**U.S. Army Corps**
**of Engineers**
Seattle District

## Skagit River Flood Control Project: Environmental Restoration and Mitigation Planning

# EVALUATION AREA STUDIES

## Draft Report
**April 2002**

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## EXECUTIVE SUMMARY

The U.S. Army Corps of Engineers (Corps) and Skagit County (County) are conducting a flood damage reduction study for the lower Skagit River. As part of the flood control study, and in conjunction with Skagit County's process to implement an agricultural buffer ordinance, several evaluation areas are being considered for either habitat restoration or mitigation in this report. The study area is made up of thirteen evaluation areas, which are located along the lower Skagit River and the Skagit Delta area from Samish Bay to Skagit Bay. Potential restoration projects developed as part of this study may be implemented either as mitigation for flood damage reduction measures or habitat restoration conducted by the County or other agencies.

Significant changes have occurred to the Skagit Delta system over the past approximately 130 years. Analysis of historic estuarine areas in the Skagit River delta region indicates that a vast majority of the vegetated tidal estuarine and freshwater wetlands have been eliminated. Loss of off-channel and estuarine slough habitat are key limiting factors to fish production in the basin. Chinook and several other salmonid species have declined dramatically over the past two decades. Both bull trout and chinook salmon are currently listed as threatened species under the Endangered Species Act (ESA).

Objectives for this restoration plan are to, 1) identify projects that restore ecosystem functions and processes, as feasible, that will maintain and create habitat for fish and wildlife habitat over time, and 2) identify projects that restore localized habitats in the Skagit River delta region that are currently lacking and critically limit fish and wildlife production, particularly for chinook salmon.

Restoration measures proposed to achieve these objectives include breaching or setting back levees/dikes to increase estuarine emergent and scrub-shrub wetland mosaics, removal of fish passage barriers, riparian and upland revegetation, freshwater wetland creation, placement of LWD, and construction of livestock fencing. These types of restoration measures will result in the restoration of hydrologic regimes, native vegetation communities, and sediment supply and transport, while also improving salmonid access and productivity, habitat diversity and connectivity, and water quality within the limitations of the watershed and river dynamics.

This study includes the development and use of a methodology that evaluates each of the proposed alternatives, for the purpose of choosing one or more economically and biologically justified alternatives, per Corps of Engineers requirements. This screening and evaluation framework was used to develop numerical scores for each of the proposed alternatives based on their expected habitat benefits. Each of the alternatives, including the no action alternative, is rated for both existing and proposed future conditions. These numerical ratings are then used to conduct an incremental cost and cost effectiveness analysis to determine which projects provide significant habitat benefits for relatively low cost. A second phase of screening was utilized to further identify the alternatives that are most feasible based on land ownership and political considerations. The evaluation parameters were selected based on several recent studies of salmon in the Skagit River and on the habitat needs of fish and wildlife in estuarine or lower

river habitats, particularly chinook. Parameters include hydrologic, riparian, fish passage, and salmon rearing conditions, as well as the proximity of the habitat to native chinook populations.

The incremental cost and cost effectiveness analysis identified which individual projects were the most cost effective (lowest average cost per habitat unit output) as well as which combinations of alternatives would provide high levels of habitat output for the lowest cost. At least one alternative within the following seven evaluation areas provide the most significant benefits:  Deepwater, Telegraph, Dry, Sullivan, No Name, Indian, and Brown's Sloughs. The moderate or maximum scale alternatives at Deepwater Slough provide the most benefits at the lowest cost of any individual projects.

The secondary screening phase further identified the alternatives that are most feasible considering landowner constraints, implementability and sustainability, and adjacent land impacts. The highest ranked plans (1 through 10) that included restoration activities at the above seven evaluation areas were evaluated with the secondary screening. The plans that are recommended for further detailed study for implementation include the seven above evaluation areas, generally with the maximum alternative most highly recommended for each area (with the exception of Dry Slough, where the moderate alternative is recommended). We recognize that the maximum alternatives proposed in this report would require significant purchases of land or easements and it may be beyond the financial capability of Skagit County to do this. Therefore, we recommend that following the review of this draft document that the project sponsors consider modifying the maximum alternatives for the seven highest-ranking evaluation areas to develop more realistic restoration plans.

Monitoring of the implemented restoration projects will be essential to their success. The goal of monitoring is to set guidelines for the operation, maintenance, and management of the site, and reporting of vegetation and fish and wildlife responses over time. Three primary monitoring tasks will be employed, including those intended to monitor natural processes, those for conditions and specific functions, and those for a larger population response. Three phases of monitoring will be necessary including pre-project baseline, during construction, and post-project.

# 1.0 INTRODUCTION

## 1.1 Project Background

The U.S. Army Corps of Engineers (Corps) and Skagit County (County) are conducting a flood damage reduction study for the lower Skagit River. As part of this study, potential projects will need to be developed for implementation as mitigation in the event that there are unavoidable adverse impacts caused by the flood damage reduction project.

At the same time, a recent Sensitive Areas Ordinance (SAO) was developed for agricultural lands, which requires buffers along streams and sloughs that are directly connected to salmon bearing water bodies (Skagit County Code 14.24.120, November, 2000). Additionally, the SAO requires that thirteen evaluation areas be considered for possible restoration and enhancement projects and further observations on whether these areas might be salmon bearing. Because of the potentially large negative impacts to Skagit Valley agricultural production, the SAO was written to exempt agricultural ditches and other water bodies that are behind tide gates or other gated culverts, and hence, not directly connected to salmon bearing water bodies, although the 13 evaluation areas identified include several major sloughs that are currently behind tide gates or gated culverts. The SAO has been the subject of appeals and the County is currently negotiating a settlement that may revise the buffer requirements for ditches behind tide gates and/or some of the buffer options for properties adjacent to salmon bearing water bodies.

It is the hope of project sponsors that a reasonable level of habitat protection and restoration may be achieved through the restoration of high priority sites within the 13 evaluation areas, rather than requiring buffers along the agricultural drainage system. The 13 evaluation areas are identified on the Agricultural Master Map available from Skagit County. The Corps and the County would like to have restoration alternatives developed at these 13 evaluation areas simultaneously, for both the SAO and the flood study, in order to ensure that flood control alternatives will be compatible with (or include as mitigation) the high priority restoration measures and provide planning guidance to Skagit County during their revisions to the SAO.

This report provides 1) descriptions of the 13 evaluation areas based on existing information and field visits, 2) descriptions of the restoration opportunities and constraints in each area, 3) three conceptual restoration alternatives for each area, 4) a methodology for screening and ranking the restoration alternatives and their rankings, and 5) recommendations of the high priority alternatives for implementation based on habitat benefits, costs and practical constraints.

## 1.2 Project Area and Description

The study area includes the 13 evaluation areas, which are located along the lower Skagit River within the historic Skagit Delta area from Samish Bay to Skagit Bay (Table 1) (Collins 1998). The majority of the evaluation areas are west of the I-5 corridor, including Edison, Joe Leary, No Name, Indian, Telegraph, Sullivan, Hall, Brown, Dry, Freshwater, and Britt Sloughs. Two evaluation areas are east of I-5 including Gages Slough and portions of Carpenter Creek.

The Skagit River drains 8,270 $km^2$, including lands within British Columbia and Washington's northwest Cascade Range and empties into Skagit Bay in the vicinity of LaConner and Conway, Washington (Figure 1). Downstream of Mt. Vernon, the mainstem splits into two major distributary channels, the North and South Forks, which encompass Fir Island. In the northern portion of the study area, the Samish River is present. Several existing sloughs in this northern area may once have served as flood overflow channels from the Skagit River and also drained a large area of freshwater wetlands (General Land Survey Office Maps, 1866-1885). Flood flows in the Skagit River historically ranged across the Skagit and Samish Flats and entered Padilla and Samish Bays.

**Table 1. Evaluation areas and their general ecological types.[1]**

| Name | Ecological Type |
|---|---|
| 1. Britt Slough | Freshwater Slough |
| 2. Brown's Slough | Estuary |
| 3. Carpenter Creek/Hill Ditch | Freshwater River/Wetland |
| 4. Deepwater Slough | Freshwater River/Wetland |
| 5. Dry Slough | Estuary |
| 6. Edison Slough | Estuary |
| 7. Gages Slough | Freshwater Slough |
| 8. Hall Slough | Estuary |
| 9. Indian Slough | Estuary |
| 10. Joe Leary Slough | Estuary |
| 11. No-Name Slough | Estuary |
| 12. Sullivan Slough Complex | Estuary |
| 13.Telegraph Slough Complex | Estuary |

[1]More specific habitat types will be presented in Section 2.0

Significant changes have occurred to the Skagit River system and delta over the past approximately 130 years. Many tens of thousands of pieces of large woody debris (LWD) were removed from the river and associated channels (Collins 1998), forested areas have been cleared, dikes and levees were constructed that cut off side channels and sloughs and reduced the frequency of flood and tidal inundation of the delta, wetlands were drained to facilitate agricultural and urban development, and significant development has occurred throughout the lower river and delta area.

Four primary habitat types are currently present within the delta region, including freshwater dominated sloughs, estuarine dominated sloughs, estuarine marsh of several vegetative types, and freshwater streams and rivers. Freshwater dominated slough habitats, such as oxbow channels and low velocity side channels, provide refuge for overwintering salmon and year-round rearing for juvenile salmon and trout. These areas are also potential spawning habitats for chum, pink or coho salmon. Estuarine dominated sloughs are tidally influenced complexes that provide essential rearing habitat for juvenile salmonids, particularly chinook (Simenstad *et al*. 1982). These areas also support the life stages of many other freshwater and marine aquatic species and are important feeding areas for waterfowl, mammals, and other wildlife. Estuarine marshes provide rearing habitat for juvenile salmonids and also provide extensive wildlife habitat. Freshwater stream and river habitats provide migration, spawning and rearing habitat for salmon and trout species and a variety of other fish species. Birds, mammals and other wildlife utilize riverine habitat and its associated riparian vegetation for nesting and foraging.

The Skagit River and its tributaries support a number of anadromous and resident fish species, including all five species of eastern Pacific salmon (*Oncorhynchus nerka, O. gorbuscha, O. keta. O. tshawytscha, and O. kisutch*), summer and winter steelhead (*O. mykiss*), and Dolly Varden/bull trout (*Salvelinus confluentus*). The Skagit River has historically had the highest production of chinook salmon (*O. tsawytscha*) in Washington State, after the Columbia River. However, decades of cumulative impacts to fisheries habitats, harvest management and hatchery practices have resulted in a decline in chinook and several other salmon species (Hayman *et al*. 1996). Both bull trout and chinook salmon are currently listed as threatened species under the Endangered Species Act (ESA). The Skagit River also supports a wide range of non-salmonid species, including threespine stickleback *(Gasterosteus aculeatus),* prickly sculpin *(Cottus asper),* shiner perch *(Cymatogaster aggregata),* and surf smelt *(Hypomesus pretiousus).*

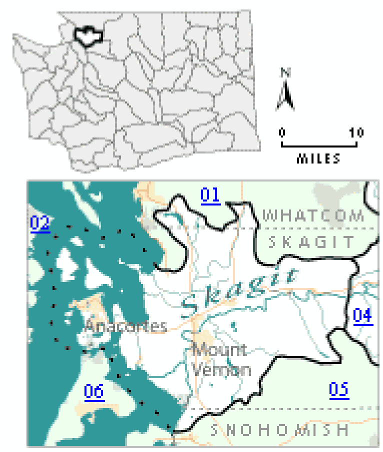


**Figure 1. Project area map**

Analysis of historic estuarine area in the Skagit River delta region indicates that 93% of the vegetated tidal estuarine and freshwater wetlands have been eliminated since the 1860s (Dean *et al*. 2000). Furthermore, studies have shown that estuarine habitat is extremely important in the life cycle of wild Chinook salmon and a loss of this habitat may limit the ability of those stocks to recover to harvestable levels (Aitkin 1998, cited in Dean *et al.* 2000).

### 1.3 Purpose of Restoration Plan

Objectives for this restoration plan are to, 1) identify projects that restore ecosystem functions and processes, as feasible, that will maintain and create key habitat for fish and wildlife habitat over time, and

2) identify projects that restore localized habitats in the Skagit River delta region that are currently lacking and critically limit fish and wildlife production, particularly chinook salmon.

### 1.4 Overview of the Screening and Evaluation Methodology

Part of this study includes the development of a methodology to evaluate each of the proposed alternatives, for the purpose of selecting one or more economically and biologically justified alternatives, per Corps of Engineers requirements for restoration and mitigation projects. This is accomplished through the development of screening criteria to evaluate and rank the conceptual alternatives. The screening criteria will be used in an evaluation methodology that assigns a numerical score based on potential habitat benefits that can be achieved with each alternative. At each evaluation area, four alternatives will be identified including no action, minimum, moderate, and maximum alternatives. This will result in a total of 52 possible alternatives. An initial ranking will be completed using the habitat scores and a preliminary cost estimate to conduct a cost effectiveness and incremental cost analysis. As several evaluation areas or alternatives may be cost effective, a secondary screening will be conducted to further identify the most feasible alternatives. The secondary screening is based on issues of land ownership, potential risk to adjacent land uses and other factors. A more detailed description of the evaluation methodology is included in Section 4.0.


Edison Slough
Planviews 16-18
Joe Leary Slough
Planviews 28-30
Gages Slough
Planviews 19-21
No Name Slough
Planviews 31-33
Indian Slough
Planviews 25-27
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Legend:
Maximum Extent of
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Scale:
4000 0 4000 8000 Feet
Skagit Evaluation Areas
Site Location Map
Site Locations for
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## 2.0 EXISTING CONDITIONS AND RESTORATION NEEDS FOR THE EVALUATION AREAS

Information on the land uses and existing conditions in each evaluation area were obtained from year 2000 aerial photos provided by the Corps, various existing reports on the Lower Skagit River, and through field visits and observations at each area.

Field visits were conducted in September and October of 2001, and some sites were revisited in January and April of 2002. Physical and biological data were collected over the course of several days and months. Physical features were identified including the location and conditions of levees, tide gates, and culverts. Road crossings were estimated for each water body using aerial photography. However, the nature of the crossing is unknown in some cases; the crossing may consist of a bridge or a culvert, which may be a fish passage barrier. Adjacent land uses and conditions were observed and described such as roads, agricultural areas and other developed lands. Bankfull widths were measured at each evaluation area and substrate was classified as silt, sand/silt, sand, or gravel. Bank conditions and slopes were also noted. No water quality data were collected, but water quality data for the sloughs in the Padilla Bay watershed (Bulthuis 1993, 1996) will likely be similar to conditions in other isolated sloughs. Biological observations included the dominant species and percent cover of vegetation, visual observations of water quality and quantity, aquatic habitat conditions, and wildlife habitat conditions. All evaluation areas were observed, as accessible, from public lands and easements or with permission from landowners. However, agricultural ditches on private lands were typically not accessible and the lower end of Sullivan Slough and adjacent ditches to the southwest of the slough were also not accessible due to landowner resistance.

Sloughs, channels, and ditches within each of the evaluation areas are operated and maintained by one or more drainage and diking districts (Table 2) for the primary purpose of draining water from the areas for agricultural production. The responsibilities of the diking districts include the operation and maintenance of constructed levees and dikes in various parts of the county. Drainage districts are responsible for maintaining workable farmland and control of water movement, including maintenance of gravity-driven drainage as well as pumping of water downstream in the event of flooding. In some areas, both diking and drainage duties are the responsibility of a single district. Drainage districts operate and maintain the pumps and tide gates located in many of the evaluation areas. Typically, the drainage and diking districts are comprised of a commission of local landowners. Typical operation and maintenance activities include clearing the sloughs of sediment and other debris and repairing or replacing tide gates, culverts or the structures associated with each. Clearing is often conducted by district members or local landowners, using privately owned equipment. However, if large-scale clearing is necessary or if dredging is needed, professionals are hired to complete the work. Currently, blockages are cleared within the Fir Island area every 3-5 years, depending on need (Curt Wiley, Chairman of Drainage District 22, pers. comm.). Other drainage districts likely have similar policies, although information could not be obtained in most cases. Infrastructure is closely monitored by drainage district members and maintenance or replacement is conducted as the need becomes apparent.

**Table 2. Summary of drainage and diking district jurisdiction for each evaluation area.**

| Evaluation Area | Drainage District(s) | Diking District(s) |
|---|---|---|
| Britt Slough | Sub-Flood Control Zone, 17 | 3 |
| Brown's Slough | 22 | 22 |
| Carpenter Creek/Hill Ditch | 17 | 3 |
| Deepwater Slough[1] | * | * |
| Dry Slough | 22 | 22 |
| Edison Slough | * | 4, 19 |
| Gages Slough | * | 12 |
| Hall Slough | 22 | 22 |
| Indian Slough | 8, 19 | 8, 12 |
| Joe Leary Slough | 14 | 5, 12 |
| No-Name Slough | 8 | 8 |
| Sullivan Slough Complex | 15 | 1, 9, 12 |
| Telegraph Slough Complex | 19 | 12 |

[1]Deepwater slough is not maintained by drainage or diking districts, but is the responsibility of the WDFW, which owns and operates several parcels for grain production for wintering and migrating waterbirds.

The following descriptions include several habitat types in addition to the general ecological types listed in Table 1. These include estuarine distributary channel, estuarine blind channel, estuarine emergent scrub-shrub wetland, freshwater wetland, and tidal channel. Distributary channels are channels that have a connection between the Skagit River and Skagit or Padilla Bays and serve to distribute flow. Blind channels are those which have a connection to Skagit or Padilla Bay, but do not drain from a significant upstream freshwater source. Estuarine wetland is typically a mosaic of emergent and scrub-shrub plant species that are able to tolerate brackish or salt waters. Freshwater wetland plant species are typically unable to tolerate even low levels of salinity. Tidal channels are similar to blind channels, but occur in brackish or entirely freshwater locations.

### 2.1 Britt Slough

The evaluation area specified for Britt Slough extends from Dike Road to its downstream connection with the Skagit River mainstem. This is a former freshwater channel that has been significantly changed by disconnection from the mainstem, and residential development, including both homes and farms. Historically, the slough likely existed as a secondary channel of the Skagit River as a result of a sizable large woody debris (LWD) jam on the mainstem (GLSO maps, 1866-1885; Collins, 1998). Currently, the upstream end of the slough has been filled in and is now the location of a wastewater treatment plant for the City of Mt. Vernon. Along the length of the slough there is continuous residential development and small farms. A road is present within 50 ft (15 m) of the majority of the east bank. Over 20 habitat breaks occur within the slough where road crossings or driveways have been built. Many of these crossings have small culverts, which would likely be fish passage barriers if fish were allowed to access the slough. The slough enters a short piped portion near its downstream end, where it runs beneath fill material and homes. Culverts are present beneath each crossing and are sized to contain only localized runoff. At the downstream end, the slough is crossed by a levee running parallel to the mainstem Skagit River. Beneath this levee are culverts controlled with flap gates, which open with sufficient hydraulic pressure and allow flood flows to drain into the river. A pump station is also present that pumps water downstream when it reaches a specified elevation. All observations for this description were made from Britt Slough Road and the downstream levee.

### *2.1.1 Physical and Biological Characterization*

Britt Slough has an average bankfull width (BFW) of 46 ft (14 m). Substrate was predominantly comprised of silt and organic material. Surrounding soils are generally mapped as silt loams, with some fine sandy loam. Adjacent landowners have deposited yard debris and soil on the banks of the slough in several locations. Standing water was present in the lower 2/3 of the slough, and the substrate was saturated in the upper end in fall of 2001. In-channel habitat complexity was minimal with minimal or no presence of LWD, gravel, overhanging banks, pools, or riffles. Currently, during the rainy season, the slough has standing ponded water. Water ponds between the culverts, indicating that the slough profile is very flat and culverts may be perched above the channel bed. If fish were allowed to access the slough under current conditions, the culverts would likely be passage barriers. Water quality was visually observed to be very turbid, either from sediment runoff or iron-fixing bacteria or both.

Riparian vegetation varies along the length of the slough, but is typically dominated by reed canary grass (cover 60-85%) and/or Himalayan blackberries (40-50%), both of non-native origin[1]. Cottonwood and alder are the dominant tree species, comprising up to 50% total cover in some locations, but typically occurring back away from the bank edge. Trees are not present along most of the slough length. The vegetation buffer is generally limited to less than 30 ft (9 m) wide on both banks and is frequently much narrower. Riparian vegetation is also comprised of ornamental species planted by private landowners.

[1] Vegetation cover frequently overlaps, particularly when multiple layers are present, such as herb, shrub, and canopy, resulting in a total percent cover that is greater than 100%. The percent covers noted in this report reflect that natural overlapping of species and layers.

Other species present include willows (*Salix* sp.), weeping birch (*Betula pendula*), spruce (*Picea sitchensis*), Lombardy poplars (*Populus nigra*), cedar (*Thuja plicata*), salmonberry (*Rubus spectabilis*), elderberry (*Sambucus racemosa*), nightshade (*Solanum dulcamara*), impatiens (*Impatiens noli-tangere*), nettles (*Urtica dioica*), morning glory (*Convolvulus arvensis*), Japanese knotweed (*Polygonum cuspidatum*), rushes (*Junc*us sp.), horsetail (*Equisetum* sp.), cattails (*Typha angustifolia* and T. *latifolia*), Canada thistle (*Circium arvense*), and spirea (*Spirea douglasii*). Several homeowners have constructed retaining walls or landscaped their property down to the bank of the slough. At the downstream end, downstream of the levee crossing, the channel enters an approximately 30-50 year old cedar forest for several hundred yards before entering the Skagit River.

#### *2.1.2 Restoration Needs and Opportunities*

In at least 3 locations, livestock have direct access to the slough. Pigs, horses, and cows were all observed on properties that were not fenced off from the slough. In addition, a large amount of trash and debris were in the upper reaches, as well as fill material that appears to have been dumped into the slough. Non-native species have become well established in and adjacent to Britt Slough, including reed canary grass, Himalayan blackberry, morning glory, Japanese knotweed, and Canada thistle. Riparian vegetation has been removed by residential and agricultural development, but could be expanded in width in some areas (ranges from ~25 to over 100 feet depending on proximity of structures) with the cooperation of private landowners. There may be some fish access through the existing tide gate on the downstream end, although no information is available on fish presence. A self-regulating tide gate or other opening could be installed to allow frequent fish use. Reconnection of the upstream end would require constructing a new inlet due to the presence of the wastewater treatment plant, which has eliminated any natural channel features upstream of Dike Road. The elevation of Britt Slough may be several feet higher than the Skagit River channel because it was formed as an overflow channel from the LWD jam in the River, and there has been more recent scouring of the mainstem as a result of confinement between levees.

Restoration opportunities at this site include fencing off livestock from the slough, removing debris and fill, allowing reconnection to tidal or backwater flows from the Skagit River at the downstream end, constructing an inlet at the upper end to restore side channel flows, restoring riparian buffers along the length of the slough, replacing culverts, removing non-native vegetation, excavating to pull back slopes where feasible (creates a wider riparian buffer and greater capacity in the channel), placing LWD in channel, and excavating the channel as needed to ensure fish passage and flow.

