESTORATION

Overview

Tacoma Power is part of Tacoma Public Utilities. It provides power to the City of Tacoma and operates hydroelectric power generation dams. One set of dam projects is called the Nisqually River Projects. Included in this set of projects are the Alder and LaGrande dams on the Nisqually River. As part of the relicensing of the Nisqually River Projects, Tacoma Power agreed to provide a number of environmental functions including elk habitat, riparian habitat, wetlands and gravel pit reclamation. The gravel pit project is an inactive 5 acre open pit on the south side of the Nisqually River directly south of Ashford, Washington (46° 44'30"N 122°0'51"W).

Restoration has been done at the site to meet the permitting requirements. Because it is a gravel pit, the site contains residual gravel and sand that was not mined out. The original gravel deposit was created some time in the past as the Nisqually River moved across the valley bottom and left coarse-graded depositional material in a complex pattern. This makes the site very quick-draining. Currently it is too high to be flooded by the river with any regularity. Plants grown on this kind of substrate would experience very dry or droughty conditions. There are, however, some depressions where water stands.

Gravel pits are strip mines that are generally abandoned when they either play out or when the project they were used for is completed. In order to be restored, they need some kind of soil importation, because the overburden containing the original topsoil is gone. On this particular site, because the owner is the City of Tacoma, TAGRO[1] was proposed and used to recreate topsoil.

Re-contouring of part of the pit was also done to intercept some of the shallow groundwater flowing from the slope into which the gravel pit was excavated. Since the site is near recent clear-cuts , and because Tacoma Power will be doing some construction that will create salvageable plants, much plant material and even sod will be available for transplantation.

1 TAGRO is the commercial name of the composted solids resulting from Tacoma's municipal wastewater treatment processing.

ASSIGNMENT 6

Your Assignment:

Reconsider the work that was done on this site by the capstone class in 2002-2003. The City of Tacoma, Tacoma Power, is required by the terms of the re-licensing agreement for the Nisqually River Project to manage their holdings along the Nisqually River to provide environmental services. Re-design this project for them. The power business is big business, so you will have the full resources of Tacoma Power behind you to accomplish novel and creative environmental goals.

There are a number of stakeholders who can apply very strong constraints on, and requirements of, Tacoma Power. Consider them in your design. Alder Dam inundated more than seven miles of riparian habitat when it was built. Consider replacing some of the services lost in that habitat was destroyed. The Nisqually Tribe is concerned about the Nisqually as a salmon stream. Is there anything that you can do in this reach, and with this project, to improve salmon habitat? Consider it, but if it is not feasible to design for salmon habitat, determine that. The National Hydropower Association website indicates that in this completed project, elk habitat was provided, wetlands were restored, riparian habitat was improved. Create a design to meet those goals.

The site is currently a gravel pit, so there are probably a few bulldozers available if you should want to re-contour the site.

Consider the City of Tacoma's decision to use TAGRO liberally to restore the site. Are there other materials that might be more appropriate, considering the close proximity of a salmon-bearing stream and the potential concentrations of undesirable compounds in TAGRO?

Estimate the quantity of TAGRO or other material that would be needed for the site. Devise a plan for stockpiling and distributing TAGRO across the site and estimate (calculate) how many worker-days would be required to spread it (include time for each trip, volume carried each trip, total volume of TAGRO, etc). Show the results for manual (example – wheelbarrow) and low intensity power equipment (example – "four wheeler" or "Quad" ATV with a trailer).

Determine what the native vegetation should be at this site. Part of the site could be coniferous forest. Part could be riparian forest. Part could be a grassland or sedge meadow for elk habitat. Select at least five species to fill each one of these groups. Determine where you would you get them and how you would you plant them. Estimate how many worker-days (use an approach that similar to your approach for estimating time requirements for spreading soil, mulch or other material over the site but remember that you have to distribute the plants and also plant them).

Once you have selected your plant material, create a calendar to indicate when your planting window is for each species and form that you select (seed, bare root, container plants, transplants, sod, etc.).

ASSIGNMENT 6

Create a plan view (and any necessary cross-sections) of the 5 acre site to show what you have done to improve environmental services. Show planting zones, re-grading, wetlands, standing water, etc. to characterize the newly restored site.