### 2.2 Brown’s Slough

The evaluation area for Brown’s Slough extends from the Skagit River downstream along Fir Island Road to Skagit Bay. This slough is a former distributary channel of the Skagit River, within the tidal zone of Skagit Bay. Brown’s Slough and Hall Slough were formerly connected, but are now physically separated by farmland. The Washington Department of Fish & Wildlife (WDFW) owns and operates a wildlife reserve on the left bank and adjacent lands (south bank) west of Fir Island Road. A house and other structures within the reserve lands have been removed. A hunting cabin is present on the right bank at the downstream end of the slough. There is a tide gate beneath Fir Island Road, which only allows freshwater flow downstream. Approximately 1000 ft downstream of Fir Island Road is a cross levee constructed after the 1990 floods, and a water control gate is present beneath this levee. The opening allows tidal exchange up to Fir Island Road (although tidal exchange is not entirely unconstrained, tide level is typically later and lower upstream of the culverts), and allows greater freshwater flow towards the Bay during high flow events. Adjacent land uses are agricultural fields on both banks and two houses at Fir Island Road. There are approximately 6 culverts or other crossings along the slough's entire length and a levee cuts off the slough near the North Fork Skagit (could not access site so did not observe if there was a culvert and gate through the levee. The slough was observed by walking the right bank levee and intertidal area, and from adjacent roads.

### *2.2.1 Physical and Biological Characterization*

The combined width of the channel and marsh downstream of the lower levee crossing was 145 ft (44 m). The water appeared milky, probably from suspension of the fine silt substrate. Surrounding soils are silt loams and findy sandy loams, generally poorly drained. The left bank levee has a long portion of riprap, placed during construction of the cross levee. This slough is used by juvenile salmonids for rearing, both upstream and downstream of the cross levee, and has been monitored by the Skagit Co-op (Beamer & LaRock, 1998). Upstream of the cross levee, the water is visually stagnant and very turbid even though tidal exchange occurs. Beamer & LaRock (1998) found water quality to be generally acceptable, although temperatures frequently exceeded state water quality standards in spite of the tidal influence (>19° C), and the only parameters measured were dissolved oxygen [DO], temperature and salinity. An additional agricultural ditch drains into the slough upstream of the cross levee from the right bank via a tide gate. Very few pieces of LWD are present in the channel or marsh areas upstream of the cross levee.

Vegetation varies from salt marsh to brackish/freshwater marsh and a very limited riparian zone. There is no buffer along the right bank, a narrow riparian zone exists along the left bank levee. Species present downstream of the cross levee include *Scirpus maritimus* (50% cover), *Carex lyngbyei* (40%), *Distichlis spicata* (90%), and *Atriplex patula* (1%). Low marsh was present adjacent to the channel, transitioning to middle/upper marsh and then upland at the levees. *Spartina anglica* has become established in the salt marsh and is being removed by WDFW staff via manual mowing. Upstream of the cross levee, the marsh was dominated by more brackish or freshwater species such as *Scirpus validus*, Douglas aster (*Aster subspicatus*) and Pacific silverweed (*Potentilla pacifica*). Some willows and cottonwoods are present on the left bank levee, but only in one clump. The levees are dominated by upland herbaceous species such as Canada thistle, yarrow (*Achillea millefolium*), and goldenrod (*Solidago canadensis*), and several grass species. No riparian zone is present upstream of Fir Island Road and the slough is essentially an agricultural drainage ditch.

#### *2.2.2 Restoration Needs and Opportunities*

The tide gates do allow fish passage and rearing up to Fir Island Road. Water quality is poor at times and habitat is limited due to the levees constraining the area. Currently, there is limited riparian zone downstream of Fir Island Road and none upstream of the road. Restoration options at this slough could include setting back levees and widening the slough, creating a riparian zone on the levees, removing non-native species, replacing both levee crossings with a bridge or removing altogether, removing additional culverts, reconnecting the upper end of Browns Slough to the NF Skagit River and reconnecting at Fir Island Road to allow freshwater and tidal flow, restoring a riparian zone along the length of Browns Slough, and placing LWD in the channel.

### 2.3 Carpenter Creek

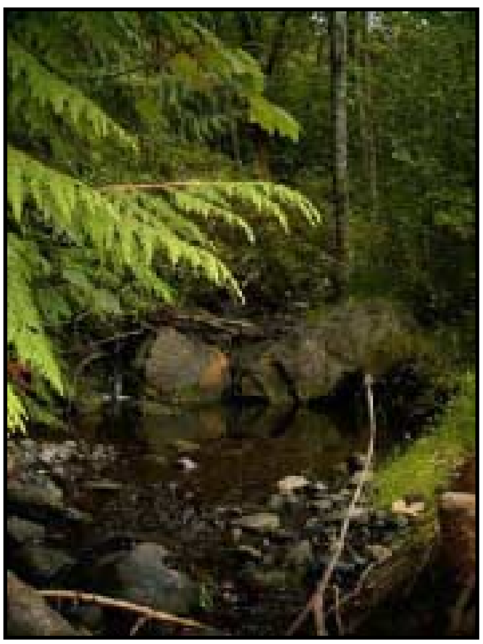
The evaluation area for the Carpenter Creek/Hill Ditch system includes Carpenter Creek from the quarry all the way through Hill Ditch and Fisher's Slough to Tom Moore Slough. Three reaches have been identified based on similarity of characteristics. The first reach extends from the headwaters to Hickox Road, the second begins at Hickox Road and extends to Highway 530, and the third reach is the most downstream end from Highway 530 to Tom Moore Slough. Salmon species can access this system readily and coho are known to spawn in Carpenter Creek and some of its tributaries. The headwaters of Carpenter Creek are located in the upper elevations of Devils Mountain and are surrounded by private timberland and rural residential development and hobby farms.

Reaches 2 and 3 are both listed for water quality standards exceedances on the 303(d) list of impaired waterbodies, while Reach 1 has relatively good water quality in comparison (WDOE 2002). However, the Reach 1 headwaters originate in agricultural and pasture lands, where livestock contribute to elevated fecal coliform levels. Water quality data were collected by WDOE for Carpenter Creek at Cedardale Road Bridge from 1999-2000 (2002). Carpenter Creek is considered a Class A water, with the following standards: 1) temperature shall not exceed 18°C, 2) dissolved oxygen shall exceed 8.0 mg/L, 3) pH shall range between 6.8 and 7.5, 4) turbidity shall not exceed 5 NTUs, and 5) fecal coliform colonies will not exceed 100/100 mL. In 1999-2000, three of these standards were exceeded, including dissolved oxygen, turbidity and fecal coliform counts. Dissolved oxygen ranged between 3.5 to 7.0 mg/L for the months from November of 1999 to June of 2000. Turbidity ranged from 5.1 to 7.3 NTUs during measurements taken in February, March, and April of 2000. Fecal coliform counts of 130 and 150 were collected in June and August of 2000, respectively.

### *2.3.1 Carpenter Creek Reach 1*

This reach is a moderate to low gradient confined stream. A commercial quarry is upslope on the left bank of this reach and has a gravel access road crossing (culvert). Residential land use occurs downstream of the quarry road and west of the creek (right bank). Carpenter Creek appears to have at least a 50 ft (15 m) wide buffer upstream of this reach for ½ mile or more, consisting of approximately 20-30 year old mixed deciduous and coniferous forest and primarily native shrubs. Approximately 8 road crossings occur in this reach, although additional crossings may be present on private property. The quarry is currently more than 100 ft (30 m) away from the creek. The upper reaches of Carpenter Creek (outside of the evaluation area) include a mix of timber lands and rural residential development. Some rural residences include horses and other livestock with continuous access to the creek and its associated wetlands. Historically, it appears that Carpenter Creek continued west from the base of the slope into a large wetland area, which ultimately drained via several small sloughs into the South Fork Skagit River (GLSO maps, 1866-1885). This reach was observed by walking the channel for the length of the reach.

#### 2.3.1.1 Physical and Biological Characteristics



The creek is confined in a narrow ravine upstream of the quarry access road; continuing downstream with a high bank on the left bank, but a wider floodplain on the right bank. The creek has been realigned to skirt the base of the slope, starting at Bacon Road. Upstream of the quarry road is a cascade and step pool complex, below the quarry road was a pool/riffle/glide complex. A representative pool above the quarry measured 17 in. (42 cm) max depth, 4 in. (11 cm) pool tailout depth. Bank full width (BFW) at this location was 28 ft (8.5 m), making a bankfull depth of 64 in. (160 cm). A representative riffle below the quarry road measured 57 ft (17 m) long with a maximum depth of 5 in. (12 cm). Pools comprised approximately 30% of habitat, riffles 50-60%, and glides 10-20%. Substrate is comprised of small gravel (30-40%), cobble (30-40%), bedrock (10-15%) and fines (15-30%). Overall, fines are higher than ideal and have accumulated in some areas, especially in glides. This upper reach has a moderate amount of smaller LWD and other natural instream habitat features, such as overhanging banks, pools, riffles, boulders, and sinuosity. There was more than 2 cfs of flow in late summer of a drought year. Average velocity in riffles was 0.8 ft/s (0.2 m/s). On the steep banks, significant areas of erosion were evident, as is expected for the soils mapped as andic xerochrepts formed from ash, sedimentary materials and colluvium. One eroding site was approximately 100 ft (30 m) long and 80 ft (24 m) tall. However, most areas of erosion were smaller, usually between 10-30 ft (3-9 m) in height and less than 40 ft (12 m) long. A lower layer of glacial till is exposed with a silty clay layer eroding at the surface. The moderately dense vegetation is keeping the banks fairly stable. Erosion was typically occurring only on the outside of meander bends.

Overall canopy cover in this reach was between 70 and 95%. This upper reach runs through a forest of 20-30 year old, 2nd growth, conifer and deciduous trees. In some locations, homes are adjacent to the right bank making the riparian buffer width very narrow (0-25 ft). However, in most of the reach, the riparian buffer extends for 100 ft (30 m) or more. Dominant tree species included cedar, cottonwood, and big leaf maple (*Acer macrophyllum*). Dominant shrubs included salmonberry and vine maple (*Acer circinatum*). Other species present in lesser amounts included Indian plum (*Oemleria cerasiformis*), alder, willow, swordfern (*Polystichum munitum*), dogwood (*Cornus stolonifera*), creeping buttercup (*Ranunculus repens*), woodrush (*Luzula* sp.), horsetail, *Scirpus microcarpus*, lady fern (*Athyrium felix-femina*), hazelnut (*Corylus cornuta*), cherry (*Prunus* sp.), red huckleberry (*Vaccinium parvifolium*), youth on age (*Tolmiea menziesii*), *Geum macrophyllum*, native blackberry (*Rubus ursinus*), Himalayan blackberry, thimbleberry (R. *parviflorus*), elderberry, and *Veronica* sp. Nurse logs and snags, which provide terrestrial habitat diversity, were present but not abundant. Numerous large (>36 in. DBH) cedar stumps were present on the undeveloped bank slopes.

##### 2.3.1.2 Restoration Needs and Opportunities

The headwaters of Carpenter Creek originate in what were historically forested wetlands. Currently, the headwater areas are developed into low density residential neighborhoods. Several homes have livestock farms, which may be contributing to high fecal coliform counts, at the source of the creek. Any successful restoration at this creek should include fencing of livestock from these headwater areas. The upper portion of Reach 1 provides moderate to good quality habitat for fish and wildlife and should be protected with an enhanced riparian buffer to reduce fine sediment input and ensure future recruitment of LWD. Juvenile fish were observed in many of the low velocity locations, such as undercut banks and pools. Placement of additional LWD would further improve instream habitat diversity and channel stability, and underplantings of conifers will contribute to LWD recruitment and terrestrial habitat diversity over the long-term. In areas where residential homes encroach on the stream, a wider riparian buffer would be beneficial. The culvert under the quarry road is sized appropriately for conveyance of high flows, but a bed of riprap on the downstream side may prevent upstream fish passage seasonally.

This reach should be protected by maintaining and enhancing the existing buffers. Restoration opportunities include increasing buffer width through the residential area, removal of riprap in creek, underplanting of conifers in the riparian zone, removal of non-native species (particularly at quarry road crossing), placement of LWD, and bank stabilization as appropriate or feasible.

#### *2.3.2 Carpenter Creek Reach 2*

Reach 2 of Carpenter Creek extends from Hickox Road through the Hill Ditch complex to the Hwy 530 crossing. Carpenter Creek/Hill Ditch is typically a constructed trapezoidal channel constrained by levees, roads, agricultural land and residential homes. It parallels the base of the hillslope throughout most of this reach and has an estimated 10 road crossings. There are several areas of moderate quality riparian vegetation on the left bank (hill). Four small tributaries enter the creek through this reach, Sandy, Johnson, Bulson and one unnamed creek. Except for Bulson Creek, these tributaries are all relatively short, arising in wetlands on top of the hill and quickly falling to the valley floor. Historically, these creeks would also have continued westward through a large wetland area, before finally draining into the South Fork Skagit River. Because Carpenter Creek/Hill Ditch has been channelized at the base of the hillside, significant deltas have built up at the confluence of each creek that cause flooding problems or other maintenance problems for roads and bridges adjacent to the channel.

#### 2.3.2.1 Physical and Biological Characterization

The channel is a trapezoidal channel, except where tributary creeks have modified the channel shape. Typically, the wetted width during low flows is 6 ft (1.8 m), with bankfull width difficult to discern because of the lack of woody vegetation. Bankfull width based on the top of the channel or levee ranges from 15 to 50 feet (4.5 to 15 m). Much of the water in the lower reaches of Carpenter Creek is slow moving, highly turbid, and tidally influenced. This reach is listed on the 303(d) list for elevated fecal coliform and temperature. Sand is the primary substrate upstream of Johnson Creek and transitions to primarily organic muck and silt downstream to the outlet. Alluvial fans are present at the mouths of each tributary, primarily composed of sands; whereas surrounding soils are primarily silt loams and mucks in low-lying areas. Velocities were less than 0.1 ft/s (0.03 m/s) and glides comprised 80-90% of instream habitat. A few riffles were present, primarily adjacent to the tributary confluences, but were very short and filled with fines. Tidal influence extends a short distance up this reach from Hwy 530. Aquatic vegetation included *Elodea crispus, Lemna minor,* and algae.

The creek alternately runs through the center of agricultural fields and along the hill on the left bank as Hill Ditch. There is a complete lack of riparian trees and shrubs in the agricultural fields. Primarily, these areas are dominated by reed canary grass and Himalayan blackberries on the ditch slopes. Where the creek is adjacent to the foothills, the left bank has better riparian cover comprised of sparse young conifer and deciduous trees. Riparian widths are limited, especially through agricultural land, to less than 20 ft (6 m). Other species present include alder, willow, nightshade, horsetail, Watson's willowherb (Epilobium watsonii), prickly lettuce (*Lactuca serriola*), dock (*Rumex* sp.), *Polygonum* sp., *Sparganium eurycarpum*, and *Juncus effusus*.

#### 2.3.2.2 Restoration Needs and Opportunities

The stream has been straightened and channelized and realigned to the base of the hillside. Historically, it meandered through a large wetland complex to the west of its present channel. Currently, the creek/ditch provides very little instream habitat diversity and no riparian or terrestrial habitat is present in approximately 70% of the reach. Creation of a riparian buffer would reduce water temperatures and provide cover. Fish have access to the Carpenter Creek/Hill Ditch system and spawn in the upper reaches and tributaries, which have moderate to good quality habitat, but must pass through this lower reach first. A riparian buffer would also filter agricultural runoff improving water quality in the creek (fecal coliform, sediment, nutrients, and pesticides/herbicides), and will be required under the agricultural sensitive areas ordinance because this is a salmon bearing stream. Levee removal or setbacks would allow restoration of floodplain wetlands and more natural meandering of the stream and tributaries.

Opportunities for restoration include restoring a more natural meander to the stream, revegetating riparian buffers along the entire length of this reach, removing non-native species, realigning levees at tributary confluences to provide room (and capacity) for natural meandering across the deltas, revegetating riparian buffers along tributaries, setting back levees to restore wetland habitats, providing wetlands for water quality treatment at agricultural ditch returns, and placing LWD in the channel.

### *2.3.3 Carpenter Creek Reach 3*

Reach 3 extends from Pioneer Highway to the connection to Tom Moore Slough. Flood gates are just downstream of the Stanwood Hwy (Pioneer Highway). Three large flap doors allow freshwater flows to drain to Tom Moore Slough. The flap doors are built into a metal wall spanning the slough and the lower elevation of the doors may be too low to allow fish passage during certain flow levels. Typically, the gates are left open during the summer and closed in winter since water backs up into creek and may overtop the dikes if gates are left open during winter high tides (Richard Smith, pers. comm). Surrounding land uses are roads, a railroad, agriculture and open space. There appear to be 3 major road crossings, all of which may be bridge structures.

#### 2.3.3.1 Physical and Biological Characterization

As with the upper reaches of this creek, this lowest reach has a moderate to good quality riparian zone. Red osier dogwood and willow make up the majority of the shrub to small tree layer. The left bank riparian buffer is constrained by a railroad and highway and is less than 50 ft (15 m) wide. Right bank buffer is greater than 100 ft (30 m). Tom Moore slough runs through a $2^{nd}$ growth stand of cedars and deciduous trees. Species present within the riparian zone include alder, reed canary grass, skunk cabbage (*Lysichiton americanum*), spirea, ninebark (*Physocarpus capitatus*), salmonberry, ladyfern, and *Scirpus microcarpus*. The railroad embankment is dominated by blackberries, Scotch broom and willows. The levee along Tom Moore slough upstream of the Carpenter Creek outlet is mowed grass.

This freshwater tidal slough has a wetted width at high tide of approximately 32 ft (10 m) and has substrate of fine mud. Below the tide gates the creek splits into two channels; one joins Tom Moore Slough and runs along the railroad and carries the majority of the flow (80%), the second runs northward along a levee and had little to no water at a moderate tide. There was no measurable velocity and water was tannic in color. *Elodea* sp. were present in the channel. This reach provides excellent forested tidal rearing habitat for fish.

##### 2.3.3.2 Restoration Needs and Opportunities

The railroad embankment and levees constrain tidal flow and habitat area. Opportunities for restoration include the removal of non-native species, setting back levees to create more tidally influenced area, riparian underplantings, reconfiguration of tide gate to allow unimpeded fish passage, and the placement of LWD in the channel.

## 2.4 Deepwater Slough

This evaluation area includes the mosaic of islands encompassed between Wiley, Freshwater, and Tom Moore Sloughs, which are braided distributary channels formed by the South Fork Skagit River. Just south of the city of Conway, the South Fork branches into Freshwater and Steamboat Slough, which then further branch to form a delta mosaic of distributary freshwater and tidal channels. The area consists of both public and privately owned lands. A large portion of the area is farmed for waterfowl wintering and is protected with several linear miles of dikes. Within these farmed areas, the WDFW plants grain crops to provide habitat for waterfowl (USACE 1999). A total of 1,421 acres has been designated as the Skagit River Wildlife Area (*ibid*). WDFW owns Milltown Island, adjacent to Tom Moore Slough, but does not operate or maintain it (*ibid*) and its dikes were breached as part of the Corps restoration project in 2000. The Deepwater Slough evaluation area has been subdivided for the purposes of this report into the Wiley Slough, Deepwater Slough, and Milltown Island areas.

Field visits were conducted for this site in April 2002 and the Wiley Slough and Milltown Island areas were visited. Information regarding the Deepwater Slough area is taken from the restoration feasibility study completed by the Corps (1999), as well as current aerial photos.

Wiley Slough is west of Freshwater Slough and marks the western boundary of the evaluation area. It is primarily owned by USFWS and WDFW and is managed for hunting and farmed for waterfowl grain crops. However, there are a limited number of private owners and these lands are also farmed. Wiley

Slough is bound by levees on both sides that separate it from Freshwater Slough and protect adjacent lands. The slough was viewed from the left bank levee.

The Deepwater Slough area is between Freshwater Slough and Steamboat Slough. Two large islands make up the majority of the site. These islands are owned by WDFW and were in grain production for waterfowl prior to the construction of the Corps restoration project in 2000 and resulting loss of access to the islands. Several restoration feasibility studies have already been completed for the Deepwater Slough area (Sheldon and Associates 1996, WDFW 1997, 1998, and USACE 1999) and restoration has been completed in parts of this evaluation area as a result. The most recent report (USACE 1999) provided a set of recommended restoration measures, including primarily the breaching of dikes near the center of the evaluation area and on Milltown Island. Specifically, 220 acres of land were opened to tidal inundation through the breaching of dikes between Freshwater, Index, and Deepwater Sloughs. On Milltown Island, a number of dikes were breached to increase connectivity with the river. Upstream of the islands is the wedge of land formed by the branching of the South Fork into Freshwater and Steamboat Sloughs. This area has approximately 160 private lots that are undeveloped. It is unclear if any development would be allowed to occur on these floodplain lots.

Milltown Island is between Steamboat and Tom Moore Sloughs and is also entirely owned by WDFW. Although it has been farmed for waterfowl grain crops in the past, it is no longer accessible, except by boat, and farming has ceased. A levee does still exist along the perimeter of the island, but has been breached in many locations. Milltown Island was accessed by boat and both shoreline and inland locations were observed.

### *2.4.1 Physical and Biological Characterization*

Water quality is generally good within the South Fork Skagit River and it is rated Class A by the State (WAC 173-201-080). The South Fork is not included on the 303(d) list. However, some impairments do exist, including elevated turbidity, ammonia, and fecal coliform, and low DO (USACE 1999). Substrate in the sloughs are generally organic enriched mud, silt, or sand, and surrounding soil types are primarily sandy loam, silt loam, and tidal hydraquents.

Wiley Slough is bisected twice by levees. The first occurs downstream of Mann Road at a parking lot on the WDFW refuge. The gravel road to the parking lot is located on top of the levee, which crosses the slough. The second levee crossing occurs just upstream of the mouth at Skagit Bay. Roads and levees encroach upon the slough at differing degrees along its path, resulting in changes in the associated riparian vegetation. At the Mann Road crossing, Wiley Slough is comprised of freshwater wetland primarily dominated by broad leaf and narrow leaf cattails. Riparian buffer widths were less than 25 ft (7.5 m) at this location, and typically dominated by herbaceous or shrub species. Bankfull width was 75 ft (22.5 m). Downstream of the parking lot, riparian trees and shrubs exist adjacent to the levees, while areas of open field exist where grain crop are farmed. Dominant species along levees included alders, willow, salmonberry, elderberry, spirea and nettles. Fields had pasture grasses and reed canary grass. There is a 5-6' diameter culvert beneath Mann Road, which appears to be relatively new, and six culverts with tide gates have been installed beneath the downstream levee crossing.

The Deepwater Slough area and associated middle islands have two distinct vegetation communities. Along dikes riparian shrubs and trees occur. Predominant conifers include red cedar and Sitka spruce. Dominant deciduous species are red alders, bigleaf maple, and cottonwood. Inside the dikes the fields are dominated by cattails, reed canary grass, and in farmed areas, barley. Low spots along the outside of dikes support more natural emergent marsh vegetation, such as bulrush and sedges. However, these communities occur rarely.

Milltown Island is similar to the middle islands in having two distinct vegetation communities. Again, a riparian buffer occurs along the island edge, in association with levees. Cottonwood, red alder, Indian plum, elderberry, salmonberry, skumk cabbage, and reed canary grass were dominant along levees. Inland species were comprised of primarily reed canary grass and cattails (both species). Other more sparse inland species included *Juncus effuses*, impatiens, birdsfoot trefoil, and *Rosa* sp. During the field visit, we encountered many freshwater tidal channels criss-crossing the inland expanse of Milltown Island, ranging from 1 to 10 ft (.3-3 m) bankfull width.

#### *2.4.2 Restoration Needs and Opportunities*

Wiley Slough is highly constrained by levees downstream of Mann Road and lacks a suitable riparian buffer. Opportunities at this site include levee setbacks and riparian plantings. In addition, Wiley Slough could be reconnected with Dry Slough (if Dry Slough were connected at its upstream end) to restore the distributary channels that fomerly existed. The middle islands adjacent to Deepwater Slough would benefit from removal or breaching of levees, which would open the area to tidal inundation and allow recolonization and tidal channels to form. Opportunities are similar for Milltown Island. Already the area is undergoing recovery and recolonization. It would further benefit from additional levee breaching to speed up the recovery of native tidal freshwater plant communities.

## 2.5 Dry Slough

The evaluation area for Dry Slough includes the entire length of Dry Slough through Fir Island (from the NF Skagit River to Skagit Bay). Dry Slough was historically the Middle Fork of the Skagit River and functioned as a major distributary channel. The upstream end begins near the North Fork Skagit (isolated by a levee) and runs through Fir Island and then through a tide gate at a second levee along Skagit Bay near the mouth of the slough. Dry Slough has two tide gates, which allow only freshwater outflow to the Bay. From the North Fork Skagit to the Skagit Bay levee, Dry Slough is primarily a cattail wetland that appears to be significantly higher in elevation than either of the Skagit River forks, with very few areas of standing water. Agricultural land and residential homes surround the entire length of the slough. A minimum of 10 road crossings are present, which would be fish passage barriers if fish had access to the slough. Dry Slough Road also constrains the left bank for most of the length of the slough, having an average distance from the slough of approximately 50 ft (15 m).

### *2.5.1 Physical and Biological Characterization*

Dry Slough is a freshwater wetland primarily dominated by broad leaf and narrow leaf cattails. A variety of other riparian vegetation also occurs in localized patches. One area had 60% willow cover, and another had 80% alder cover. However, the average riparian buffer width is less than 25 ft (7.5 m), and typically dominated by herbaceous or shrub species. Other species present include reed canary grass, cottonwoods, Himalayan blackberry, red osier dogwood, spirea, big leaf maple, yellow flag iris (*Iris pseudacorus*), and smartweed (*Polygonum* sp.). Many locations have little to no riparian buffer and are directly adjacent to agricultural fields. South of Fir Island Rd. to the Skagit Bay levee, the slough is dominated by cattails and has no riparian buffer at all. Downstream of the Skagit Bay levee, narrow leaf cattails (50%), rose (30%) and goldenrod (30%) were the dominant species. Other species include *Carex lyngbyei*, *Scirpus validus*, Douglas aster, *Chenopodium sp.*, prickly lettuce, crabapple (*Malus fusca*), and Pacific silverweed.

Organic enriched mud and silt are the dominant substrate types for this slough, and surrounding soils are primarily silt loam and fine sandy loams. Water is relatively clear, but many aquatic macrophytes are present seasonally. A tide gate is present beneath the Skagit Bay levee, but does not allow tidal influence upstream. There are two channels near the Skagit Bay levee, and it appears from historic mapping that Dry Slough had two channels at its outlet.

### *2.5.2 Restoration Needs and Opportunities*

A conceptual plan for restoration on Dry Slough was completed in February 2001 by Northwest Chinook Recovery (NCR). Restoration alternatives evaluated included returning the Slough to a tributary channel with construction of levees along both banks, restoration downstream of Fir Island Road by reconnecting tidal influence, and a controlled flow of both freshwater and tidal flows with engineered inlet and outlet structures. Other features included riparian restoration, slough excavation, and placement of LWD in the channel. These features address the restoration needs in Dry Slough. As part of our scope of work for this report, we have provided a review of the restoration plan for Dry Slough as presented by Northwest Chinook Recovery, in Section 4.4.1. In addition, we have prepared the minimum, moderate, and maximum proposals for alternatives at this site, using the components proposed in the NCR report and newly developed components.

## 2.6 Edison Slough

The evaluation area for Edison Slough extends from Samish Bay to slightly upstream of Chuckanut Drive. Historically this slough was a channel that drained freshwater wetlands and was tidally influenced for a portion of its length (Collins 1998). SRT structures are present beneath East Edison Road that allow tidal exchange upstream adjacent to a public school. The slough is constrained downstream of East Edison Road on both sides by levees and also constrained by structures and roads within the town of Edison. Between the SRT structure and Chuckanut Drive, however, there are fewer constraints. Five road crossing are present and some or all of them may limit or prevent fish passage. The majority of this slough was observed from the town of Edison and East Edison Road.

### *2.6.1 Physical and Biological Characterization*

The average wetted width at high tides (width of channel and marsh habitat between levees) downstream of the tide gates is approximately 100 ft (30 m). Water quality was visually observed to be somewhat turbid and tannic. Further upstream near the second crossing of East Edison Road, the water was extremely turbid and the slough transitions to an agricultural drainage ditch. Livestock are present between the elementary school and Chuckanut Drive. The substrate is fine silty mud, and surrounding soils are primarily silt loams and fine sandy loams.

Downstream of the tide gates, the slough has both salt marsh and mudflat areas, and two blind channels are present near the outlet into the Bay (outlets for ag ditches). The salt marsh was dominated by salt grass (*Distichlis spicata*, 60%) and bentgrass (*Agrostis* sp., 20%), with less than 20% cover of fat hen (*Atriplex patula)*, tufted hair grass (*Deschampsia cespitosa*), gum weed (*Grindelia integrifolia)*, velvet grass (*Holcus lanatus)*, and ryegrass (*Lolium* sp.). Few upland riparian species were present and the distance to roads or structures on both banks was less than 30 ft (9 m). Downstream of and adjacent to the tide gates, vegetation included primarily velvet grass (30%) and lesser amounts of Lyngby's sedge (*Carex lyngbyei)*, fat hen, Pacific silverweed, tall fescue (*Festuca arundinaceae*), reed canary grass, laurel (*Laurus nobilis*), Himalayan blackberry, willow, salt grass, and bindweed. Upstream of the road crossing (still within the tidal zone), vegetation was dominated by salt grass, Douglas aster, velvet grass and Pacific silverweed. Upstream of the SRT, the riparian zone is limited or non-existent and the banks are primarily covered with reed canary grass or blackberries, which transition immediately into agricultural fields.

#### *2.6.2 Restoration Needs and Opportunities*

Downstream of the tide gates, the slough is constrained by dikes that protect agricultural fields from high tides. Upstream of the gates there are no dikes or levees. Within the town of Edison, the slough is highly constrained by structures and roads within 5-50 ft of the Slough. The main limitation in this area is a significant reduction (from historic conditions) of estuarine wetland habitats. There is also a general lack of LWD and buffers. Shrub wetland or riparian plantings could improve cover and wildlife habitat throughout the reach, as well as reducing runoff of sediment and other pollutants. Upstream agricultural runoff is a problem particularly for turbidity and also likely for nutrients/pesticides and may reduce dissolved oxygen conditions. Wetlands for water quality treatment could be an option upstream of the tidal zone, and also a restoration of freshwater wetlands that existed historically. Culverts are present beneath driveways, which cross the slough adjacent to East Edison Road, and may need to be replaced to improve fish passage.

Opportunities for restoration at Edison Slough include setting back levees to restore estuarine emergent wetlands and blind tidal channels downstream of the tide gates, removal of non-native species along the existing slough alignment, and creation of a riparian buffer. Other possibilities include creation of water quality improvement wetlands and allowing tidal influence further upstream, although saltwater intrusion issues must be investigated further. Ducks Unlimited may be negotiating for purchase of the agricultural land north of the mouth of this slough, which would be an excellent opportunity to set back dikes a significant distance to restore estuarine emergent wetland.

### 2.7 Gages Slough

The evaluation area extends from Gardner Road to District Line Road in southwest Burlington. The evaluation area is a former meander of the Skagit River. Currently, Gages Slough is entirely isolated from the Skagit River by levees and gated culverts. Residential and commercial development and small farms border a large portion of the slough. Hwy 20 and a railroad line cross the slough through this area. There are an estimated 13 road crossings between Gardner and District Line Roads. An estimated 15 crossings occur between Hart's Slough and Gardner Road, and many more likely exist from Gardner Road to the downstream most end of Gages Slough. The slough nearly disappears and is highly confined in one portion of this reach as a result of farm activities.

### *2.7.1 Physical and Biological Characterization*

The slough substrate is organic muck, although surrounding soils are primarily silt loams and fine sandy loams. Standing water was only present in one portion of the reach, although the channel bed (where defined) was saturated in all locations. There is no fish access to this reach of Gages Slough, it is isolated by a large levee adjacent to the Skagit River and Highway 20 further upstream out of the Evaluation Area. Few LWD pieces were observed in the channel. Culverts are present under each of the many road crossings. Water is present year-round in only portions of the evaluation area. Levees are generally not present along the slough, although are present adjacent to the River. There is no connection at the downstream end of Gages Slough to the River, but a pump station is present to facilitate freshwater outflow.

The riparian zone is dominated by reed canary grass, Himalayan blackberry, willow and alder species. Other species include *Polygonum persicaria*, nightshade, Canada thistle, Japanese knotweed (*Polygonum sachalinense*), weeping willow, spirea, and yellow-flag iris. The riparian zone is typically one tree wide or less (less than 25 ft or 7.5 m) throughout the entire reach, except for one area south of Hwy 20 where the riparian zone is typically 80 ft on each bank. Downstream of this, the slough disappears into a seasonal wetland for a few hundred feet. In the residential areas, the riparian zone is dominated by ornamental species or has been eliminated.

### *2.7.2 Restoration Needs and Opportunities*

The riparian zone is very minimal and would definitely provide better wildlife habitat if it were expanded. Restoration options include reconnection of the slough to the Skagit River via controlled inlets, excavation of the slough channel to create a continuous flowing channel, restoration of riparian buffers along both banks, removal of non-native vegetation, and placement of LWD in the channel. However, these restoration opportunities will be limited due to the significant number of houses and other structures in close proximity to the slough.

## 2.8 Hall Slough

The evaluation area for Hall Slough extends from Skagit Bay, beneath Maupin Road, to Brown’s Slough. Although historically Hall and Brown’s Sloughs were connected, they are now separated by a strip of agricultural land. Downstream of Maupin Road is a tidal salt marsh slough constrained on both sides by levees. Agricultural land and homes are present behind the levees. Agriculture is the primary adjacent land use with approximately 4 homes and associated barns and garages present. The levee crosses the slough immediately downstream of Maupin Road. A tide gate is present beneath this levee, but is currently inoperable due to siltation behind the gate (Nolan Lee, pers. comm.). It is designed to only allow freshwater outflow when functioning. There is also a pump station at Maupin Road, which currently pumps freshwater out from behind the gate. Maupin Road and the levee that houses the pump station are the only two apparent crossings on this slough. The evaluation area was observed from the right bank levee and the marsh.

### *2.8.1 Physical and Biological Characterization*

The wetted channel width at high tide is approximately 30 ft (9 m) and has a fine silt substrate. This slough is intertidal up to Maupin Rd. No tidal exchange occurs upstream of the tide gate.

Low marsh, middle marsh, and upland vegetation are present adjacent to the channel, downstream of the tide gate. Low marsh is characterized by species such as *Scirpus maritimus* and *Carex lyngbyei*. Low marsh transitions to middle marsh which is characterized by a mixture of salt grass, *C. lyngbyei*, Pacific silverweed, and fat hen. Middle marsh abruptly converts to upland vegetation at the toe of the levees. Levee species included European dune grass (*Ammophila arenaria*), bull thistle (*Cirsium vulgare*), and velvet grass. Other species present included Watson's willow herb, tansy *(Tanacetum vulgare*), American three-square (*Scirpus americanus),* seaside arrowgrass, brass buttons (*Cotula coronopifolia*), Douglas aster, and yarrow. Upstream of Maupin Road, there is essentially no riparian buffer, consisting only of herbaceous species such as reed canary grass on the bank slopes.

### *2.8.2 Restoration Needs and Opportunities*

A small levee spur extends a few hundred feet from the main levee on the right bank into the marsh. It is an unnecessary constraint on the marsh habitat and currently a significant amount of LWD is stacked up on its west side. Replacement of the tide gate at Maupin Road would increase tidal channel habitat, although significant restoration would be required upstream since the slough is currently a ditch that runs through agricultural land with no riparian buffer. Other options include setting back the levee on the north side, downstream of Maupin Road, and reconnecting the Hall/Brown's Slough system to the NF Skagit

River. Riparian and/or wetland restoration is needed upstream of Maupin Road if reconnections are made to Brown's Slough.

Potential restoration opportunities at this evaluation area include removal of levee spur, removal of non-native species, creation of riparian buffer along banks and levees, set back levee on right bank to create a wider marsh, reconnect the slough upstream of Maupin Road, create riparian buffer upstream of Maupin Road, and reconnect upper end of Hall to Brown's Slough and reconnect Brown's Slough to the NF Skagit River to allow the system to once again function as a distributary channel.

## 2.9 Indian Slough

The evaluation area for Indian Slough extends from Padilla Bay to Highway 20. Indian Slough is a former blind tidal channel from Padilla Bay that also drained localized runoff from the surrounding wetlands. It also formerly extended southward, but has been cut-off by Hwy 20 and the RR and diverted into a roadside ditch. There are two branches of Indian Slough, Big Indian and Little Indian Slough (south and north branches, respectively). Currently, Indian Slough is tidal up to Bayview-Edison Road on both branches. Tide gates are present at the Bayview-Edison Road crossings, which prevent tidal inundation upstream (although it does back up the freshwater outflow at high tides) and is the only road crossing for both Little and Big Indian Sloughs. A pump station is present at the Big Indian Slough crossing. There are only two structures within 200 feet (60 m) of the slough. The slough was observed from the right bank levee on Little Indian Slough and the left bank levee on Big Indian Slough and from Farm to Market Road.

### *2.9.1 Physical and Biological Characterization*

All channels west of Bayview-Edison Road have a fine silty mud substrate. Marsh and channel width in both channels varied from approximately 70 to 100 ft (21 to 33 m). West of the road, Big Indian Slough has good channel sinuosity, although further meandering is constrained by levees. The Little Indian channel is more tightly confined by levees. East of Bayview-Edison Road, both channels become trapezoidal in shape, with no tidal influence or riparian habitat present. Water quality has not been measured recently, but in the 1980s there were problems with fecal coliform, temperature and DO. Levees are present along Big Indian Slough upstream of Bayview-Edison Road to the RR, where it then turns into a narrow ditch at the railroad and runs east-west immediately adjacent to the railroad line. Little Indian Slough has no levees east of the road, although it is highly channelized and has steep slopes.

West of Bayview-Edison Road, an area of low and middle marsh habitat exists between the levees on both channels. The largest channel widths are approximately 300 to 500 ft (91-152 m) downstream of the confluence of Big and Little Indian Sloughs. Marsh habitat in this area is alternately distributed on both banks or exists only on one bank. High/middle marsh vegetation was comprised primarily of *Agrostis* sp. (50%), fat hen (40%), and seaside arrowgrass (30%), with lesser amounts of tufted hair grass, prickly lettuce, ryegrass, Douglas aster, and Canada thistle. The low marsh was dominated by pickleweed

(*Salicornia virginica)* (100%) and salt grass (30%), with lesser areas of fat hen, Douglas aster, tufted hair grass, and European beach grass. Upland levee species include cherry, elderberry, and Himalayan blackberries. These species are only at the shrub stage and no trees are present. Both channels are similar in species composition, but Little Indian Slough has a much narrower area of marsh habitat because of the confinement of the levees. East of Bayview-Edison Rd the channel has limited vegetation, no tidal influence, and no trees. Dominant vegetation on the levee slopes here includes reed canary grass (80%) with lesser areas of Himalayan blackberry, and velvet grass. Agricultural uses start immediately behind the levees.

#### *2.9.2 Restoration Needs and Opportunities*

The levees on both channels confine the area of tidal influence and reduce the marsh habitat. Levees could be set back to allow greater salt marsh habitat area and creation of additional dendritic channels. The riparian zone is limited or non-existent along Indian Slough, and is composed entirely of reed canary grass and blackberries upstream of Bayview-Edison Road. Replacing the tide gate beneath Bayview-Edison Road on Big Indian Slough to allow tidal exchange would increase marsh and tidal channel habitat, and levees already exist upstream of the road to prevent saltwater intrusion and flooding at high tides. Water quality upstream of Bayview-Edison Road is highly turbid and the channel has extensive growth of aquatic macrophytes, an indicator of nutrient loading. The turbidity may be caused by suspension of fine materials or iron-fixing bacteria, and should be investigated further to determine if it would be harmful to fish. High temperatures are also a potential problem, but would be improved with tidal exchange and/or the creation of a riparian zone.

Restoration opportunities at Indian Slough include removing non-native species, setting back levees, restoring riparian buffers along the levees, and reconnecting tidal inundation upstream of Bayview-Edison Road.

### **2.10 Joe Leary Slough**

The evaluation area for Joe Leary Slough extends from Padilla Bay to Bayview-Edison Road. Historically, this slough was one of two major drainage channels for the large Olympia Marsh wetland complex (the other major drainage was the Samish River) (GLSO Map 1866-1885). It may also have periodically been a flood channel for the Skagit River (Collins 1998). Currently, tidal influence extends up to a levee crossing with tide gates about 500 ft (151 m) downstream of Bayview-Edison Road. At the levee crossing there are 12 culverts with tide gates that only allow freshwater outflow (although one gate was damaged and leaking in fall of 2001). Between the tide gates and Bayview-Edison Road, levees are not present. Downstream of the gates, the slough is constrained on both banks by dikes with agricultural lands immediately behind. The distance between the dikes is greater on this slough than most other areas (approximately 300 ft [91 m]) and allows for some natural meandering of the tidal channel and small secondary channels. Only two structures are within 200 ft (60 m) of the slough. Five road crossings appear on aerial photos, although two are known to be bridges. Other crossings could prevent fish passage if fish were allowed to access the slough.

### *2.10.1 Physical and Biological Characterization*

At the tide gates, marsh and channel width was approximately 100 feet (30 m). Water quality was visually extremely turbid, and monitoring by the Skagit Stream Team (2000) indicates that turbidity is frequently high (15-89 NTUs), with high fecal coliform concentrations (up to 400 colonies/100 ml geometric mean) and low DO concentrations (0.10 - 6.6 mg/L). Additional water quality sampling, done by WDOE in 2000, reports that dissolved oxygen and turbidity measurements exceeded state water quality criteria in every month of that year (WDOE 2002). Initially, it was thought that recent dredging in the channel just downstream of Bayview-Edison Road had caused the highly turbid water, but aerial photos from previous years show that the water has the same level of turbidity much of the year and the turbidity extends all the way upstream to the end of the slough/ditch system. The water quality conditions may be due to iron-fixing bacteria or silty runoff from farm fields or both. A large cattle ranch is located along D'arcy Road, upstream of the evaluation area, and the water quality appears very poor (turbid and foamy) downstream of the ranch. Some saltwater intrusion occurs upstream of the tidegates at high tides (gates are not closed entirely; Skagit Stream Team, 2000). Riprap is present along the right bank of the slough, downstream of Bayview-Edison Rd. The channel substrate is fine silty mud and surrounding soils are primarily silt loams and fine sandy loams.

Downstream of the levee crossing, the habitat was a mixture of low marsh, middle/high marsh and mud flat. The low marsh habitat was dominated by seaside arrowgrass (*Triglochin maritimum)* (10%), *Scirpus maritimus* (30%), salt grass (70%), and Pacific silverweed (40%). The middle/high marsh habitat was dominated by Douglas aster (20%), Pacific silverweed (75%), *Chenopodium rubrum* (50%), and salt grass (30%). On the levees, dominant species were alder, Himalayan blackberry, velvet grass, and European beachgrass. Upstream of the Bayview-Edison crossing, there is an area of natural second-growth forest vegetation along the left bank for approximately 1000 ft (300 m) and a hybrid poplar plantation along both banks, which provides some shading and buffering of the channel, temporarily.

Upstream of the poplar plantation the channel is essentially an agricultural drainage ditch, although the channel still maintains a meandering alignment similar to the historic channel alignment. There is very little riparian vegetation; a small forested patch exists on the left bank just upstream of the Bayview-Edison Road crossing. Upstream of the poplar plantation, the vegetation is typically reed canary grass on the channel slopes and some cattails in the channel, with an average width less than 5 ft (1.5 m).

#### *2.10.2 Restoration Needs and Opportunities*

The banks have steep riprap covered slopes downstream of Bayview Edison Road. The area is closely constrained by agricultural land and has very poor water quality. The water quality problems might be a hindrance to fish use, even if the slough were to be reconnected to tidal influence. However, recommended restoration would include setting back dikes downstream of Bayview-Edison Road to restore estuarine emergent marsh and blind tidal channels, creating riparian buffers along the dikes, placement of LWD in the channel, reconfiguring tide gates to allow tidal influence upstream of the levee crossing, creation of freshwater wetlands upstream for both water quality improvements and to restore portions of the historic marsh. We further recommend investigating the water quality conditions in the slough to determine the cause of the extremely high turbidity and to determine if it would be detrimental to fish.

### 2.11 No Name Slough

The evaluation area for No Name Slough extends from Padilla Bay to the edge of the flats (approximately 2600 ft [800 m] upstream of Bayview-Edison Road. This slough has likely always been the outlet for a small creek feeding into it from the adjacent hillslope (Bay View Ridge). There is a tide gate and pump station located at the mouth of the slough at Padilla Bay, which is crossed by a dike with a public trail. There is some brackish water influence for a short distance upstream of the trail dike (Skagit Stream Team, 2000), although primarily the freshwater is backed up during high tides. Fish can access the slough during low and medium tides, but not while water is being pumped out. Adult coho salmon have been observed spawning in the creek further upstream of the evaluation area (D. Bulthuis, pers. comm.). Upstream of the trail there are no levees on either bank. All adjacent land uses in the evaluation area are agricultural or recreational (trail). Three road crossings are apparent on aerial photographs. Land use upstream of the evaluation area along the creek is rural residential.

#### *2.11.1 Physical and Biological Characterization*

This slough has an average channel and marsh width of 19 ft (5.8 m) with a fine silt and organic muck substrate. Water was relatively clear, but a solid cover of algae was present. Monitoring by the Skagit Stream Team (2000) indicates that water quality is moderately impaired by high turbidity (3-121 NTUs) and high fecal coliform concentrations periodically (up to 540 colonies/100 mL geometric mean). Juvenile fish (unidentified) and crabs were observed west of Bayview-Edison Road. A culvert is present under Bayview-Edison Road and another culverted crossing is present a short distance downstream, but there are no additional tide gates. Immediately upstream of Bayview-Edison Road there is a small patch of riparian buffer along the right bank dominated by rose, blackberries and willow; however, the buffer only extends for a short distance past the road, and then becomes dominated by reed canary grass on the bank slopes with agricultural crops immediately adjacent. The water quality visually appears to become worse (more turbid, more algae) upstream of Bayview-Edison Road.

Riparian vegetation west of Bayview-Edison Road is limited to less than 25 ft (7.5 m) in most locations and is comprised of shrubs and herbs such as ninebark, willows, and blackberries, with no mature trees. The east side runs through agricultural land as well and has limited riparian habitat comprised primarily of non-natives such as reed canary grass and blackberries. However, the tributary stream flows through forested land on the hillslope with second growth cedar, big leaf maple and cottonwood. The dominant riparian species west of Bayview-Edison Road included rose (*Rosa nutkana*) (60%), tufted hair grass (40%), and evergreen blackberry (*Rubus laciniatus*) (30%), with lesser areas of ninebark, Himalayan blackberry, reed canary grass, Canada thistle, willow, spirea, and cherry.

#### *2.11.2 Restoration Needs and Opportunities*

It appears that backup of freshwater at high tides is the only tidal influence in No Name Slough. Installing an SRT that allows tidal exchange upstream of the trail would increase estuarine channel and marsh habitat as well as provide better fish passage for both juveniles and adults to and from the system. This may necessitate construction of levees to protect the agricultural land from saltwater intrusion, although some of the farmland is owned by the Padilla Bay Estuarine Research Reserve. Another option would be to widen the channel area to allow more capacity for drainage and formation of estuarine wetland habitat. Removal of non-native species and revegetation with native shrubs would be beneficial along the levees. Setback of the levees along the bay would increase the mudflat and marsh area and allow natural development of blind channels.