Checklist:

- ☐ Riparian habitat
- ☐ Salmon habitat
- ☐ Elk habitat
- ☐ Wetlands
- ☐ Re-contour
- ☐ TAGRO? Alternative?
- ☐ Coniferous forest vegetation
- ☐ Riparian vegetation
- ☐ Grassland or sedge meadow vegetation
- ☐ Plant sources
- ☐ Installation methods?
- ☐ Labor (worker-hour or worker-day) requirements
- ☐ Project calendar

ASSIGNMENT 7

Overview

Cascade Pass was one of the earliest heavily-used passages across the Cascade mountain range. At 1641 meters, it is along a route from the Stehekin River watershed (Lake Chelan) into the upper part of the Skagit River watershed. Native Americans used it, and when settlers came they used it as well. It became part of the Mount Baker Snoqualmie National Forest and was used for overnight camping starting in the 1920's. North Cascades National Park (NOCA) came into being in 1968; Cascade Pass, now part of NOCA, was eventually closed to overnight camping but is still a popular day hike and is the access route to many backpacking trips.

Recreational use has caused extensive impacts to subalpine vegetation communities and soils. Both trampling and camping cause impacts such as reduced vegetation cover, reduced species diversity, changes in species composition, soil compaction and soil loss. These impacts further impair soil conditions and processes so that natural re-colonization by plants is extremely slow. The vegetation is dominated by woody *Phyllodoce* and *Vaccinium*, a community type that is made up of species that are neither tolerant of trampling impacts, nor particularly resilient. The Pass has heavy snow pack, which creates a short 10-12 week growing season, further limiting regrowth.

A study done in 1970 found that there were 48 campsites and connecting trails within a 12 ha area. They had compacted, bare soil. As a consequence of this study, the park superintendant closed all camping and initiated a research and restoration program with the intention of finding out how to repair the damage, and then to repair it. Management recommendations included a call to actively revegetate the site using locally collected seed of plant species resistant to trampling (and likely to establish from seed). A 1979 revegetation study for the district emphasized the use of on-site transplants, as the technique had been very successful at lower elevations. Another study found, as others have, that aspect (the direction the slope faces) was a very important control on seeding success.

Ramsay in 2004 sowed seed of sedges, rushes, grasses and a common subalpine forb, *Polygonum bistortoides*. He prepared compacted sites by scarifying to 15 cm. Following seeding, sites were covered with excelsior mats. Treatments included weed-free soil, peat, and watering, in various combinations. A number of plots were left un-amended and un-seeded as a control.

Germination rates were low (14%). Highest germination was in plots that had the best soil moisture. It was found that there was a threshold of dryness that killed seedlings, and the treatments that avoided this threshold, such as adding peat or frequent watering, showed the best revegetation success. Soil-added treatments without watering were worse than no treatment.

ASSIGNMENT 7

Your Assignment:

Cascade Pass has not changed much since it was closed to camping in 1972. It is still shot through with a system of trails and denuded tent sites, even though it has been closed to camping for almost 40 years. The Pass is accessible by driving up the Cascade River road 37 km (23 mi) from Marblemount on the Skagit River. A forest road takes you to a trailhead, and then a trail to the pass takes you 6 km (3.7 mi) along a path that gains 550 m (1804 ft) of elevation. Any plants, seed, soil, amendments, geotextiles, excelsior mats, water, tools, or anything else probably goes up on your back. The site is also within a wilderness area, and so any actions taken must comply with provisions of the Wilderness Act.

The Superintendant of the park has decided that the area needs to be restored. There is Congressional funding for a contractor-provided project, and there is a provision for ongoing monitoring and maintenance within that funding package. Because the site is located in the Stephen Mather Wilderness Area, you will be limited to a maximum of 5 total employees on site, but you may solicit and use volunteer labor on an approval-for-each-event basis.

This is a simple ecosystem that does not have much of a successional pathway. But it is in a stressful, disturbance-prone location with access problems and a short growing season. You need to deal with stopping the disturbance while allowing continued transit through the site by hikers.

The goal is to restore the site. **List** what you think **the most important functional requirements** would be. **What are the major constraints?** The location is interesting because you do not know exactly when the snow cover will melt away in the spring, and you are out of business after it snows in the fall. So you need to create a schedule that minimizes the likelihood that you will not accomplish your work. **List your tasks. Determine precedence** (which must come before others, which must come after). **Estimate time** to perform each task. **Create a flowchart** that allows you to visualize which tasks logically group together, and allows you to see where interim deadlines need to be set. Because there are 48 campsites, you will probably restore only part of them during the first growing season, with others restored in subsequent seasons. **Draw a sketch** of the network of sites, and **designate** which sites you will do the first season, which the second, etc. **Tell why** you have chosen the sequencing you are describing. Use the task list to **prepare a budget** for the first year of the restoration project. Make defensible estimates of quantities and worker productivity. Make appropriate assumptions about labor rates, benefits, profit and risk, etc.

ASSIGNMENT 7

Checklist: In this project you will deal with trying to get plants to grow in small compacted campsites and along trails. Assume that the campsites are 5 ft by 10 ft, and that the impacted trails are 1.5 ft wide. In addition to the items specified in the preceding paragraph:

- ☐ Sketch a cross-section of a trail, and detail the soil treatments, mulch, excelsior mats, width of treatment, anchoring techniques.
- ☐ Prepare a similar sketch for a campsite.
- ☐ Provide specific answers to the following questions:
  - ☐ What plants will you use?
  - ☐ What forms (seed, container plants, etc.) will you install?
  - ☐ What densities will you specify?
  - ☐ Where will you get the plants or seeds?
  - ☐ Exactly how will you treat the sites (scarification, mulch, soil),
  - ☐ How will you plant,
  - ☐ When will you plant,
  - ☐ How will you leave the site (mulch, mat, bare)?
  - ☐ Will you water, fertilize?
  - ☐ What is the total area you will restore? Year one area?
  - ☐ Given this, how many total plants or seeds will you use? Year one plants and seed?
  - ☐ What will you do to control human re-entry after you have installed the restoration features?
  - ☐ Where will you keep materials and equipment?
  - ☐ What about water for the plants?
  - ☐ Where will people working on the restoration stay?
  - ☐ What decisions have you made to lighten your load as you hike up the trail again and again?
- ☐ Develop a plan for transporting and managing all equipment, materials and supplies to be used for the project. The plan should identify several options for storage, transportation, and loss prevention. It should justify the selected approach – a decision matrix would be an excellent way to do this.
- ☐ Propose a schedule and a budget for the first year's work.

ASSIGNMENT 8

Overview

Thornton Creek is an urban creek in Seattle. It drains the largest watershed of any Seattle Creek (12 sq mi). It includes 18 miles of creeks and tributaries (15 numbered and named channels and tributaries).

The Thornton Creek Alliance began creek restoration efforts in the 1990's. Over time, small projects have had an incremental effect. Salmon have moved back into the system as far north as Twin Ponds, at 155th St. NE, next to I-5. Seattle Public Utilities and the City of Shoreline continue to support the restoration of sections of the creek system. The re-development of the creek segment that was buried under the south parking lot of the Northgate Mall has recently been completed.

Your Assignment:

On a map, identify all of the restoration projects that have been completed or are in the planning stage, any place along Thornton Creek.

Propose four new sites, or sites that would be modifications or re-working of existing restoration projects, and rank them according to your criteria. State the criteria (they could include potential size of restored parcels, environmental value, cost, closeness to completed restoration projects, etc.). The sites may be in-stream, lake or pond, riparian vegetation, connection corridor, adjacent forested watershed, or whatever else you perceive as providing an important improvement in the environmental functions provided for and by Thornton Creek.

List the constraints that would need to be considered at any of the four sites.

Make a simple plan and profile of your number one site to show what you would propose to do to restore it.

AUTHORS' NOTES AND CONTRIBUTIONS

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Jake is currently finishing up an undergrad degree in Environmental Science and Resource Management from the University of Washington. He has a passion for policy, planning, land management, and brainstorming creative ideas to create solutions for projects in these areas. His senior project involved creating a management plan for the Raging River State Forest.

CONTRIBUTIONS:

1. **Wiley Slough: Saltwater Marsh Restoration** - Initial idea for which dikes to remove/replace, strategies for removal/replacement of dikes, and implementation.
2. **Cedar River Watershed: Transmission Corridor Restoration** - Ideas for how the corridor should look, creating wildlife corridors throughout the power line corridor, how to manage downed woody debris and shrubbery in the long term.
3. **Union Bay Natural Area: Freshwater Wetland Restoration** – Introduction, idea for lowering the E-5 lot so that it will always have water, removing Douglas Road for a larger wetland area.
4. **Marcellus Shrub-Steppe Preserve: Vernal Pool Restoration** – Vernal pool and shrub-steppe delineations and the reasons for classifications, through the use of GIS.
5. **Padilla Bay: Saltwater Marsh and Agriculture Restoration** – Decision Matrix and statistics that help to clarify the meaning of the decision matrix. Also generated the criteria for the decision matrix.
6. **Nisqually Gravel Pit: Mining Restoration** – Materials and Implementation ideas, including how much Tagro and the flipped sod idea.
7. **North Cascade Pass: Recreation Restoration** – Decision Matrix and related statistics, Discussion of Alternatives, calculations for how much Excelsior/labor is needed, how long the project will take.