### 2.12 Sullivan Slough

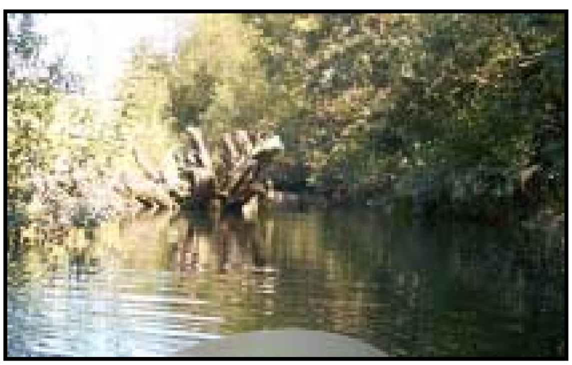
The evaluation area for Sullivan Slough includes Sullivan Slough from the Swinomish Channel connection to Skagit Bay and some additional blind tidal channels to the southwest of the slough. Historically, the slough was a large tidal channel from Skagit Bay with several branches and it also drained a large wetland area to the west of the NF Skagit River. The slough exists in its historic alignment from Skagit Bay up to the Chilberg Road crossing, and then as agricultural ditches and a constructed spur channel that outlets to the Swinomish Channel. Several houses are adjacent to the slough downstream of Chilberg Road as is the City of La Conner’s sewage treatment plant. Several structures are adjacent to the manmade channel flowing into the Swinomish Channel.

Tidal influence extends up to Chilberg Road on the main channel, while on the spur channel, tidal influence ends at the first road crossing (approximately 500 ft [152 m]). Downstream of Chilberg Road it is a tidal brackish slough constrained by levees on both sides and surrounded by agricultural land. The

City of LaConner's wastewater treatment plant is located south of Chilberg Rd on the right bank and occupies approximately 5 acres. North of Chilberg Rd. the spur channel is a trapezoidal ditch with little to no riparian vegetation or instream habitat. It runs first through agricultural land and then through the City of La Conner in a riprapped channel. The spur channel has 2 road crossings and the main channel is crossed only by Chilberg Road. There is no tidal exchange at Chilberg Road because of an elevated, gated culvert and pump station.

### *2.12.1 Physical and Biological Characterization*

Sullivan Slough, south of Chilberg Road, is comprised of a braided channel system, which runs through an approximately 500 ft (152 m) wide brackish and salt marsh habitat, constrained on both sides by levees. The area is a mosaic of salt and fresh water, riparian, and upland habitats. A narrow riparian zone has become established on the levees. The dominant vegetation was *Carex lyngbyei* (60%), willow (40%), broad leaf cattail (40%), and narrow leaf cattail (30%) with lesser cover of kneeling angelica (*Angelica genuflexa)*, impatiens, Douglas aster, *Scirpus validis*, horsetail (*Equisetum telmateia*) and reed canary grass. Cottonwoods were also present adjacent to and on the levees. Levees on both banks were overgrown with willows, cottonwoods and upland shrub species. The high invasive purple loosestrife (*Lythrum salicaria*) was also observed in at least one location in the slough. The diversity of vegetation is high and generally dominated by native species, and communities transition from riparian to brackish marsh to saltwater marsh habitat. Apparently, since the construction of the jetty between the Swinomish Channel and the NF Skagit River, Sullivan Slough has been filling in with sediment (Steve Hinton, pers. comm.). Much of what was formerly intertidal mudflat or shallow subtidal habitat is now transitioning to vegetated salt marsh.



The wetted width of the slough, downstream of Chilberg Road, during high tide varies between approximately 10-40 ft (3-12 m). Substrate was fine mud and sand and surrounding soils are primarily sandy loams and silt loams. Water was only slightly turbid. Numerous pieces of LWD were present, many of them fallen cottonwoods from the adjacent riparian zone. Numerous branching blind channels exist in this marshy area.

The additional evaluation area includes a blind channel southeast of Sullivan Slough and two agricultural ditch systems further southeast, all on private property. These sites were not accessible and no observations were made of their conditions. Aerial photos indicate that these blind channels have tidegates at their outlets and some limited shrubby growth on the dikes. All land use immediately adjacent is agricultural.

### *2.12.2 Restoration Needs and Opportunities*

This area offers an excellent opportunity for protecting and enhancing an area of good habitat immediately adjacent to the NF Skagit River. Levee setbacks would increase estuarine emergent habitat area. Reconnection with the upstream area north of Chilberg Rd. would provide a greater area of slough habitat and allow an additional connection between the Swinomish Channel and Skagit Bay. Water quality is a concern north of Chilberg Road due to agricultural runoff and elevated turbidity. As with many other sites, it is recommended that an investigation of water quality conditions and potential effects on fish be completed prior to implementing restoration measures that would allow fish access to the agricultural drainage system. Riparian buffer restoration should be included for any reconnection to upstream areas. Non-native vegetation removal would further enhance the habitat. There may be a need to breach the jetty to allow greater flushing of sediment out of the NF Skagit River to reduce sediment buildup at the outlet of Sullivan Slough and to improve water quality conditions in the Swinomish Channel (Steve Hinton, pers. comm.). The existing deposition of sediment is increasing salt marsh habitat in Skagit Bay and reducing former mud flat and channel habitat. Although this is a natural process of mountain weathering and sediment transport, it has been increased as a result of the jetty and increased sediment transport down the North Fork due to channelization and reduction of overbank flows (the floodplain would have formerly accumulated much of the sediment transported down the river). The City of La Conner is investigating putting a stormwater runoff outlet into the Slough adjacent to the wastewater treatment plant. This would provide more freshwater runoff into the slough, but would also introduce pollutants and potentially increase water temperatures.

## 2.13 Telegraph Slough

The evaluation area extends from Highway 20 south to the Swinomish Channel, including Blind Slough and lower Higgins Slough. This system is part of a historically large blind channel system from Padilla Bay that may have occasionally received flood overflows from the Skagit River, and also received drainage from freshwater wetlands. Currently, this system has some tidal influence from the Swinomish Channel, but not from Padilla Bay. There are no culverts beneath Highway 20. The surrounding land use is agricultural with one house located near Highway 20, and several houses more than 200 ft south of the slough, adjacent to the Swinomish Channel. The slough is crossed at Highway 20 and again at the downstream end where the tide gates exist. Levees are present on the left and right banks throughout much of the system, but are old and generally overgrown with shrubs and trees. Tide gates are present at the Swinomish Channel that allow generally continuous tidal exchange. The majority of Telegraph Slough was walked and Blind and Higgins Sloughs were observed from the levee along the Swinomish Channel.

### *2.13.1 Physical and Biological Characterization*

A tidal channel is present throughout Telegraph Slough, ending in high salt marsh immediately south of Highway 20. The slough is a mosaic of upland, riparian, high marsh, middle marsh and low marsh habitats. In low marsh areas, braided channels of silt/mud substrate were present, and became more defined and larger with less vegetation as they neared the Swinomish Channel. The water that does not drain entirely out of the slough was highly turbid and had extensive algae growth on the surface. In at least two locations within the Slough, two low marsh channels are present and separated by upland islands. The Slough is bordered at both right and left banks by levees.

In the marsh habitats, dominant plant species included salt grass (70%), pickleweed (20%), *Chenopodium* sp. (30%), tufted hair grass (*Deschampsia cespitosa*) (30%), *Scirpus maritimus* (20%), *Heracleum lanatum* (10%), Canada thistle (5%), bull thistle (10%), prickly lettuce (5%), and *Juncus effusus* (10%). Uplands were dominated by velvet grass (50%) and tufted hair grass (30%), with lesser areas (<15%) of mountain ash (*Sorbus scopulina*), foxglove (*Digitalis purpurea*), evergreen blackberry, cherry species, fireweed *(Epilobium angustifolium*), goldenrod, Himalayan blackberry, and pearly everlasting (*Anaphalis margaritacea*). Other species observed adjacent to the slough included cottonwood (*Populus balsamifera*), alder, spirea, European weeping birch, yarrow, *Agrostis* sp., and Pacific silverweed.

### *2.13.2 Restoration Needs and Opportunities*

Reconnection of Telegraph Slough to Padilla Bay would increase the amount of tide channel and marsh habitat available in the Padilla Bay system. Connections would need to be made via culverts or a bridge at the Highway 20 crossing and railroad crossing. The existing tidal connection at the Swinomish Channel could be improved by enlargement of the existing culverts and installation of SRTs. This area would have a high chance of successful restoration since the portion of the slough north of Highway 20 is within the Padilla Bay preserve and already has a relatively large area of high quality natural habitat. Removal of non-native species and enhancement of the riparian zone would further improve this area for wildlife use. Levees could be setback to create additional marsh area.

Restoration opportunities include setting back levees, reconnecting the slough to Padilla Bay, increasing tidal exchange at the Swinomish Channel, removing non-native species, enhancing and widening the riparian zone along levees, and placing LWD in channel.

# 3.0 RESTORATION OPPORTUNITIES AND CONSTRAINTS

## 3.1 Known Problems, Causes and Significance of Impacts

Anthropogenic alterations to the Skagit River delta region include changes to hydrology, sediment transport, riparian zone, floodplain, and water quality, and have caused significant elimination or isolation of natural habitats. The causes of these alterations are similar having resulted from the development of the floodplain for agricultural and urban purposes. The known problems discussed below are evident at each of the evaluation areas to some degree. A matrix has been prepared at the end of this section to summarize the problems present at each evaluation area and their overall level of functioning (Table 3).

### *3.1.1 Altered Hydrologic Regime*

Changes in land use from human settlement and development have altered the hydrologic regime in the Skagit River basin from historic conditions. Upstream, the river has been modified by the construction of dams, removal of forest cover and increased amounts of impervious surfaces in the watershed, which have increased the rate and volume at which precipitation and runoff enter stream channels, but have also reduced flood peaks significantly. Construction of dikes and levees reduces overbank flow frequency and depth, resulting in diminished floodplain storage and groundwater recharge, and prevents tidal inundation in the estuarine zone. Agricultural ditches and tiles constructed in the floodplain have drained former wetlands and also lower the water table and further decrease groundwater inputs to the river system (upstream of the tidal zone) during low flows. Construction of tide gates, culverts, and dikes further prevent tidal flows and have changed large areas of the delta from estuarine to freshwater systems.

All of these factors contribute to a hydrologic cycle that is significantly different from historical conditions. High flows result in scour of the channel bed and banks (including scour of redds, and increased sediment and LWD transport) and increased sediment transport downstream to the delta (which was formerly deposited in the floodplain). Off-channel and wetland habitats have been substantially reduced and are generally disconnected from the river, except during major flood events. The tidal zone has been significantly reduced, although the estuarine marsh is prograding out from the North and South Forks to some extent. The vast majority of historic sloughs and other waterways within the delta have been channelized and diked, and are artificially controlled via gated culverts and pump stations. This has dramatically reduced the area of estuarine tidal habitats: approximately 68% of the estuarine emergent marsh, 66% estuarine forested transition and 84% of riverine tidal habitats have been lost as a result of the altered hydrologic regime and other factors (Collins and Montgomery 2000). These changes will continue to place constraints on restoration of habitat. Tidal and river influences can be restored to some areas, but human uses of the delta will preclude a return to anything close to the historic conditions. The vast former Olympia Marsh has been drained for agriculture and now rarely receives flows from the river. This cuts off a major flood storage area and Fir Island has now become the current major flood distributary area.

### *3.1.2 Alterations to Sediment Supply and Delivery*

Changes in sediment load and transport within a system can significantly alter in-channel habitats. A lack of cobble/gravel sediment supply or increased transport rates of coarse sediments leads to decreased salmon spawning and rearing areas. An increase in fine sediments can cover over existing spawning areas and reduce egg survival as well as eliminating preferred invertebrate prey species. Sediment quality is an indicator of erosion and deposition processes in the watershed. Sediment conditions can become poor in the Skagit River delta region as a result of increases of sediment to estuarine and freshwater channels as a direct result of urbanization, forestry, livestock grazing, and other agricultural land uses. Additional factors include increased peak flows, a lack of LWD to maintain coarse sediment within the channel, channelization of streams and sloughs, and the lack of overbank flood flows which formerly deposited significant amounts of sediment in the floodplain. The mainstem and North and South Forks have likely incised as a result of increased sediment transport, and the marshes and mudflats in Skagit Bay have significantly increased as a result of sediment transport to the delta.

Areas that were formerly connected to the river used to receive sediment on a regular basis; now, that sediment supply is cut off. These sloughs, however, are likely now at an elevation that is significantly higher than the mainstem or North and South Forks due to main channel incision and due to the fact that many of the distributary channels and side channels were historically formed and connected due to backwater on the mainstem from LWD and other channel obstructions. Any restoration efforts will need to obtain detailed topographic surveys to determine if excavation is necessary to reconnect the sloughs. Areas that are currently farmed and located behind dikes and levees have also experienced subsidence as a result of the lowering of the groundwater table (which causes drying and compaction of organic enriched soils), lack of sediment deposition from frequent flooding, and farming activities which remove organic material that might otherwise accumulate in the soil and also from compaction due to use of equipment. Many areas that are behind sea dikes are now lower than the estuarine areas outside of the dikes.

### *3.1.3 Loss of Riparian Zone*

Degraded and nonexistent riparian buffers are the result of timber harvest, fires, agricultural use, and urban development. Unsuitable buffering occurs in areas where no vegetation exists, where vegetation is sparse, or where vegetation is primarily composed of non-native species or young deciduous trees. In areas with little or no vegetation, inadequate shading can lead to increased water temperatures, which limit fish survival and reproduction. These areas also fail to provide LWD recruitment, which is crucial for instream cover, and do not provide a buffer for stormwater runoff or other human activities. Riparian zones composed primarily of deciduous forest are also typically unable to provide adequate LWD recruitment because deciduous trees decompose more rapidly than coniferous species. A lack of LWD leads to increased sediment transport, decreased pool habitat, and increased scour. Narrow or otherwise poor riparian zones also lack adequate cover or habitat for wildlife movements along stream corridors.

Recent actions to develop a sensitive areas ordinance to improve water quality and habitat are directed at the lack of riparian vegetation within the lower Skagit River area and the need to restore this resource. Field observations revealed that many sloughs within the delta region have extremely limited riparian vegetation, due to dike maintenance and constraints posed by roads, agricultural uses, and residential development. Many areas, particularly those adjacent to agricultural land uses, have no riparian buffer at all. Currently, the sensitive areas ordinance does not require buffers along sloughs or ditches that are not directly connected to salmon bearing water bodies. If salmon access is restored to any of these evaluation areas that currently do not have salmon access, then ditches and tributaries feeding into the restored area would be required to have buffers. Even if not required, a lack of buffers on upstream areas would reduce the habitat value of any restoration downstream because of the continued water quality problems.

### *3.1.4 Floodplain Connectivity and Function*

A lack of off-channel and wetland habitats are associated with changes in the hydrologic regime, a reduction of floodplain connectivity and channel migration due to the construction of dikes and levees, and development of floodplain areas. The conversion of active channel migration zones to a single confined river channel has occurred in many areas as a result of roads, levees, bank armoring, and channel realignment to facilitate agricultural and urban development. Rip-rap and channelization prevent lateral migration of the channel and subsequent development of off-channel habitats, which are important rearing and refuge areas for salmonids. Channelization and reduced floodplain connectivity also contribute to increased bed scour during higher flows because the flows are entirely contained within the channel, rather than spreading out into numerous side channels and floodplain storage areas. These higher flows in the channel can scour/destroy spawning areas and reduce other habitat features such as pools and LWD, and may further reduce floodplain interactions by promoting channel incision.

Estuarine and tidal connectivity has been reduced in the delta region as well. Diking, use of tide gates to prevent tidal inundation, channelization, infill, and development have resulted in a significant reduction of estuarine marsh and tide channel habitat. These areas are crucial for providing habitat for salmon rearing and wildlife. Estuarine emergent marsh habitat has expanded adjacent to the North Fork mouth as a result of increased flows and sediment loads in the North Fork.

### *3.1.5 Isolation of Habitat*

Aquatic and terrestrial habitats that are disconnected from adjacent upstream, downstream, and upland habitat are considered isolated. Urbanization and agricultural development are the primary causes of isolated habitat and includes blockages such as dikes, tidegates, or impassable road crossings. In addition, stretches of degraded habitat can also act as an isolation mechanism. As salmonids pass through sloughs and streams, for example, high temperature areas may prevent further movement, actively isolating the suitable habitats upstream or downstream. Many of these blockages and fragmented areas occur within the Lower Skagit River area. Restoration actions will need to address not only the lack of physical connectivity, but water quality barriers.

#### *3.1.6 Water Quality*

Water quality in the project area has been negatively affected directly by human activities and loss of wetlands, riparian buffers, and floodplain connectivity. High water temperatures are the most common problem and can greatly reduce the survival and reproduction of salmonids, which are adapted to cooler temperatures. High temperatures and their associated impacts are frequently due to loss of tree canopy and shading, and reduced low flows (caused by impervious surface runoff, reduced groundwater discharge to streams and water withdrawals). Although water quality is typically not the primary goal of restoration actions, it may be enhanced directly or indirectly in areas where poor riparian and floodplain conditions are addressed.

The primary water quality problems within the project area include high temperatures, fecal coliform exceedances and low dissolved oxygen. A total of five of the evaluation areas have been listed on the 303(d) list of impaired waterbodies for one or more of these problems, and other areas may become listed as more data is acquired. Browns Slough from its mouth to Fir Island Road is listed for exceeding fecal coliform standards. Carpenter Creek exceeds fecal coliform standards in Reach 3 and temperature in Reaches 2 and 3. Both Joe Leary and Big Indian Slough are listed for dissolved oxygen, fecal coliform, and temperature. No Name Slough has been listed for dissolved oxygen and fecal coliform impairments upstream of Bayview-Edison Road. Adjacent listings in the study area include fecal coliform exceedences in Gages Slough at its downstream end and in the Skagit River upstream of Conway. While the 303(d) list is a good starting point for understanding water quality conditions for a waterbody, it may not be a comprehensive picture of the conditions for the region. A lack of data collection or delays in the process of listing a waterbody may result in failures to include certain waterbodies on the 303(d) list which would otherwise qualify for listing.

### 3.2 Other Issues and Constraints

#### *3.2.1 Risks to Private Landowners*

The Skagit valley has been highly modified in order to allow agricultural and urban development. The Skagit valley is very flat and was formerly mostly wetland with a water table at or above the surface. Agriculture would be difficult if not impossible without the draining of wetland areas and a reduction of flooding frequency. Drain tiles and agricultural ditches exist to drain the water table down lower to allow crops that are not adapted to wet conditions to survive in the surface soils. Blocking off sloughs to either river flows or tidal inundation helps to maintain lower groundwater tables, particularly when pump stations are also utilized to pump water out when it reaches a critical elevation. The drainage of the water table also facilitates the drainage of nutrients, herbicides and pesticides. Many farmers use large quantities of fertilizers and herbicides or pesticides. These chemicals can accumulate in the soil and cause mortality to crops if they are not drained away. These chemicals can also cause great harm to aquatic ecosystems. A preferred approach would be to significantly reduce the use of these chemicals.

Tidal inundation can also introduce salts into the water table and destroy non-salt tolerant plants, such as the agricultural crops grown throughout the project area. The system of tide gates and dikes within the sloughs is designed to protect crops from damages caused by both flooding and saltwater intrusion. Very little research has been done in Washington regarding saltwater intrusion and even less information is available for saltwater intrusion into agricultural lands. Although saltwater encroachment is of major concern to farmers in the project area, the true extent of intrusion via sloughs has never been studied. In previous years, the Natural Resources Conservation Service (NRCS) assisted farmers with drainage of their farmland if conductivity was found to exceed a certain level (an indicator of salts). However, conductivity data are protected from the Freedom of Information Act and can only be obtained with permission of the landowners (Steve Nissley, pers. comm.).

In general, saltwater can enter agricultural lands through surface flooding at high tide or via groundwater. In the winter, rainwater leeches salt out of the soil profile. During the summer, salt may wick back up into soils, especially in soils with poor tilth. Typically, the lower tilth soils have the greatest saltwater encroachment problems due to poor drainage and overworking (Steve Nissley, pers. comm.). Low tilth soils are those that are highly farmed, have poor drainage, and are used to grow low residue crops, meaning that little organic matter remains in the soil following harvest. Poor tilth soils retain salt, which further reduces the soil quality, creating a cycle that is difficult to break. Several poorly drained soils are present around the evaluation areas, including silty clay loams and fine sandy loams (NRCS 1989).

The use of self regulating tide or flood gate structures would alter hydrologic conditions in surrounding areas. In some cases these structures do not allow complete drainage and may elevate the water table. These alterations can reduce crop cultivation success if the water table rises into the root zone of the crops.

#### *3.2.2. Hydrologic and Other Upstream Conditions*

The presence of dams on the Skagit River will continue to significantly reduce natural flood flows for the foreseeable future. Additionally, the formerly massive LWD jam that occurred at the approximate location of Mt. Vernon is not likely to ever be replaced. These two conditions have dramatically changed the extent of the floodplain from historic conditions. Today, many sloughs and wetlands that were formerly connected to the river on a frequent basis cannot be reconnected without major effort to excavate channels and divert flows (i.e. Samish River and other sloughs that drain into Samish and Padilla Bays; Gages and Britt Sloughs that now are likely much higher than the river channel).

Levees line the majority of the Skagit River from Sedro Woolley along both forks to their outlets on Skagit Bay. These levees were constructed to protect development behind the levees in the floodplain.

Removing or breaching levees will almost always require the construction of new levees set further back in order to prevent significant economic damages.

**Table 3. Level of known impacts at each evaluation area (L=low, M=medium, H=high).**

| **Evaluation Area** | Altered Hydrologic Regime | Alterations to Sediment Supply and Delivery | Loss of Riparian Zone | Floodplain Connectivity and Function | Water Quality | Isolation of Habitat | Number of Landowners | Presence of Structures |
|---|---|---|---|---|---|---|---|---|
| Britt Slough | H | H | H | H | H | H | H | H |
| Brown's Slough | H | H | L[1] | H | H | H | M | M |
| Carpenter Creek | L | M | H | H | H | M | H | M |
| Dry Slough | H | H | L[1] | H | H | H | H | H |
| Edison Slough | M | M | H | H | H | M | M | L |
| Gages Slough | H | H | H | H | H | H | H | H |
| Hall Slough | H | H | L[1] | H | H | H | M | L |
| Indian Slough | H | M | L[1] | M | M | M | M | L |
| Joe Leary Slough | H | M | H | M | H | H | L | L |
| No-Name Slough | H | M | L[1] | M | M | M | L | L |
| Sullivan Slough | M | H | M | M | M | M | M | M |
| Telegraph Slough | H | L | L[1] | M | L | M | L | L |

[1]These sloughs were historically located primarily in the estuarine emergent marsh zone, so did not have riparian vegetation historically. Now that they have been converted to primarily freshwater systems, it may be appropriate to provide riparian buffers to improve water quality.

# 4.0 RESTORATION ALTERNATIVES

## 4.1 Restoration Components Described

Restoration features and alternatives were identified based on the need to address the known habitat problems identified above. This study prioritizes restoring estuarine hydrologic functions and habitats that are of particular importance to chinook salmon, although two of the evaluation areas are upstream of tidal influences. Restoration elements that have been proposed below are intended to restore natural hydrologic functioning, riparian buffers, floodplain communities and functions, habitat connectivity, and contribute toward restoring natural sediment transport processes and water quality conditions. These improvements are intended to increase the amount and quality of habitat available to chinook and other salmon species. The alternatives described below reflect this focus on estuarine habitats and chinook salmon.

Because known problems and constraints are similar throughout the evaluation areas, the proposed restoration measures are also frequently similar. Proposed measures include alterations to dikes and levees, tide gates and culverts, riparian revegetation, estuarine and freshwater wetlands, LWD placement, construction of livestock fencing, and removal of non-native vegetation. Each of these components are described in the following sections.

### *4.1.1 Dike or Levee Setback/Breaching*

Several options for dike or levee alterations exist, including levee setback, breaching of existing levees, and construction of new levees as necessary to prevent flooding induced by setback or breaching. Some form of levee reconfiguration is proposed in almost every proposed restoration alternative. Levee setback allows for existing levees to be relocated away from the existing waterbody. It is the most efficient way to increase the area of habitat because it allows more area to be inundated through tidal fluctuations or natural stream flow. This will promote natural hydrologic processes in the area and will initiate the return to properly functioning conditions. Levee setback allows for the recovery of estuarine or floodplain habitat through natural recolonization of native vegetation, increases habitat connectivity and diversity, allows the formation of additional channels, and creates a buffer between the aquatic habitats and agricultural or otherwise developed lands, which improves water quality.

In some cases, levees are proposed in areas where they do not currently exist in order to protect adjacent land uses when hydrologic connections are re-established by the removal of gates or other control structures on upstream or downstream portions of the waterbody or behind where levees will be breached. Removal of tide gates may necessitate protection of the surrounding lands through construction of levees.

### *4.1.2 Removal or Reconfiguration of Fish Passage Barriers*

Culverts, tide gates, levees and other infrastructure within streams and sloughs reduce habitat connectivity and may act as partial or complete fish passage barriers. Tide gates and pump stations have been placed for the purpose of drainage, and by design, typically prevent the movement of water upstream.

Restoration measures have been proposed that include the replacement, relocation, or removal of flood control structures and culverts, as well as the excavation of fill materials and/or debris, for the purpose of improving fish passage, natural hydrology, sediment transport, and habitat connectivity.

### *4.1.3 Riparian Revegetation*

Historically, saltwater influence likely reached to roughly the 5 to 6 foot elevation, based on historic studies in Ebey Slough (Snohomish delta) and the Oregon coast (Collins 1998). For this reason, we have delineated the delta restoration alternatives into 3 vegetation classes. Vegetation in areas of 0-5 ft elevations will be salt or brackish species, will transition to freshwater species between 5-10 ft elevations, and will be upland species at 10 ft elevations and above (does not apply to upper Carpenter Creek, Britt or Gages Sloughs which are upstream of tidal influence). In some cases, both salt and fresh water habitat types are present at the same evaluation area. Restoration in these areas reflects the transition from tidal, saltwater to upstream freshwater habitats (e.g. Edison Slough).

Two saltwater influenced vegetation classes are present in the evaluation areas, including estuarine emergent/scrub-shrub wetland mosaic and forested tidal lands. Vegetation restoration measures for estuarine habitats do not include plantings. Instead, these areas will be allowed to naturally recolonize the habitats opened up to tidal inundation following restoration. However, it may be necessary to excavate small low-flow channels to facilitate this recolonization or even provide fill in areas of substantial subsidence. Forested tidal systems are primarily freshwater and dominated by trees and shrubs. Areas where this type of habitat would be likely to occur will be planted with species such as red alder, Sitka spruce, willows, ninebark and crabapple, as necessary.

Freshwater riparian vegetation may include emergent species along the stream bank or in floodplain wetlands, but would primarily consist of shrubs and trees adjacent to the stream bank, which transition to upland coniferous forest. Upland species would also be coniferous forest and other species that do not prefer hydric soils. In general, riparian and upland species will be planted on levees adjacent to estuarine habitats and riparian species will also be planted along freshwater streams and sloughs. Widths for the riparian/upland buffers vary with each alternative, depending on adjacent land uses and structures or on the width of the levee that they will be planted on. However, the minimum width should be 25 ft and maximum widths extend as wide as 1000 ft. Appendix A includes a list of proposed species for riparian and wetland plantings and densities for freshwater revegetation alternatives.

In both salt and freshwater habitats, these areas provide essential habitat for wildlife species, contribute to the nutrient cycling of the waterbody, allow for recruitment of LWD and small woody debris, provide cover via overhanging vegetation, and provide shading which reduces water temperature.

A final component of vegetation restoration is the removal of non-native species. Many evaluation areas have extensive cover of blackberry, reed canary grass or other non-native species. Removal will facilitate the growth of native species.

### *4.1.4 Estuarine and Freshwater Wetland Creation*

Freshwater wetlands can be created to increase salmonid rearing habitat adjacent to freshwater channels, improve habitat diversity for wildlife, and improve water quality. Many areas proposed for wetland creation are currently in use as agricultural lands. For this reason, these areas are typically comprised of non-native monocultures and would require wetland plantings and non-native species removal. Appendix A provides a list of species recommended for freshwater wetland plantings.

Estuaries are typically composed of a mosaic of marsh areas made up of emergent, salt-tolerant species, pockets of scrub-shrub wetlands, forested tidal wetlands, and small areas of upland vegetation. Telegraph Slough south of Highway 20 is a good example of this type of mosaic. As described above, these areas would not be planted, but would be allowed to recover through natural succession after being opened to tidal inundation.

### *4.1.5 Placement of LWD*

Placing wood in the evaluation areas will increase habitat diversity, provide cover and promote the formation of pools and riffles because wood traps sediment and creates a diversity of hydraulic conditions. Historically, huge numbers of logs and enormous jams were present in the Skagit River (Collins 1998). Construction of engineered log jams and placement of other wood throughout the evaluation areas may be appropriate but will require detailed design analysis to ensure that infrastructure are not at undue risk from the downstream movement of wood.

### *4.1.6 Livestock Fencing*

Livestock fencing is proposed for evaluation areas that are adjacent to lands that are used by commercial ranching, dairy farms, or domestic animals. Streams and sloughs exposed to livestock and livestock wastes are often reported to have higher fecal coliform counts, increased turbidity, and lower dissolved oxygen. In addition, livestock access to slough and streams increases streambank impacts, causing erosion and loss of riparian vegetation. Currently, the Skagit River and six of the evaluation areas identified in this report have been listed on the 303(d) list of impaired water bodies for exceedance of fecal coliform standards. Effective livestock fencing must exclude livestock from water bodies without exception. This requires landowner willingness and possibly the provision of pumps and tanks for alternative water supply for the animals.

### *4.1.7 Reconfiguration of Bank/Channel*

In many areas, slough or stream banks are steeply sloped, which causes decreased stability and increased erosion and landsliding. Sloping banks back to a flatter slope allows for riparian revegetation to have a higher rate of success since it is more stable, and it allows for a wider band of riparian vegetation. Widening the channels as well as sloping banks back also increases the capacity of the channels which may reduce effects on the groundwater table and adjacent farms from river and tidal reconnections. Currently, many of these steeply sloped banks accommodate only non-native species such as reed canary grass or Himalayan blackberry. In evaluation areas with steep banks, sloping to a minimum of 2:1 or 3:1 ratio is recommended.

## 4.2 Proposed Restoration Alternatives

A total of 52 action restoration alternatives have been proposed for the 13 evaluation areas. In this section, we will describe 3 action alternatives for each evaluation area, for a total of 39 described alternatives. The 3 action alternatives will include a maximum, moderate, and minimum alternative. In general, the maximum alternative proposes a significant suite of restoration elements possible in the evaluation area, without regard to current land uses or condition. The minimum alternative proposes only those elements necessary for a small degree of improvement for either chinook access or wildlife habitat. The moderate alternative is a compromise between the two. Each of the conceptual restoration planviews and several representative cross-sections are provided in figures at the end of this report.

Although the primary goal is to improve habitat area and functioning for chinook and other salmonids, several alternatives propose restoration measures intended primarily to benefit wildlife species, especially when salmonid benefits are likely to be limited. However, the focus of most alternatives is to improve chinook and other salmon species habitat.

Each of the alternatives are highly conceptual at this stage and will require significantly more detailed design-phase analysis prior to implementation. It will also be necessary to evaluate each restoration plan for compatibility with the any future proposed flood damage reduction alternative. For example, Telegraph and Indian Slough are near the proposed floodway bypass location and may be incorporated into that flood control alternative if desirable. However, none of the restoration alternatives proposed in this report have been designed to specifically be combined with any particular flood damage reduction alternative at this stage. Planviews (1-39)and cross-sections (A-I) are provided at the end of this section. Cross-sections have not been completed for each site, but are general conceptual renderings of types of restoration projects. The examples of Britt Slough and Dry Slough have been used for cross-sections.

### *4.2.1 Britt Slough*

The minimum alternative for restoration at Britt Slough, a former side channel to the Skagit River, includes the least amount of restoration components needed to improve fish and wildlife habitat. The minimum alternative is proposed to include riparian revegetation to a maximum width of 50 feet on each bank, replacement of the existing tide gate at the downstream end with a self-regulating tide gate (SRT) that allows greater tidal exchange and fish passage, the removal of fill material and culverts that could impede fish passage, the construction of livestock fencing in some areas, and placement of LWD.

The moderate alternative includes each of the measures proposed for the minimum alternative. It is also proposed that an upstream connection be created with the Skagit River through excavation of an inlet to the east of the water treatment plant. In addition, the riparian revegetation zone should be expanded to a maximum of 100 feet where possible and wetlands should be recreated near the downstream end of the slough. This will be accomplished through easements or purchase of lands in the area and the relocation of Britt Slough Road will not be necessary. Because of the steep bankslopes of Britt Slough, it is recommended that the slopes be regraded to a 2:1 minimum slope.

The maximum alternative includes measures that would open up several hundred acres of habitat between the Skagit River and Britt Slough and result in the creation of conditions that most closely resemble the historical side-channel condition. An inlet would be excavated from the Skagit River at the upstream end of Britt Slough and the tide gates at the downstream end would be removed. The land between the river and newly reconnected side-channel would be returned to natural influences, requiring the purchase of all lands in the area. Britt Slough Road would be set back by approximately 100 ft and would be constructed on or adjacent to a 100-year flood protection levee. The existing levees along the Skagit River would be utilized to construct new levees, or could be breached in several locations to allow flooding of the reclaimed area. This area would also be replanted with riparian vegetation along both the Skagit and Britt Slough. Wetlands would be recreated in naturally low elevations, requiring minimal excavation, and small pockets of upland species would be planted throughout the area. The remainder of the area would be allowed to recover plant species naturally, although extensive non-native species removal would be required.

| Summary of Britt Slough Alternatives | | | |
|---|---|---|---|
| **Restoration Elements** | **Minimum** | **Moderate** | **Maximum** |
| Reconnection | | Inlet from Skagit River | Inlet from Skagit River |
| Tide Gates | Replace with SRT | Replace with SRT | Remove |
| Britt Slough Road | | | Setback 100' |
| Levees | Revegetate | Setback | Setback and Breach |
| Culverts | Replace | Replace | Remove |
| Riparian Revegetation | 25-50' | 100' max | 50% of reclaimed area |
| Wetlands | | Excavate as necessary | Excavate as necessary |
| Slope | | 2:1 | 2:1 |
| **Planview/ Cross-Section** | **1/G** | **2/H** | **3/I** |
| **All Alternatives Include:** | • Removal of debris and fill material<br>• Construction of livestock fencing<br>• Placement of LWD<br>• Removal of non-native plants | | |

### *4.2.2 Browns Slough*

Browns Slough extends from the North Fork Skagit River southward, beneath Fir Island Road, to Skagit Bay. The minimum alternative proposes to concentrate restoration efforts south of Fir Island Road only. Here, non-native plant species would be removed from the marsh and levees, and the levees would be revegetated. Marsh species would be allowed to naturally recover. The levee that crosses the slough between Fir Island Road and Skagit Bay would be removed and the SRT structure would be relocated to Fir Island Road. LWD would be placed within the slough.

| Summary of Brown's Slough Alternatives | | | |
|---|---|---|---|
| **Restoration Elements** | **Minimum** | **Moderate** | **Maximum** |
| Reconnection | | | Inlet from NF Skagit River and connection to Hall Slough |
| Tide Gates | Relocate SRT to Fir Island Road | Relocate SRT to Browns Slough Road | Remove |
| Levees | Revegetate south of Fir Island Road | Construct new levees between Browns Slough and Fir Island Roads, setback existing levees to ~500' | Construct new levees from inlet to Fir Island Road, setback existing levees to ~1000', remove levee crossing near bridge overpass |
| Levee Breaching | | 4 locations | 6 locations |
| Plantings | | Forested tidal upstream of SRT | Forested tidal upstream of SRT |
| Hall Slough Maximum Alternative Measures | | | Include |
| **Planview/ Cross-Section (Downstream of SRT), (Upstream of SRT)** | **4/A** | **5/B, E** | **6/C, F** |
| All Alternatives Include: | • Removal of levee crossing<br>• Removal of culverts and fill material as necessary<br>• Riparian/upland plantings along levees<br>• Natural estuarine emergent/scrub-shrub wetland recovery<br>• Placement of LWD<br>• Removal of non-native plants | | |

The moderate alternative includes all of the restoration measures from the minimum alternative. In addition, the moderate alternative would include the relocation of the existing SRT (beneath the levee crossing) to the Browns Slough Road crossing. New levees would be constructed between Fir Island and Browns Slough Roads, and existing levees south of Fir Island Road would be setback approximately 500 feet (150 m). Non-native marsh and riparian plant species would be removed. Marsh opened to tidal inundation would be allowed to naturally recover native plant species while levees would be revegetated with riparian species. The current USGS quadrangle shows a left bank levee just upstream of Fir Island Road. This levee was not observed to be present during field visits.

The maximum alternative includes each of the components identified for the moderate alternative. Additional proposed restoration measures for the maximum alternative include the excavation of an inlet from the North Fork Skagit River and reconnection of Browns Slough to Hall Slough. Other measures include the construction of levees from Fir Island Road to the North Fork Skagit River inlet and the setback of levees south of fir Island Road by approximately 1000 feet. Marsh and riparian vegetation will be extended from Fir Island Road north to the North Fork Skagit River. Furthermore, the connection to Hall Slough necessitates the inclusion of the restoration measures identified for the maximum alternative for Hall Slough. In other words, the maximum Brown Slough alternative will always be combined with the maximum Hall Slough alternative. The maximum Hall Slough alternative is described below in Section 4.2.8. The current USGS quadrangle shows levees existing at the upstream end of Brown's Slough, near the proposed inlet area. A levee does cross the slough near the overpass, but south of that, the levees shown on the quadrangle were not observed to be present during field visits. The levee crossing the slough will need to be removed.

### *4.2.3 Carpenter Creek*

The minimum alternative for Carpenter Creek includes restoration components that are located between Stackpole Road and its confluence with Tom Moore Slough. Components proposed include riparian revegetation in a 50 to 100 foot buffer, the creation of wetlands, construction of livestock fencing, and placement of LWD. In addition, to allow a better connection to Tom Moore Slough, and ultimately Skagit Bay, it is proposed that the existing tide gate be modified to allow passage during low flow periods. Currently, a metal sill prevents passage at low flows and this sill should be notched to the low flow elevation. Finally, high spots and culverts that impede fish passage will be excavated or replaced.

The moderate alternative includes each of the components proposed for the minimum alternative. The moderate alternative also includes setting back levees to an approximate average of 500 feet between Stackpole Road to the Thomas Moore confluence and an increase in the size of created wetlands. Roads located within the proposed restoration areas will be setback as necessary. Riparian revegetation should be extended to fill the area between Carpenter Creek and the newly setback levees. Riparian revegetation or underplantings will be extended upstream from Stackpole Road to Hickox Road at an average width of 100 feet on both banks.  High spots will be excavated as necessary to improve fish passage. This alternative also includes the realignment of the Sandy Creek confluence with Carpenter Creek as shown in the figure.

The maximum alternative includes the restoration measures proposed for the moderate alternative. Again, the maximum alternative proposes that a greater area be restored. In this alternative, the levees are setback up to 1000 feet and setbacks begin further upstream near Hickox Road. Wetlands are larger and more numerous. A new component of stream realignment is proposed to reintroduce a more natural meandering pattern into the stream. Finally, tributary confluences will all be realigned, including Sandy, Johnson, Bulson, and the unnamed Creek.

| **Summary of Carpenter Creek Alternatives** | | | |
|---|---|---|---|
| **Restoration Elements** | **Minimum** | **Moderate** | **Maximum** |
| Tide Gates | Notch tide gate to low tide elevation | Notch tide gate to low tide elevation | Notch tide gate to low tide elevation |
| Levees | Revegetate | Setback average ~500' | Setback average ~1000' |
| Confluences | | Realign Sandy Creek confluence | Realign Sandy, Johnson, Bulson, and Unnamed Creek confluences |
| Riparian Plantings | 50-100' both banks from Stackpole Road to Thomas Moore Slough | Up to 500' both banks from Stackpole Road to Thomas Moore Slough | Up to 1000' both banks from Hickox Road to Thomas Moore Slough |
| **Planview/ Cross-Section** | **7/G** | **8/H** | **9/I** |
| All Alternatives Include: | • Wetland creation and plantings<br>• Excavation of fill material and culverts as necessary to allow fish passage<br>• Construction of livestock fencing<br>• Placement of LWD<br>• Removal of non-native plants | | |

### *4.2.4 Deepwater Slough*

The minimum alternative for this area is proposed to include breaching of levees along Deepwater, Freshwater, Streamboat, Old River and Brandstedt Sloughs. This, along with cessation of grain crop cultivation, would open the two middle islands to more natural hydrological connections, restoring connectivity, and allowing natural vegetation recovery. Very little additional work would be required, limited only to placement of LWD in adjacent sloughs. No riparian or wetland plantings are proposed.

The moderate alternative would include the minimum alternative measures as well as inclusion of the Wiley Slough piece. At Wiley Slough, levees would be set back to Mann Road and elminated between Wiley Slough and Freshwater Slough. Limited riparian plantings are proposed for areas adjacent to levees, along with non-native plant species removal.

The maximum alternative for Deepwater Slough is proposed to include each of the measures from the minimum and moderate alternatives, as well as increased reconnection of Wiley Slough and Milltown Island to surrounding hydrologic influences. The levee along the perimeter of Milltown Island would be breached in additional locations. Wiley Slough would be reconnected to Dry Slough at the upstream end, levees constructed on both banks along Wiley Slough for its entire length, and riparian species would be planted along levees. Placement of LWD would occur in all sloughs affected by restoration.

| Summary of Deepwater Slough Alternatives | | | |
|---|---|---|---|
| **Restoration Elements** | **Minimum** | **Moderate** | **Maximum** |
| Levee Breaching | Middle islands, 6 locations | Middle islands and between Wiley and Freshwater Sloughs, 12 locations | Middle islands, between Wiley and Freshwater Sloughs, and on Milltown Island, 14 locations |
| Levee Setback | | West of Wiley Slough to Mann Road | Along entire length of Wiley Slough |
| Plantings | | Forested tidal upstream of SRT on Wiley Slough | Forested tidal upstream of SRT on Wiley Slough |
| **Planview/ Cross-Section** | **10/A** | **11/B** | **12/C** |
| All Alternatives Include: | • Placement of LWD<br>• Natural recovery of freshwater wetlands<br>• Riparian/upland plantings along levees<br>• Removal of non-native plants | | |

### *4.2.5 Dry Slough*

**Dry Slough Conceptual Design Report 2001**

Northwest Chinook Recovery (NCR) recently prepared a restoration conceptual plan for Dry Slough (2001). The plan was designed to provide salmonid habitat via opening Dry Slough to upstream freshwater influence and downstream tidal inundation. It was estimated that several thousand additional chinook salmon smolts could potentially be added to the annual production of the Skagit River system as a result of restoring Dry Slough (NCR 2001). Essentially, the slough would be designed to act as a middle fork of the Skagit River, however it would be highly controlled, with an engineered inlet and outlet to prevent flooding. Although levees are not proposed, the plan does call for the placement of earthen embankments to provide further protection to adjacent agricultural lands. The final major component to the restoration of Dry Slough is the creation of a riparian buffer zone ranging from 25-75 feet wide, depending on availability of land.

The NCR (2001) preferred alternative was designed to provide chinook salmon rearing habitat in a former distributary channel while minimizing any potential impacts on adjacent land uses and infrastructure. While this is certainly an essential consideration in the development of any restoration plans in the Lower Skagit River delta, it significantly limited the range of alternatives considered in the report. Other alternatives are only briefly described and then eliminated from further consideration. This may have been due to costs, however no rationale is given. Overall, we felt that the range of alternatives and features considered was very limited in the NCR (2001) draft report. The selected alternative does have many good features and we have incorporated portions of the Dry Slough conceptual plan from the NCR report into this restoration plan and it is proposed as the moderate alternative below.

Although controlled inlets are suitable for restoration, the maximum alternative proposed here reflects a free-flowing Dry Slough, which more closely resembles the historic conditions. As with all of the evaluation areas, lands behind the dikes at Dry Slough have probably experienced significant subsidence and may require fill or other measures to ensure that the restored areas become marsh as opposed to subtidal habitats.

**Proposed Restoration Alternatives**

The proposed measures for the Dry Slough minimum alternative include the replacement of the existing tide gates with SRT structures at the outlet, revegetation of a buffer zone approximately 50 feet wide along the slough south of Fir Island Road, and placement of LWD. Although the USGS quadrangle indicates the presence of levees along Dry Slough south of Fir Island Road, we did not observe levees, which may be extremely eroded or degraded due to farming activities or may have been removed.

The moderate alternative proposes measures similar to those of the Dry Slough Conceptual Plan (NCR 2001). This alternative includes the excavation and construction of a controlled inlet at the upstream end. From the inlet to Fir Island Road, the area would be revegetated to create a buffer zone of approximately 100 feet. South of Fir Island Road to Skagit Bay, levees would be set back or constructed to allow creation of several acres of additional marsh habitat adjacent to the slough. These areas would be allowed to naturally recruit marsh plants. Finally, to facilitate the recovery of marsh habitat, the existing tide gates would be removed and a self-regulating tide gate would be installed at Fir Island Road. LWD would be placed throughout the slough. Levees along Skagit Bay would be used to construct new levees at the set back positions. Additional low channel areas would be excavated to facilitate marsh habitat recovery.

The maximum alternative includes the construction of levees, which precludes the requirement for control structures at the inlet or outlet. At the upstream end, another small side-channel could be excavated and designed to be the inlet to Dry Slough. Concerns regarding sedimentation at the proposed Dry Slough Conceptual Plan inlet (NCR 2001) may be avoided using this alternative inlet location. Homes and roads would have to be set back beyond the newly constructed levees, which would extend from the inlet to Skagit Bay. Within the levees, lands that were once agricultural will be returned to natural influences and should, with time, revert back to wetland, marsh, scrub-shrub or riparian habitats. However, some plantings for scrub-shrub or emergent wetlands may be necessary. Road crossings will be modified to bridges or bottomless arches. LWD will be placed throughout the slough.

| Summary of Dry Slough Alternatives | | | |
|---|---|---|---|
| **Restoration Elements** | **Minimum** | **Moderate** | **Maximum** |
| Reconnection | | Controlled inlet from Skagit River | Controlled inlet from Skagit River |
| Tide Gates | Replace with SRT | Replace with SRTand relocate to Fir Island Road | Remove |
| Levees | | Constuct levees south of Fir Island Road ~1000' from slough, remove levee crossing at downstream end | Construct levees along entire slough, place ~1000' from slough on both banks |
| Levee Breaching | | 6 locations | 8 locations |
| Plantings | | Forested tidal upstream of SRT | Forested tidal upstream of SRT |
| Culvert | | Replace as necessary with bridges or bottomless arches | Remove all |
| **Planview/ Cross-Section (Downstream of SRT), (Upstream of SRT)** | **13/A** | **14/B, E** | **15/C, F** |
| All Alternatives Include: | • Removal of debris and fill material<br>• Placement of LWD<br>• Natural estuarine emergent/scrub-shrub wetland recovery<br>• Riparian/upland plantings along levees<br>• Removal of non-native plants<br>• Excavation of low elevation channels within marsh | | |

#### *4.2.6 Edison Slough*

At Edison Slough, the minimum alternative includes a levee setback downstream of the SRT and revegetation of the levees. On the north bank, west the adjacent road, the levee will be set back approximately 100 feet. The levees would then be revegetated with riparian species on both banks and LWD would also be placed from the most downstream tide gate to Samish Bay. A small area of marsh would be allowed to recover naturally.