8. **Thornton Creek: Urban Stream Restoration** – Decision Matrix and related statistics.
9. **Portfolio** – Wrote the Introduction chapter, made final edits on projects one and two.

ROBERT EDSFORTH

Robert Edsforth is a Master of Environmental Horticulture candidate at University of Washington. His main emphasis of study is in restoration ecology. His master's degree project involves the restoration of the land on and that which surrounds golf course property. He is also looking into natural areas being more incorporated into the future development of golf courses and other large area recreational facilities. Robert earned his bachelor's degree from the University of Washington in 1991 in Business Administration, and worked as an accountant for 18 years. This is a career change, as he is pursuing his passion for the environment. He brings a unique background and perspective to the environmental sciences. His understanding of the business and ecological communities will place him in a good position to bridge the gap between the two.

CONTRIBUTIONS:

1. **Wiley Slough: Saltwater Marsh Restoration** - Stakeholders and ideas for cooperation section, as well as the final edit prior to submittal.
2. **Cedar River Watershed: Transmission Corridor Restoration** - Site history and analysis section, discussion of stakeholder issues and relationships, long term management, maintenance and monitoring sections, editor duties prior to final report submittal.
3. **Union Bay Natural Area: Freshwater Wetland Restoration** – Mitigation points and reference sites used for the study, conducted research to determine what the Washington State Department of Ecology uses for mitigation credit computations, wrote about how to make the

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restoration site provide the most function, researched and wrote about the stakeholder issues and relationships, performed editing duties prior to final report submittal.

4. **Marcellus Shrub-Steppe Preserve: Vernal Pool Restoration** – Researched and discussed the stakeholder issues and relationships, discussed the grazing alternatives and ideas to minimize the impact of this activity, performed editing duties prior to final report submittal.
5. **Padilla Bay: Saltwater Marsh and Agriculture Restoration** – Helped with the stakeholder and history section, wrote the planning for Padilla Bay sections, wrote the instructions and descriptions of the decision matrix and statistical calculations, and performed final edit prior to submittal.
6. **Nisqually Gravel Pit: Mining Restoration** – Helped with the project site introduction, wrote the stakeholders section, editing prior to the final report submission.
7. **North Cascade Pass: Recreation Restoration** – the budget section including research on equipment and supply costs, discussions on employment, and on legal issues, editing prior to final report submission.
8. **Thornton Creek: Urban Stream Restoration** – Site Options, explanations for the decision matrix and statistical calculations, site design section, stakeholders and key organizations to work with, contacted the manager of Jackson Park Golf Course, Thornton Creek Alliance and Seattle Utilities in order to enhance proposal, editing prior to final submittal.
9. **Portfolio** – final edits on projects 3 and 4, "in conclusion" section, editing prior to final submittal.

GAR-YUN HO

Gar-Yun Ho is an undergraduate student, pursuing a double degree in Environmental Science and Resource Management and Landscape Architecture at the University of Washington - Seattle. She is particularly interested in restoration ecology and environmental horticulture, and how research in these fields informs and interacts with the process of urban landscape design. She also has a passion for fine art, illustration, and graphic design.

CONTRIBUTIONS:

1. **Wiley Slough: Saltwater Marsh Restoration** - Introduction: site analysis; Planning: process section; Planning: sequencing; Editing
2. **Cedar River Watershed: Transmission Corridor Restoration** - Introduction: site history and analysis; Planning: potential issues and planning process; Planning: parameters and functional constraints; Cross section diagrams; Final editing
3. **Union Bay Natural Area: Freshwater Wetland Restoration** – Planning: functional requirements and constraints; All diagrams and images including topographical maps, profiles, cross-cut sections, flooding elevation/planting zone diagram, water flow diagram; Final editing
4. **Marcellus Shrub-Steppe Preserve: Vernal Pool Restoration** – Shrub-steppe section including habitat description, site analysis, goals/objectives, functional requirements, cryptogamic crust section; Images: habitat types and potential levels of grazing threat; Collaged images; Task flow diagram; Monitoring; Final editing
5. **Padilla Bay: Saltwater Marsh and Agriculture Restoration** – Images; Functional requirements; Constraints; Task flow diagram; Design: phase 2; Management and monitoring; Final editing
6. **Nisqually Gravel Pit: Mining Restoration** – Images: topographical maps, diagrams, cross section diagrams; Introduction: site analysis; Final