The moderate alternative has the same components as the minimum alternative, but requires the set back of the north levee west of Best Road to approximately 500 ft. Riparian revegetation would extend along the setback levees downstream of the SRT and a 50-100 ft riparian buffer would be planted along the slough from the SRT to Chuckanut Drive. A larger area of marsh that would be allowed to recover naturally. Upstream of the elementary school, wetlands would be excavated and replanted. Much of the land in this area is already wetland and would likely require minimal excavation, non-native species removal, and wetland plantings. LWD would be placed from the mouth to Chuckanut Drive.

The maximum restoration proposed here includes the realignment of the north bank levee along Best Road north of the town of Edison. The levee along Samish Bay would be breached to allow tidal inundation into the area for recovery of natural marsh habitat. Riparian revegetation would extend from Samish Bay to Chuckanut Drive and would have an average width of 100 feet. Wetland areas would be excavated and replanted and would be larger and more numerous than in the moderate alternative.

**Summary of Edison Slough Alternatives**

| **Restoration Elements** | **Minimum** | **Moderate** | **Maximum** |
|---|---|---|---|
| Slough Levees | Set back 100’ | Set back 500’ | Set back to adjacent road north of Edison |
| Samish Bay Levee | | | Breach |
| Levee breaching | | 4 locations | 6 locations |
| Culverts | | Replace as necessary for fish passage | Replace as necessary for fish passage |
| Freshwater Wetland Creation | | Yes | Yes |
| Riparian/Upland Revegetation | Samish Bay to SRT | 50-100’ buffer from Samish Bay to Edison Station | 100’ buffer from Samish Bay to Edison Station |
| **Planview/ Cross-Section (Downstream of SRT), (Upstream of SRT)** | **13/B** | **14/B, G[1]** | **15/B, H[1]** |
| All Alternatives Include: | • Placement of LWD<br>• Removal of non-native plants<br>• Natural estuarine emergent/scrub-shrub wetland recovery | | |

[1]According to historic data (Collins 1998), the saltwater extent of Edison Slough ends at the approximate location of the current SRT. As described above, restoration reflects the change from salt to fresh water conditions.

### *4.2.7 Gages Slough*

The minimum restoration measures for Gages Slough include riparian revegetation of a narrow buffer zone (25-50 ft wide) from District Line Road to the cemetery, excavation of three small wetlands along the channel, and LWD placement.

The moderate alternative proposes the reconnection of Gages Slough to Hart Slough and to the Skagit River, allowing flow-through during winter and spring. The reconnection point to the Skagit River would be located beneath Lafayette Road, where Gages is south of Highway 20. The side-channel would be controlled with inlet and outlet structures engineered to prevent flooding while allowing fish passage. This alternative includes riparian revegetation (50 to 100 feet wide) and placement of LWD along the length of the reconnected portion. A single large wetland would be excavated between District Line Road and Highway 20. It is also proposed that high spots be excavated and culverts be replaced as necessary to allow flow-through and fish passage.

The maximum alternative also proposes to reconnect Gages Slough to Hart Slough and to the Skagit River, although the reconnection point to the river would be located at the extreme downstream end of Gages Slough. Riparian buffers would be created at 50 to 100 foot widths for the entire length of the slough. Several wetlands would be excavated and planted at appropriate locations along the slough.

**Summary of Gages Slough Alternatives**

| **Restoration Elements** | **Minimum** | **Moderate** | **Maximum** |
|---|---|---|---|
| Inlet | | Controlled inlet to Hart Slough | Controlled inlet to Hart Slough |
| Outlet | | Controlled outlet to Skagit River at Lafayette Road | Controlled outlet to Skagit River at downstream end of Gages Slough |
| Fill and Culverts | | Replace and excavate as necessary for fish passage | Replace and excavate as necessary for fish passage |
| Wetlands | 2 small | 1 large | Several in appropriate locations |
| Riparian Revegetation | 25-50’ from District Line Road to cemetery | 50-100’ along entire reconnected length | 50-100’ along entire reconnected length |
| **Planview/ Cross-Section** | **16/G** | **17/H** | **18/H** |
| All Alternatives Include (District Line Road to cemetery): | • Placement of LWD<br>• Removal of non-native plants | | |

### *4.2.8 Hall Slough*

Minimum alternative components are proposed to include set back of the west bank levee by an average of 300 feet. The low-lying area within the levee will be allowed to recruit marsh species naturally, while the levees on both banks will be revegetated with riparian and upland species. A levee spur, present on the right bank, will be removed and the cache of LWD currently caught behind the spur may be redistributed. Riparian revegetation is also proposed to extend east of Maupin Road to the end of Hall Slough and have an average width of 50 feet. Non-native plant species will be removed from levees.

**Summary of Hall Slough Alternatives**

| **Restoration Elements** | **Minimum** | **Moderate** | **Maximum** |
|---|---|---|---|
| Reconnections | | | Connect to Browns Slough and excavate inlet from Skagit to Brown's Slough |
| Tide Gates | Replace with SRT | Replace with SRT | Remove |
| Levee | Set back an average of 300' on right bank | Set back up to 1000' on right bank | Set back up to 2000' on right bank |
| Levee Breaching | | 3 locations | 4 locations |
| Plantings | | Forested tidal upstream of SRT | Forested tidal upstream of SRT |
| **Planview/ Cross-Section (Downstream of SRT), (Upstream of SRT)** | **19/B** | **20/B, E** | **21/C, F** |
| All Alternatives Include: | • Removal of the levee spur<br>• Removal of culverts and fill as necessary for fish passage<br>• Placement of LWD<br>• Riparian/upland plantings along levees<br>• Removal of non-native plants<br>• Natural estuarine emergent/scrub-shrub wetland recovery | | |

Moderate restoration is proposed to include the same components as the minimum alternative, although setbacks and riparian buffers will be greater. The west bank levee will be set back up to 1000 feet. Riparian buffers will extend from Maupin Road to the end of Hall Slough and are proposed to be at least 100 feet wide on average. LWD will be added to all parts of Hall Slough as necessary, and non-native plants will be removed from the levees.

The maximum alternative includes the reconnection of Hall Slough to the Skagit River via Brown's Slough. Inlet construction to Browns Slough would require the installation of a controlled tide gate, or some other flow-regulation structure, to prevent flooding. The levee west of Maupin Road would be set back across several parcels and expand the marsh recovery area up to 2000 feet on the west bank. Again, levees would be revegetated and non-native species would be removed. Areas of marsh elevation would be allowed to recruit marsh species naturally. The slough between Maupin Road and Browns Slough would be revegetated to an average width of 200 feet. Because this alternative requires the reconnection of Hall to Brown's Slough and Brown's Slough to the Skagit River, it is also proposed that Brown's slough be revegetated to a buffer width of 100 feet.

#### *4.2.9 Indian Slough*

The minimum Indian Slough alternative includes the revegetation of the levees from the mouth to Bayview Edison Road. The existing tide gates will be replaced with SRT structures to allow more frequent tidal inundation and fish passage. Both channels east of the road will also be revegetated with a 25 to 50 foot riparian buffer. LWD will be placed as appropriate and non-native species will be removed.

In the moderate alternative, the west bank levee on the main channel will be setback by approximately 200 feet. Inside this levee, marsh vegetation will be allowed to naturally recover. Levees along the Big Indian channel, east of the road, will be setback by approximately 100 feet on both banks. As with the minimum alternative, the channels east of the road will be revegetated with a riparian buffer. On Big Indian Slough the buffer will extend up to the levees (100 feet on both banks), while the Little Indian Slough buffer will remain at 25 to 50 feet. Tide gates will be reconfigured at both channels. The Little Indian tide gate will be replaced with an SRT and the Big Indian tide gate will be changed to an SRT and relocated to the Highway 20 crossing.

The maximum alternative for Indian Slough incorporates both Telegraph and No Name Sloughs as well. In this alternative, a large area between Telegraph Slough and No Name Slough will be opened to natural recovery of marsh habitat. Levees will be constructed along Highway 20 between Telegraph Slough and Bayview-Edison Road, and along Bayview-Edison Road from Highway 20 to just north of the No Name Slough crossing. Existing levee materials may be used to construct new levees. Within the newly constructed levees, marsh habitat will be allowed to naturally recover, and selected areas of riparian and upland vegetation will be planted. On No Name Slough, the tide gate beneath the outer levee will be completely removed and an SRT gate will be installed beneath Bayview-Edison. On Indian Slough, reconfiguration of the tide gates will be the same as in the moderate alternative. Also, No Name, Little Indian, and Big Indian Sloughs will all have approximately 100 feet of riparian vegetation on both banks east of Bayview-Edison Road.

The flood reduction floodway bypass alternative is designed for construction along Highway 20 and will outlet into Swinomish Channel adjacent to Telegraph Slough. Connection of the floodway bypass with

Indian Slough beneath Highway 20 may be possible. This would improve hydrologic connectivity and provide fish passage from Padilla Bay to the Skagit River.

| **Summary of Indian Slough Alternatives** | | | |
|---|---|---|---|
| **Restoration Elements** | **Minimum** | **Moderate** | **Maximum** |
| Reconnections | | | Breach of existing levees north of Hwy 20, east of BVE[1] |
| Levees | | Setback west bank of main channel by 200', setback both banks Big Indian east of BVE by 100' | Construct along Hwy 20 and BVE, setback both banks Big Indian east of BVE by 100' |
| Levee Breaching | | 4 locations | 12 locations |
| Plantings | | Forested tidal upstream of SRTs | Forested tidal upstream of SRTs |
| Tide Gates | Replace all with SRT | Replace Little Indian with SRT, remove existing gate on Big Indian and install SRT at Hwy 20 | Same as moderate + No Name Slough: remove downstream gate and place SRT at BVE crossing |
| **Planview/ Cross-Section (Downstream of SRT), (Upstream of SRT)** | **22/A** | **23/B, D[2] and E[3]** | **24/C, F** |
| **All Alternatives Include:** | • Placement of LWD<br>• Natural estuarine emergent/scrub-shrub wetland recovery<br>• Riparian/upland plantings along levees<br>• Removal of non-native plants | | |
| [1]Bayview-Edison Road<br>[2]Little Indian Slough upstream of SRT<br>[3]Big Indian Slough upstream of SRT | | | |

### *4.2.10 Joe Leary Slough*

The minimum alternative at this slough includes the setback of the north levee downstream of the existing tide gate by approximately 200 feet, revegetation of the levees downstream of the tide gates and of the channel between the tide gates and Bayview-Edison Road, natural marsh recovery, removal of non-native species and placement of LWD.

The moderate alternative includes all of the measures in the minimum alternative. However, the north bank levee setback is greater (approximately 500 feet), the tide gate will be replaced with an SRT, and a riparian buffer is included on both banks (approximately 100 feet wide) from Bayview Edison Road crossing up to D'arcy Road. A larger area of marsh recovery is created compared to the minimum alternative.

The maximum alternative includes all of the measures from the moderate alternative. However, the north bank levee will be setback by approximately 1000 feet, the channel upstream of the road crossing will be realigned to a more natural meandering pattern, and the riparian buffer along the channel will extend to approximately 200 feet. Again, a greater area of marsh recovery is created. In addition, a parcel of land south of No Name Slough will also be included in the maximum alternative. This parcel is located south of the orchards and north of the area where levees were breached during a recent storm. A levee will be constructed on the north end of the parcel, and the area will be allowed to recover marsh species naturally. A riparian buffer approximately 100 feet wide will be planted adjacent to Bayview-Edison Road.

**Summary of Joe Leary Slough Alternatives**

| **Restoration Elements** | **Minimum** | **Moderate** | **Maximum** |
|---|---|---|---|
| North Bank Levee | Setback 200' downstream of tide gate | Setback 500' downstream of tide gate | Setback 1000' downstream of tide gate |
| Levee breaching | | 2 locations | 6 locations |
| Tide Gates | | Replace with SRT | Replace with SRT |
| Channel Realignment | | | Re-meander channel away from D'arcy Road by 200' |
| Riparian/Upland Revegetation | Along levees | Same as minimum plus 100' buffer east of tide gate to D'arcy Road | Same as minimum plus 200' buffer east of tide gate |
| Southern Parcel | | | Construct north side levee, plant 100' riparian buffer, allow marsh recovery |
| **Planview/ Cross-Section (Downstream of SRT), (Upstream of SRT)** | **28/B** | **29/B, G** | **30/B, H[1]** |
| **All Alternatives Include:** | • Placement of LWD<br>• Remove fill and culverts as necessary for fish passage<br>• Natural estuarine emergent/scrub-shrub wetland recovery<br>• Removal of non-native plants | | |

[1]There will be no wetlands included in this restoration plan, although they appear in cross-section H.

### *4.2.11 No Name Slough*

The measures included in the minimum alternative are all located west of Bayview-Edison Road. They include the replacement of the existing tide gate with an SRT, setback of levees on both banks by approximately 100 feet, revegetation of the levee, removal of non-native species and placement of LWD as appropriate.

The moderate alternative is proposed to include setback of the levees west of Bayview-Edison Road on both banks by approximately 500 feet. This would allow the removal of the levee crossing and tide gate at the mouth of the slough. An SRT structure will be placed beneath Bayview-Edison Road. Downstream of the SRT, levees would be vegetated with riparian and upland species and the remainder of the area between the levees would be allowed to recover marsh species naturally. Upstream of the road, a riparian buffer will be planted of an average width of 100 feet and will extend upstream to the forested area. Also, the levee along Padilla Bay to the north of No Name Slough would be breached to allow more frequent and natural inundation of the newly opened marsh area.

The maximum alternative is similar to that of the Indian Slough maximum. Each of the features would be the same, except the area included in the alternative will not include the lands between Indian and Telegraph Slough. Tide gate replacements and relocations, revegetation, and levee setbacks will all be the same as the Indian Slough maximum.

| **Summary of No Name Slough Alternatives** | | | |
|---|---|---|---|
| **Restoration Elements** | **Minimum** | **Moderate** | **Maximum** |
| Levees | West of BVE setback by 100’ | West of LCS setback by 500’, construct new levees east of BVE | Construct along BVE between No Name and Big Indian Slough, also construct new levees east of BVE 100’ from Big Indian |
| Levee Breaching | | 3 locations | 12 locations |
| Plantings | | Forested tidal upstream of SRT | Forested tidal upstream of SRT |
| Tide Gates | | Remove existing and install SRT beneath BVE | Same as moderate<br>+<br>Replace Little Indian tide gate with SRT, remove Big Indian tide gate beneath BVE, install Big Indian SRT at Hwy 20 |
| **Planview/ Cross-Section (Downstream of SRT), (Upstream of SRT)** | **31/B** | **32/B, E** | **33/C, F** |
| **All Alternatives Include:** | • Placement of LWD<br>• Remove fill and culverts as necessary for fish passage<br>• Riparian/upland plantings along levees<br>• Removal of non-native plants | | |
| BVE: Bayview-Edison Road | | | |

#### *4.2.12 Sullivan Slough*

The minimum alternative includes planting a 25 foot riparian buffer along the spur channel, revegetating the area north of Chilberg Road to the dirt road crossing with riparian and wetland species, and revegetating the levees south of Chilberg Road. In addition, the existing tide gates on the spur channel and main channel of Sullivan Slough would be replaced with SRT gates. Non-native species would be removed and LWD would be placed as appropriate.

The moderate alternative will include similar, but larger scale measures. The spur channel and mainstem channel north of Chilberg Road will be revegetated up to 100 feet. Downstream of Chilberg Road, the levee on the west bank will be set back up to 1200 feet and planted with riparian and upland species to a width of 100 feet. The area within the levee will be allowed to naturally recover marsh species.

The maximum alternative includes revegetation of the spur channel with a 100 foot buffer, and revegetation of the area upstream of Chilberg Road. However, in this alternative, the upstream area will also include wetland creation. Downstream of Chilberg, levees will be set back on both banks up to 5000 feet, reaching Alberson Road on the east side and Maple Road on the west side. Within the levees, 200 feet of riparian buffer will be planted along the levees and the rest of the area will be allowed to naturally recover marsh species. Selected higher elevation areas will be planted with upland species and small pockets of scrub-shrub species will also be planted. The jetty and causeway may have additional options to be incorporated at a later date.

| **Summary of Sullivan Slough Alternatives** | | | |
|---|---|---|---|
| **Restoration Elements** | **Minimum** | **Moderate** | **Maximum** |
| Levees | Upland revegetation | Set back up to 1200' on west bank | Set back up to 5000' on both banks |
| Levee Breaching | | 6 locations | 12 locations |
| Plantings | | Forested tidal plantings upstream of SRT | Forested tidal plantings upstream of SRT |
| Tide Gates | Replace all with SRT | Replace all with SRT | Replace all with SRT |
| **Planview/ Cross-Section (Downstream of SRT, Upstream of SRT)** | **34/A** | **35/B, D** | **36/C, E** |
| **All Alternatives Include:** | • Placement of LWD<br>• Remove fill and culverts as necessary for fish passage<br>• Riparian/upland plantings along levees<br>• Removal of non-native plants | | |

### *4.2.13 Telegraph Slough*

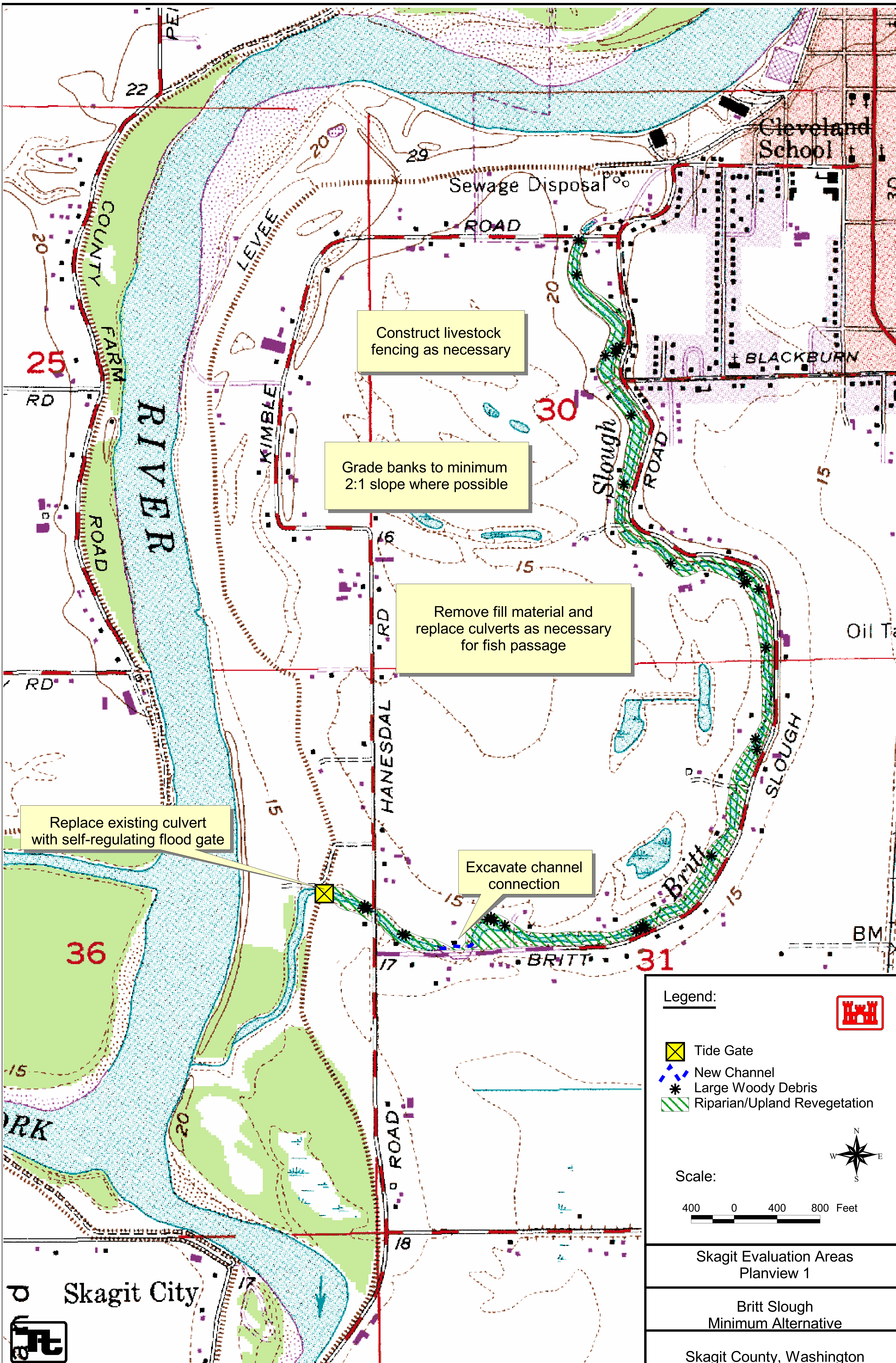
The Telegraph Slough minimum alternative will include revegetation of the existing levees, replacement of the existing tide gate with an SRT gate, removal of non-native species and placement of LWD.

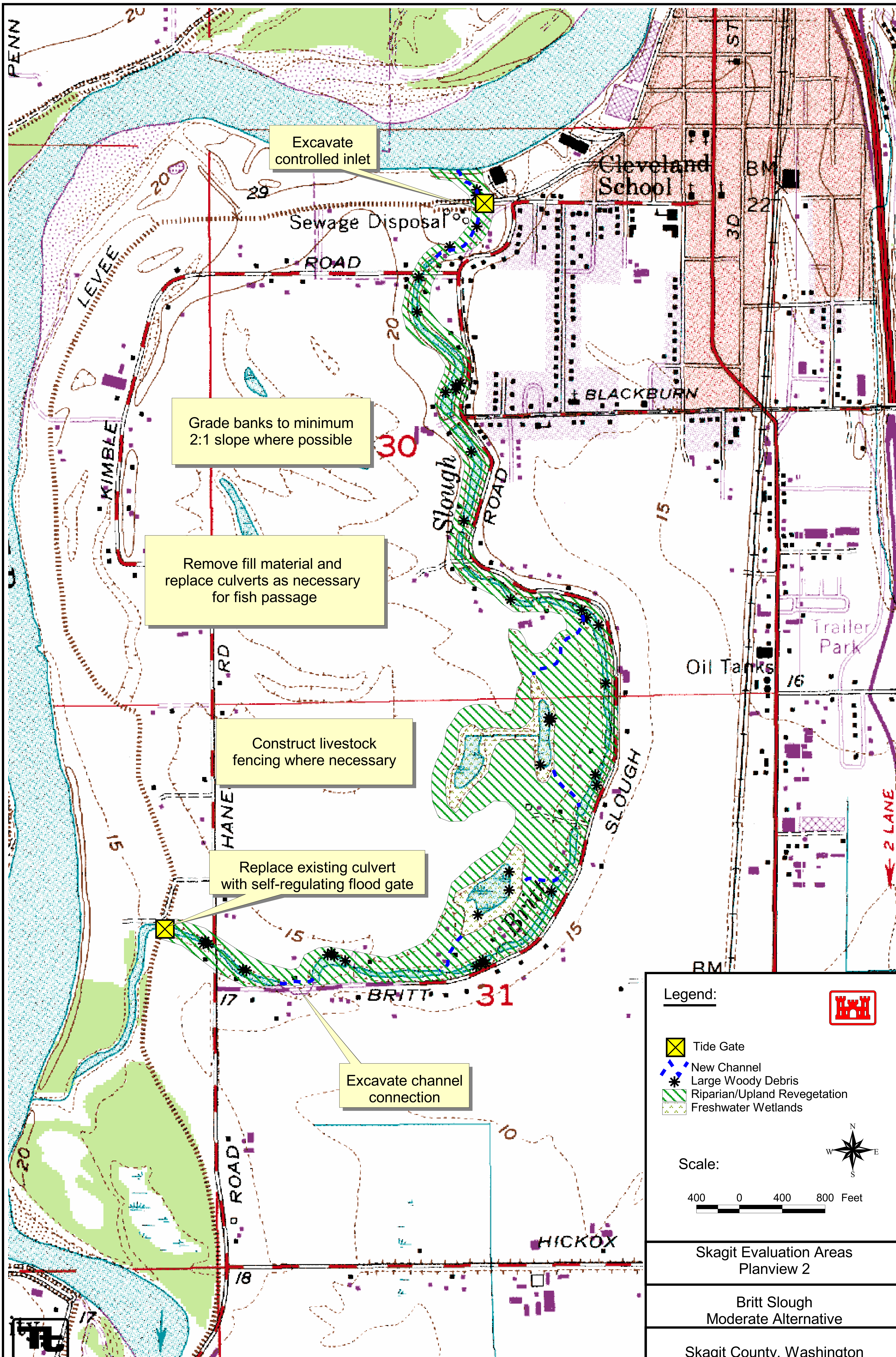
The moderate alternative will include replacement of the tide gate with an SRT and levee setbacks up to 500 feet. The areas within the levees will be revegetated with a mixture of scrub/shrub, riparian, and upland species for a width of approximately 100 feet. Within the riparian areas, marsh will be allowed to recover naturally. Non-native species will be removed and LWD will be placed as appropriate.

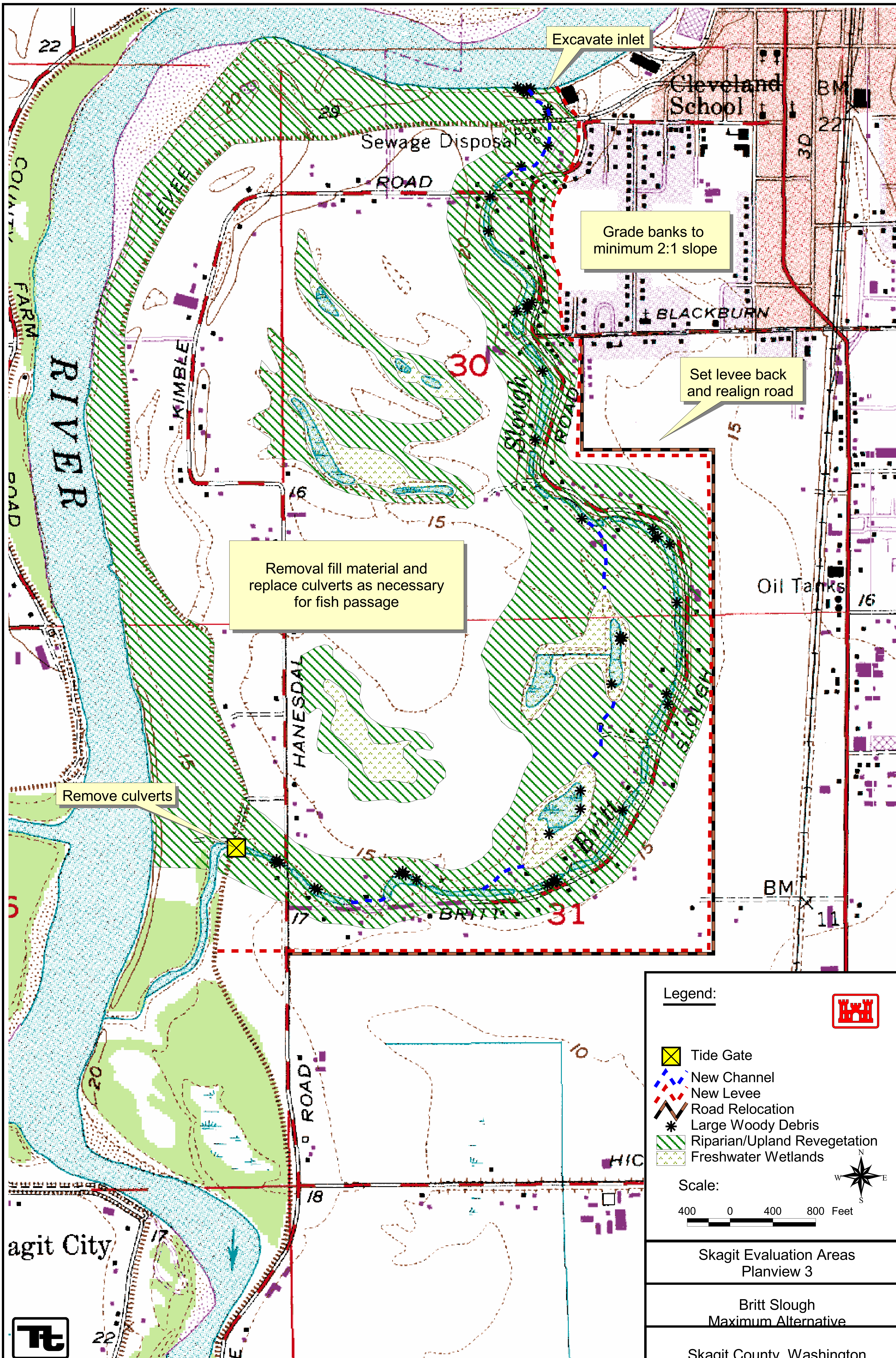
In the maximum alternative, levees will be setback from both Telegraph and Blind Sloughs all the way to Highway 20 west of Telegraph Slough. East of the slough, the levee will be set back approximately 1000 feet. A connection will be created beneath Highway 20 via the construction of a bridge or placement of bottomless culverts. The existing tide gates will be removed to allow natural tidal inundation. Levees will be vegetated with a 200 foot buffer and remaining areas will be allowed to recover marsh habitat naturally. Naturally occurring upland hummocks will be revegetated with upland species to facilitate greater habitat complexity. Non-native species will be removed and LWD will be placed as appropriate.

The flood reduction floodway bypass alternative is designed for construction along Highway 20 and will outlet into Swinomish Channel adjacent to Telegraph Slough. The maximum alternative would be highly compatible with the floodway bypass. Connection of the floodway bypass with Telegraph Slough beneath Highway 20 may be possible. This would improve hydrologic connectivity and provide fish passage from the Skagit River to Padilla Bay.

| **Summary of Telegraph Slough Alternatives** | | | |
|---|---|---|---|
| **Restoration Elements** | **Minimum** | **Moderate** | **Maximum** |
| Levees | Revegetate | Set back by 500’ both banks | Set back to Hwy 20 on west bank, up to 1000’ on east bank |
| Levee Breaching | | 6 locations | 12 locations |
| Tide Gates | Replace with SRT | Replace with SRT | Remove |
| **Planview/ Cross-Section** | **37/A** | **38/B** | **39/C** |
| **All Alternatives Include:** | • Placement of LWD<br>• Remove fill and culverts as necessary for fish passage<br>• Riparian/upland plantings along levees<br>• Removal of non-native plants<br>• Scrub-shrub and upland plantings | | |


Construct livestock fencing as necessary
Grade banks to minimum 2:1 slope where possible
Remove fill material and replace culverts as necessary for fish passage
Replace existing culvert with self-regulating flood gate
Excavate channel connection
Cleveland School
Sewage Disposal
RIVER
COUNTY FARM ROAD
LEVEE
KIMBLE RD
HANESDAL ROAD
BLACKBURN
Slough ROAD
Britt SLOUGH
BRITT
Oil Ta
Skagit City
Legend:
Tide Gate
New Channel
Large Woody Debris
Riparian/Upland Revegetation
Scale:
400 0 400 800 Feet
Skagit Evaluation Areas
Planview 1
Britt Slough
Minimum Alternative
Skagit County, Washington

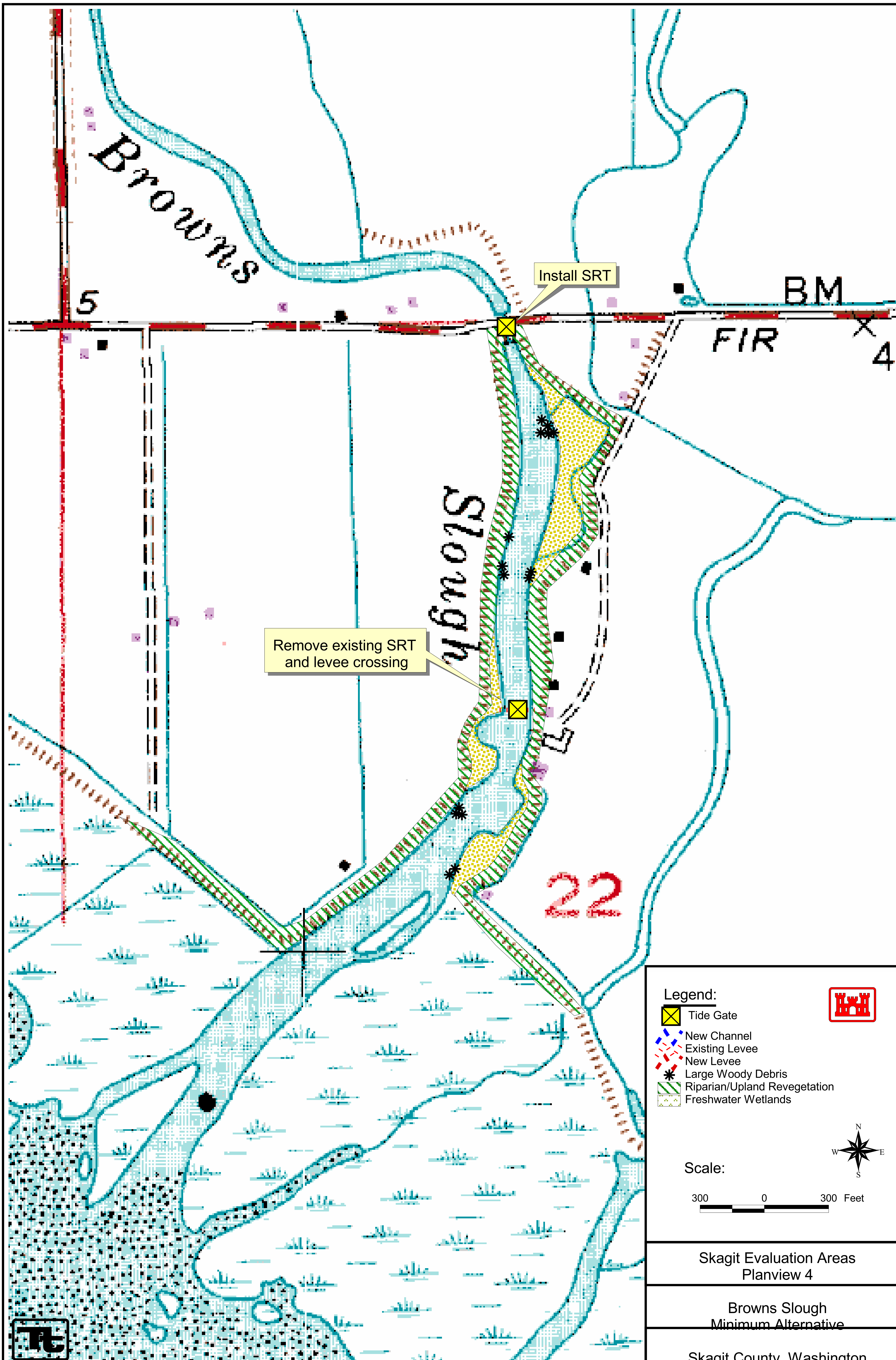

Excavate controlled inlet
Grade banks to minimum 2:1 slope where possible
Remove fill material and replace culverts as necessary for fish passage
Construct livestock fencing where necessary
Replace existing culvert with self-regulating flood gate
Excavate channel connection
Sewage Disposal
Cleveland School
Oil Tanks
Trailer Park
Slough
Britt
SLOUGH
LEVEE
KIMBLE
ROAD
BLACKBURN
BRITT
HICKOX
HANE
RD
PENN
2 LANE
Legend:
Tide Gate
New Channel
Large Woody Debris
Riparian/Upland Revegetation
Freshwater Wetlands
Scale:
400 0 400 800 Feet
Skagit Evaluation Areas
Planview 2
Britt Slough
Moderate Alternative
Skagit County, Washington

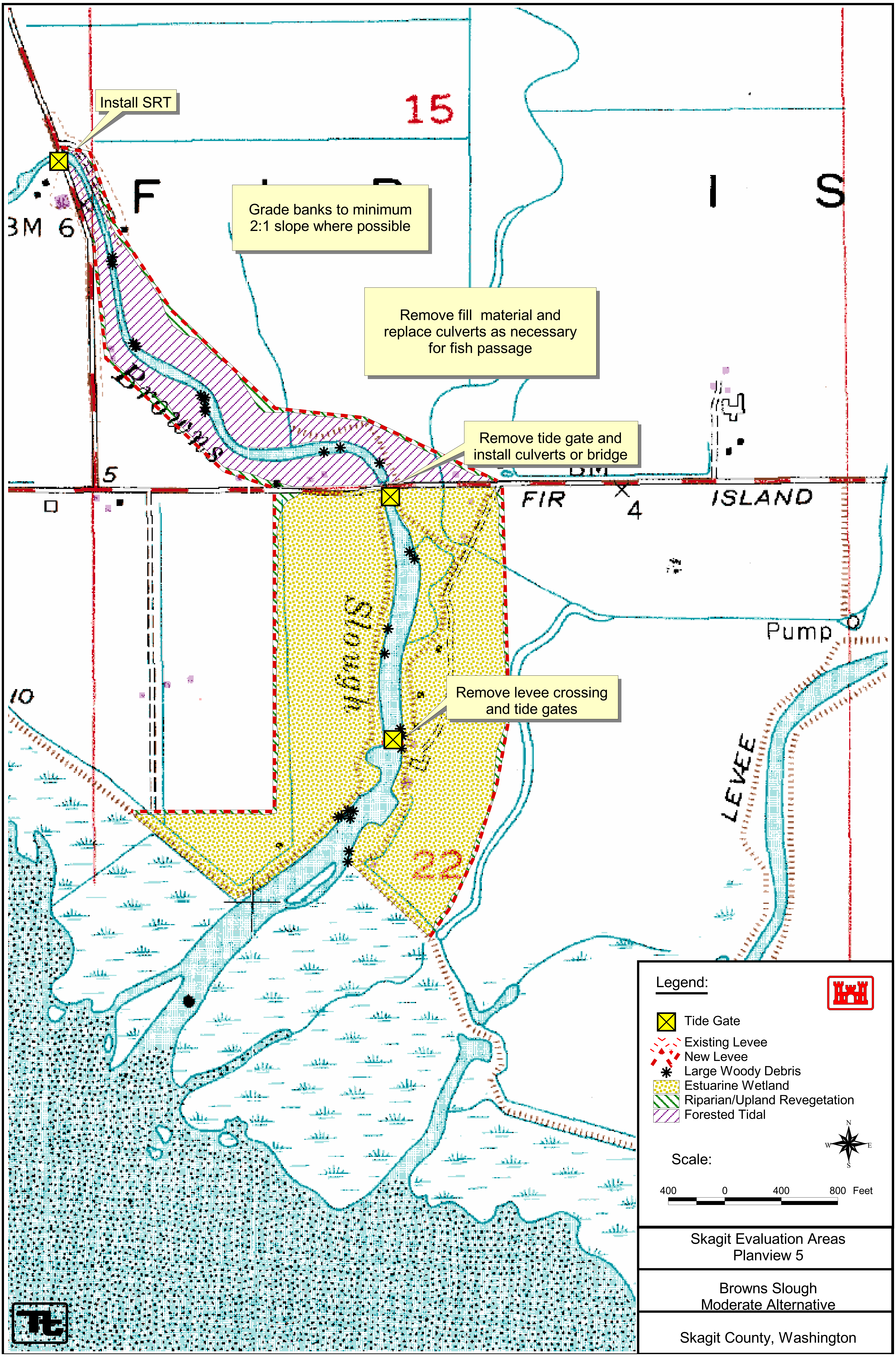



Skagit Evaluation Areas
Planview 3

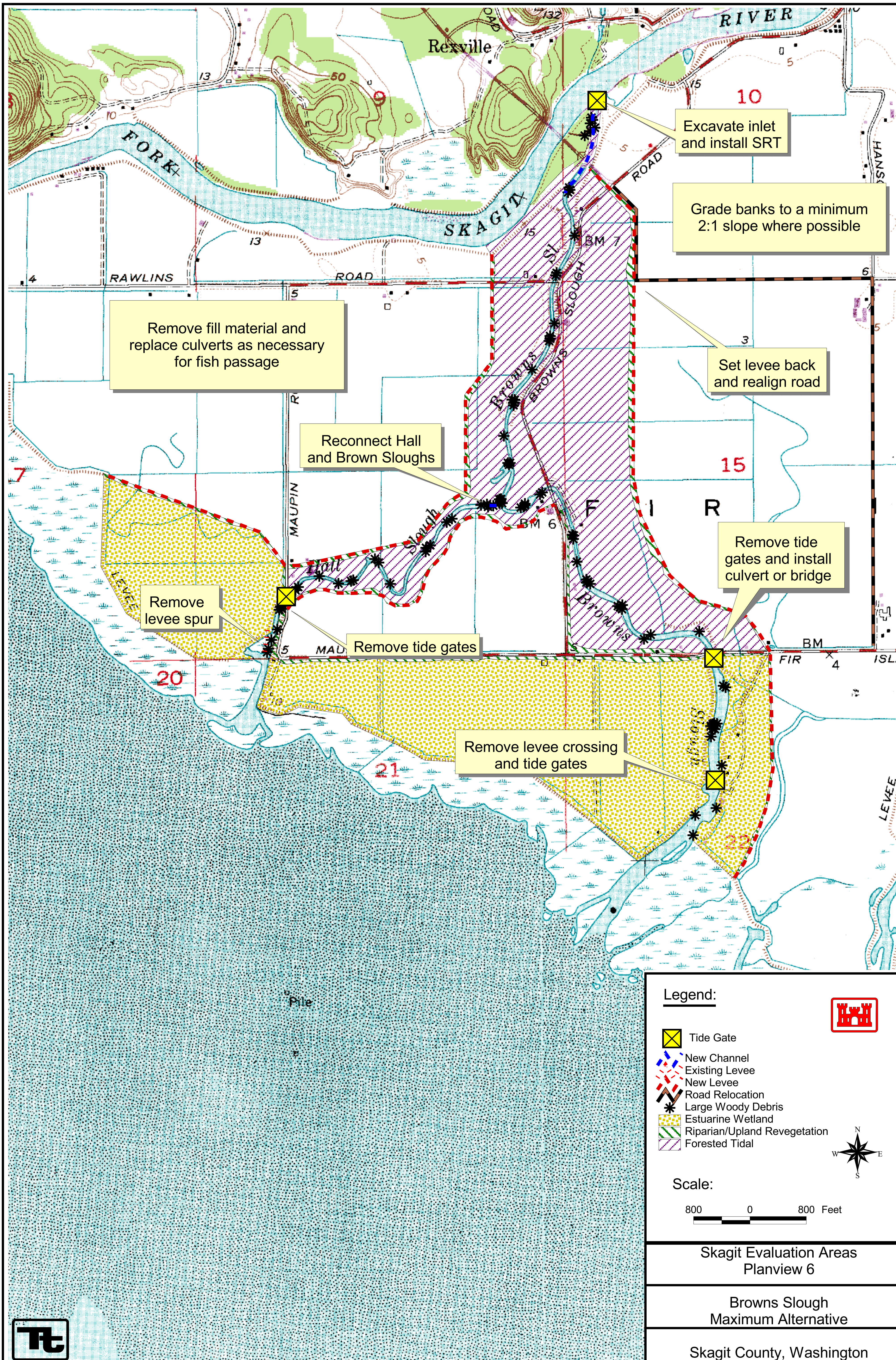
Britt Slough
Maximum Alternative

Skagit County, Washington

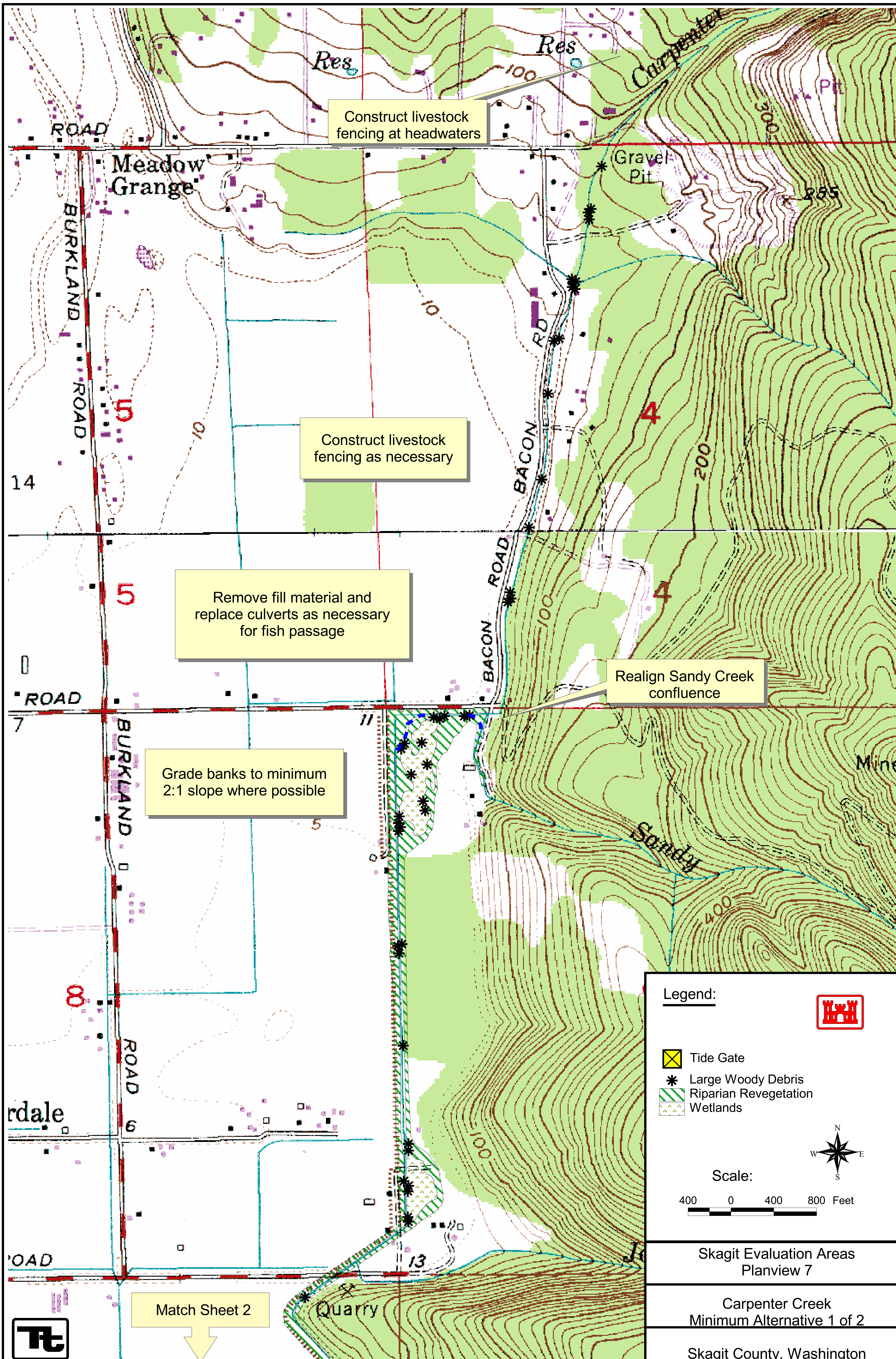

Browns
Slough
5
BM
FIR
4
22
Install SRT
Remove existing SRT
and levee crossing
Legend:
Tide Gate
New Channel
Existing Levee
New Levee
Large Woody Debris
Riparian/Upland Revegetation
Freshwater Wetlands
N
W
E
S
Scale:
300
0
300 Feet
Skagit Evaluation Areas
Planview 4
Browns Slough
Minimum Alternative
Skagit County, Washington