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editing

7. **North Cascade Pass: Recreation Restoration** – All images and diagrams; Site design; Final editing
8. **Thornton Creek: Urban Stream Restoration** – Introduction; All images and diagrams; Site design and planning; Final editing
9. **Portfolio** – Portfolio assembly, Re-editing of graphic elements, Formatting, Final editing of all projects, Front page painting

AUTUMN NETTEY

Autumn Nettey is a Landscape Architect major with a minor in Restoration Ecology. She believes that community will be created and enhanced when we work together to help heal the wounds we have inflicted upon our Earth. It is her desire to not only restore damaged areas but to also create urban green spaces with an emphasis on sustainability and community.

In her spare time (spare time?) she likes to crochet, garden and hang out with friends and family.

CONTRIBUTIONS:

1. **Wiley Slough: Saltwater Marsh Restoration** - Goals, Objectives, Strategies, Potential problems, Management and Post restoration monitoring
2. **Cedar River Watershed: Transmission Corridor Restoration** - Solutions/Strategies ROW Riparian Forest Ecosystem, Solutions/ Strategies Wetland Ecosystems, Long term management, maintenance and monitoring, Editing
3. **Union Bay Natural Area: Freshwater Wetland Restoration** – Objectives, Site design elements, designing for wetland conditions, Project management and sequencing, Appendix A – Plan list, Editing

4. **Marcellus Shrub-Steppe Preserve: Vernal Pool Restoration** – Vernal pools habitat description, vernal pool site analysis, Goals, Functional requirements, editing and late night humor.
5. **Padilla Bay: Saltwater Marsh and Agriculture Restoration** – Site analysis, Discussion of options, Editing
6. **Nisqually Gravel Pit: Mining Restoration** – Goals, Objectives, Site design, Habitat plant species, Planting, Management, Editing
7. **North Cascade Pass: Recreation Restoration** – Functional requirements, Constraints, intern and volunteer event ideas, Plants, Sequencing and Planning, Tasks, Equipment and Tools, Supplies, Monitoring and Maintenance, Editing
8. **Thornton Creek: Urban Stream Restoration** – Goals, Criteria, Constraints, Vegetation
9. **Portfolio** – Epilogue, final editing of Projects 7 & 8

CHUHAN ZHENG

Chuhan Zheng is currently an Environmental Studies (PoE) and Communication Environment & Planning (CEP) double major junior student at University of Washington. Her interests of focus are ecotourism planning and historic preservation. With limited knowledge in restoration design, Chuhan worked hard to learn from and with group members. As an international student with multiple study background, Chuhan brought a diverse way of group working as well as different perspectives to group discussion.

CONTRIBUTIONS:

1. **Wiley Slough: Saltwater Marsh Restoration** - marking site design on a map using Photoshop; composing site analysis, goals and objectives; final formatting of the paper.
2. **Cedar River Watershed: Transmission Corridor Restoration** -

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composing goals, objectives, and solutions/strategies for snags and LWD.

3. **Union Bay Natural Area: Freshwater Wetland Restoration** – composing project management and sequencing; helping with cross cuts drawing.
4. **Marcellus Shrub-Steppe Preserve: Vernal Pool Restoration** – searching knowledge of sagebrush communities and restoration that helped group make decision; composing site history, goals and objectives; made decision matrix and Gantt chart.
5. **Padilla Bay: Saltwater Marsh and Agriculture Restoration** – composing history, stakeholders and management plan; making general decision matrix and Gantt chart; final editing.
6. **Nisqually Gravel Pit: Mining Restoration** – composing introduction; making sequencing table and Gantt chart; final editing.
7. **North Cascade Pass: Recreation Restoration** – calculation for workload and working time; making Gantt chart; composing volunteers and internship management.
8. **Thornton Creek: Urban Stream Restoration** – help composing site options, criteria and constraints.
9. **Portfolio** – project assembly, assignment compilation, editing of images, editing of projects 5 and 6