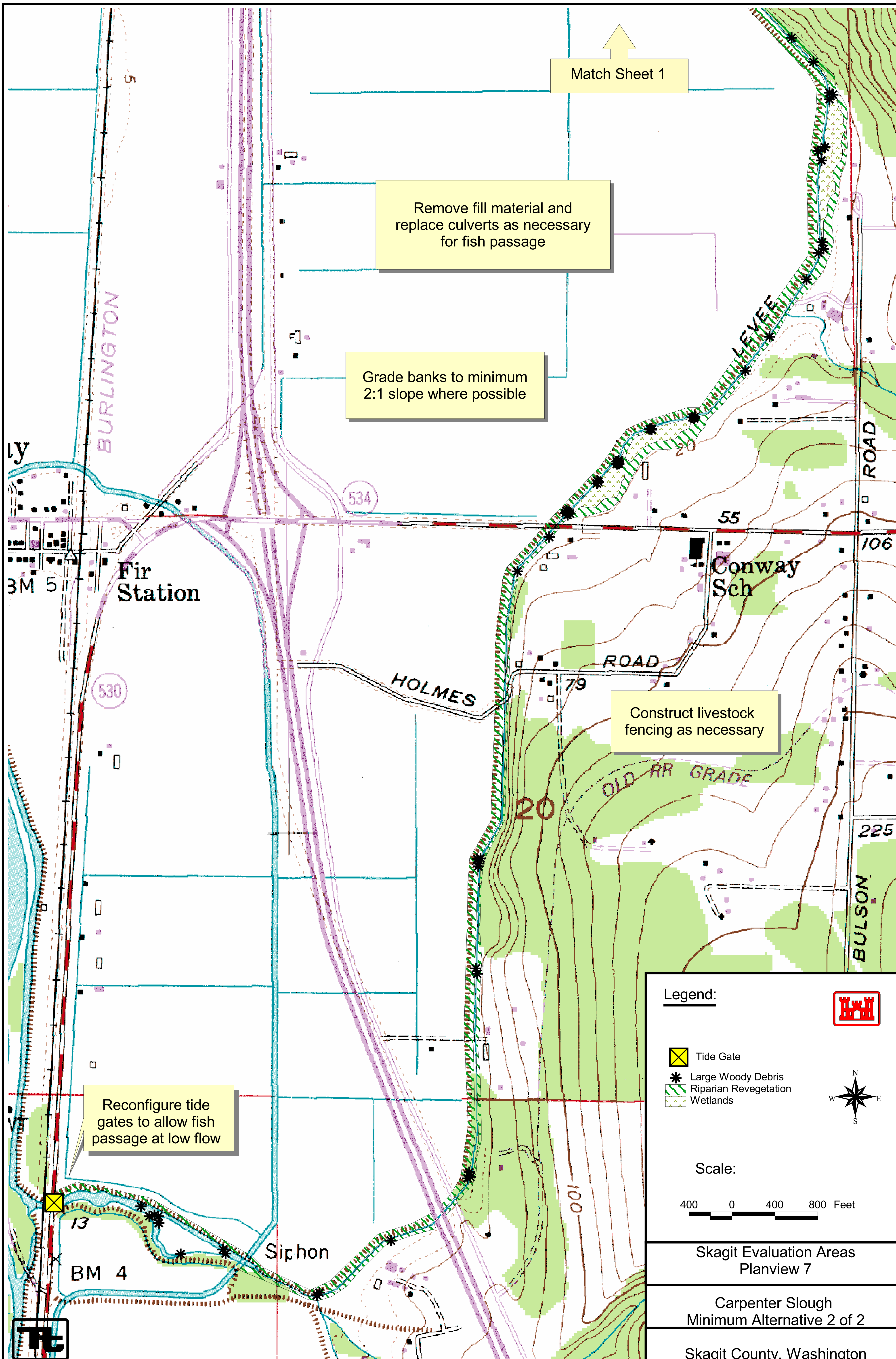


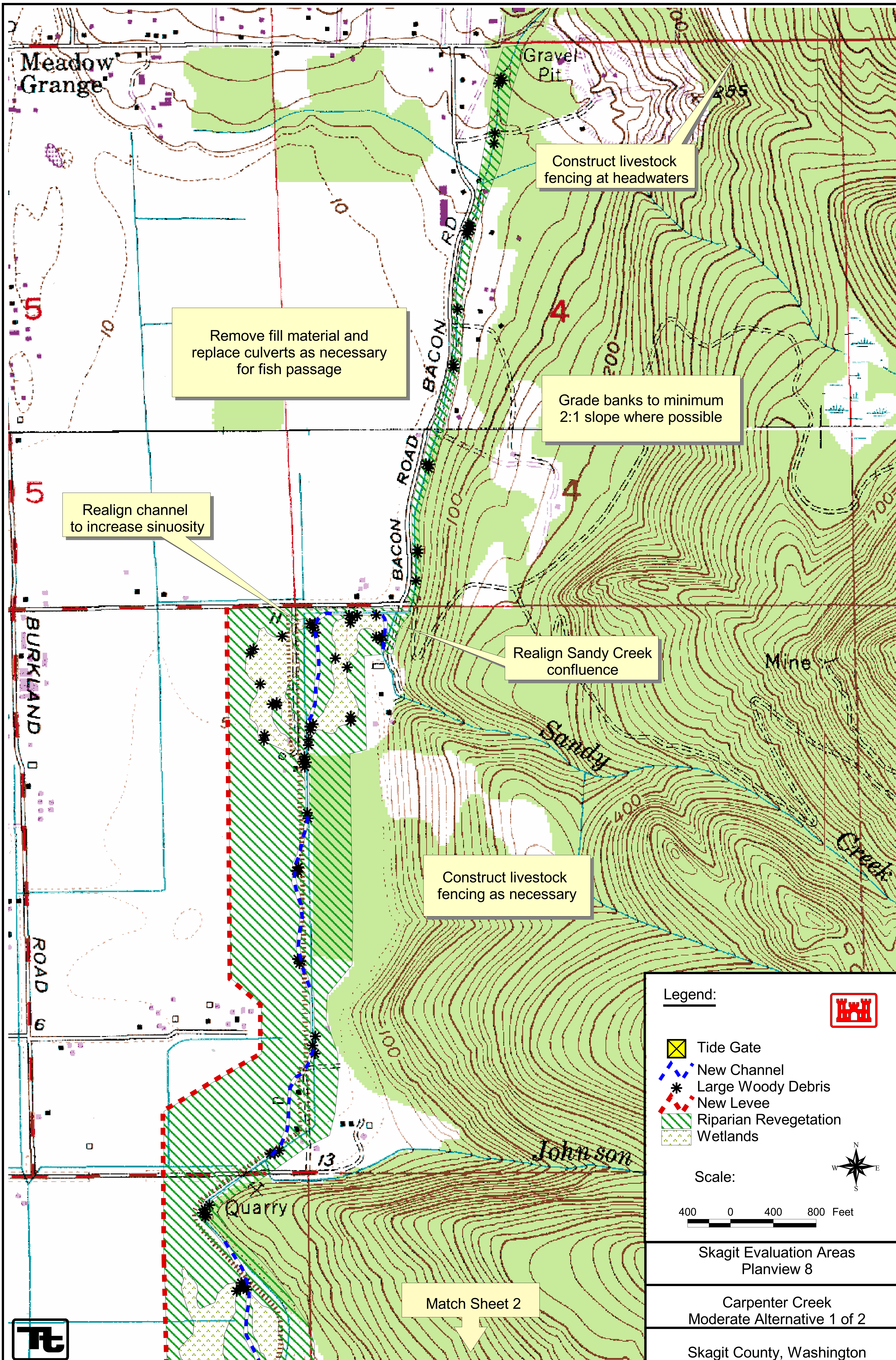
Install SRT
Grade banks to minimum 2:1 slope where possible
Remove fill material and replace culverts as necessary for fish passage
Remove tide gate and install culverts or bridge
Remove levee crossing and tide gates
15
22
FIR ISLAND
Pump
LEVEE
Browns
Slough
Legend:
Tide Gate
Existing Levee
New Levee
Large Woody Debris
Estuarine Wetland
Riparian/Upland Revegetation
Forested Tidal
Scale:
400 0 400 800 Feet
Skagit Evaluation Areas
Planview 5
Browns Slough
Moderate Alternative
Skagit County, Washington

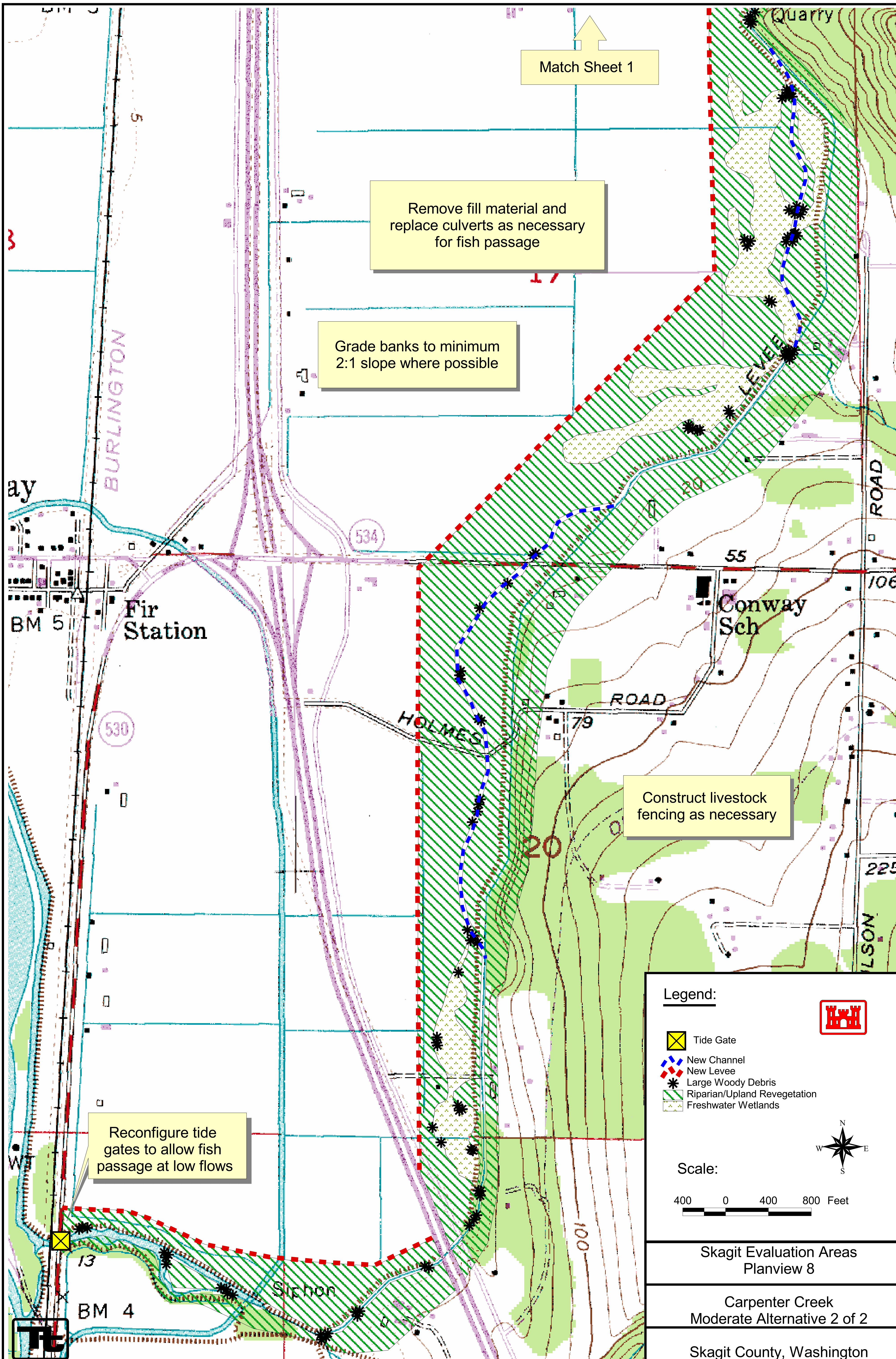


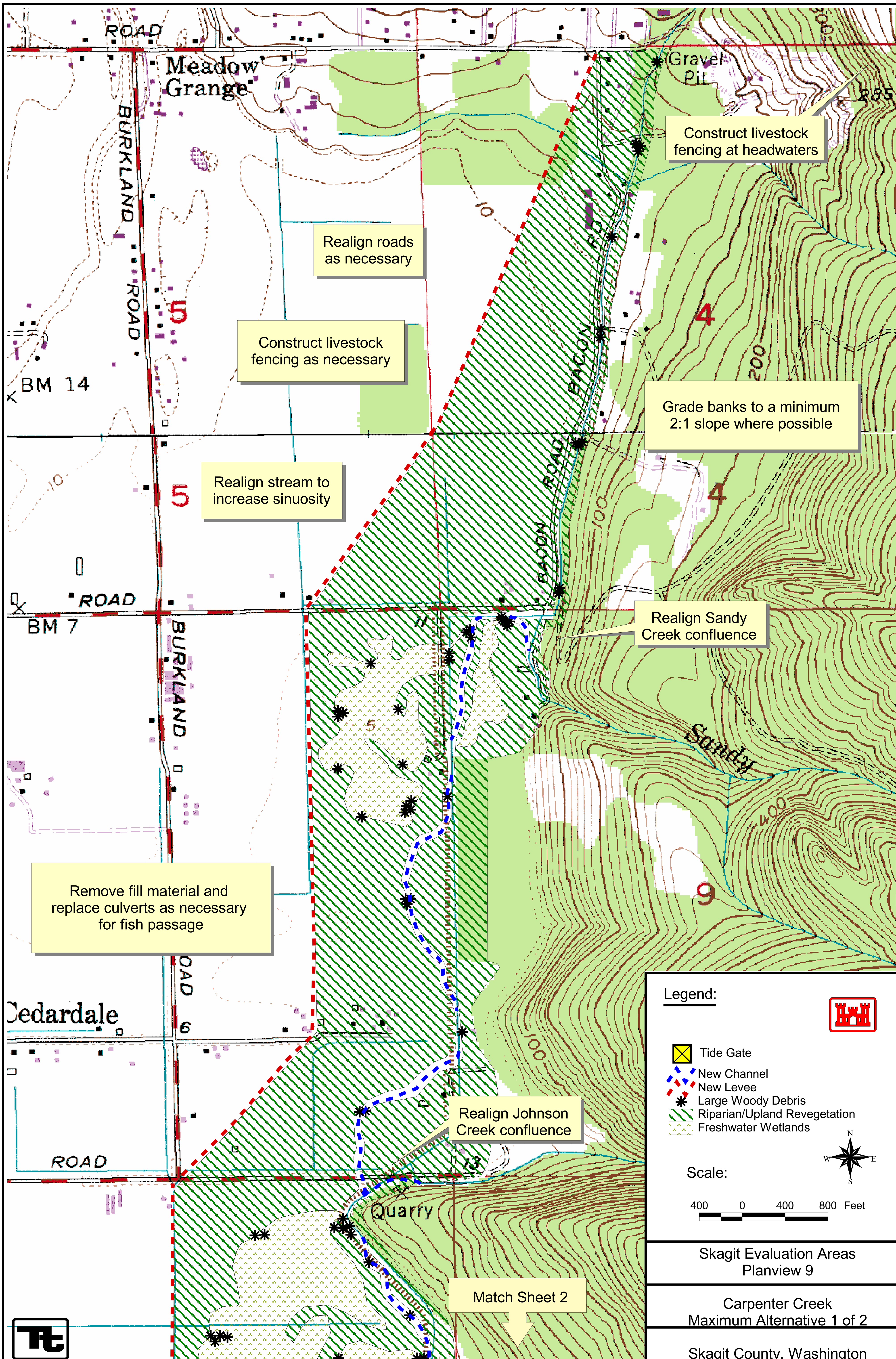
Rexville
RIVER
FORK
SKAGIT
RAWLINS
ROAD
MAUPIN
Browns Sl.
BROWNS SLOUGH
Hall Slough
Browns Slough
F I R
FIR
ISL
LEVEE
Pile
BM 7
BM 6
BM
10
15
20
21
22
7
9
Excavate inlet and install SRT
Grade banks to a minimum 2:1 slope where possible
Remove fill material and replace culverts as necessary for fish passage
Set levee back and realign road
Reconnect Hall and Brown Sloughs
Remove tide gates and install culvert or bridge
Remove levee spur
Remove tide gates
Remove levee crossing and tide gates
Legend:
Tide Gate
New Channel
Existing Levee
New Levee
Road Relocation
Large Woody Debris
Estuarine Wetland
Riparian/Upland Revegetation
Forested Tidal
N
S
E
W
Scale:
800
0
800 Feet
Skagit Evaluation Areas
Planview 6
Browns Slough
Maximum Alternative
Skagit County, Washington


Construct livestock fencing at headwaters
Construct livestock fencing as necessary
Remove fill material and replace culverts as necessary for fish passage
Realign Sandy Creek confluence
Grade banks to minimum 2:1 slope where possible
Match Sheet 2
Res
Res
Carpenter
Meadow Grange
Gravel Pit
Pit
ROAD
BURKLAND ROAD
BACON RD
BACON ROAD
Sandy
Quarry
Mine
rdale
Legend:
Tide Gate
Large Woody Debris
Riparian Revegetation
Wetlands
Scale:
400 0 400 800 Feet
Skagit Evaluation Areas
Planview 7
Carpenter Creek
Minimum Alternative 1 of 2
Skagit County, Washington

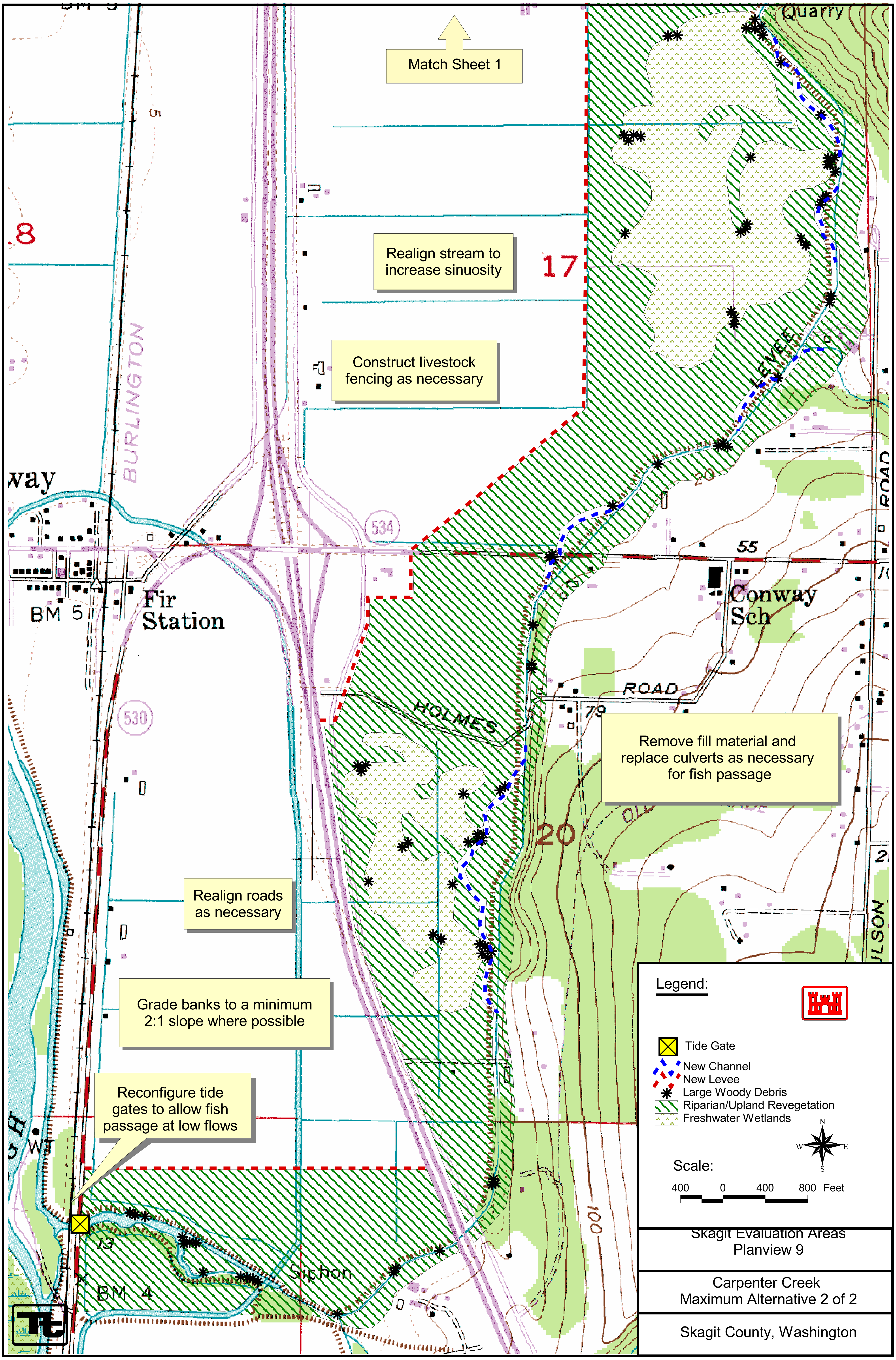

Match Sheet 1
Remove fill material and replace culverts as necessary for fish passage
Grade banks to minimum 2:1 slope where possible
Construct livestock fencing as necessary
Reconfigure tide gates to allow fish passage at low flow
BURLINGTON
Fir Station
BM 5
534
530
HOLMES
ROAD
LEVEE
55
106
Conway Sch
79
OLD RR GRADE
20
225
BULSON
ROAD
Siphon
BM 4
13
100
Legend:
Tide Gate
Large Woody Debris
Riparian Revegetation
Wetlands
N
W
E
S
Scale:
400 0 400 800 Feet
Skagit Evaluation Areas
Planview 7
Carpenter Slough
Minimum Alternative 2 of 2
Skagit County, Washington


Meadow Grange
Gravel Pit
Construct livestock fencing at headwaters
Remove fill material and replace culverts as necessary for fish passage
Grade banks to minimum 2:1 slope where possible
Realign channel to increase sinuosity
Realign Sandy Creek confluence
BACON RD
BACON ROAD
BURKLAND ROAD
Mine
Sandy Creek
Construct livestock fencing as necessary
Johnson
Quarry
Match Sheet 2
Legend:
Tide Gate
New Channel
Large Woody Debris
New Levee
Riparian Revegetation
Wetlands
Scale:
400 0 400 800 Feet
Skagit Evaluation Areas
Planview 8
Carpenter Creek
Moderate Alternative 1 of 2
Skagit County, Washington

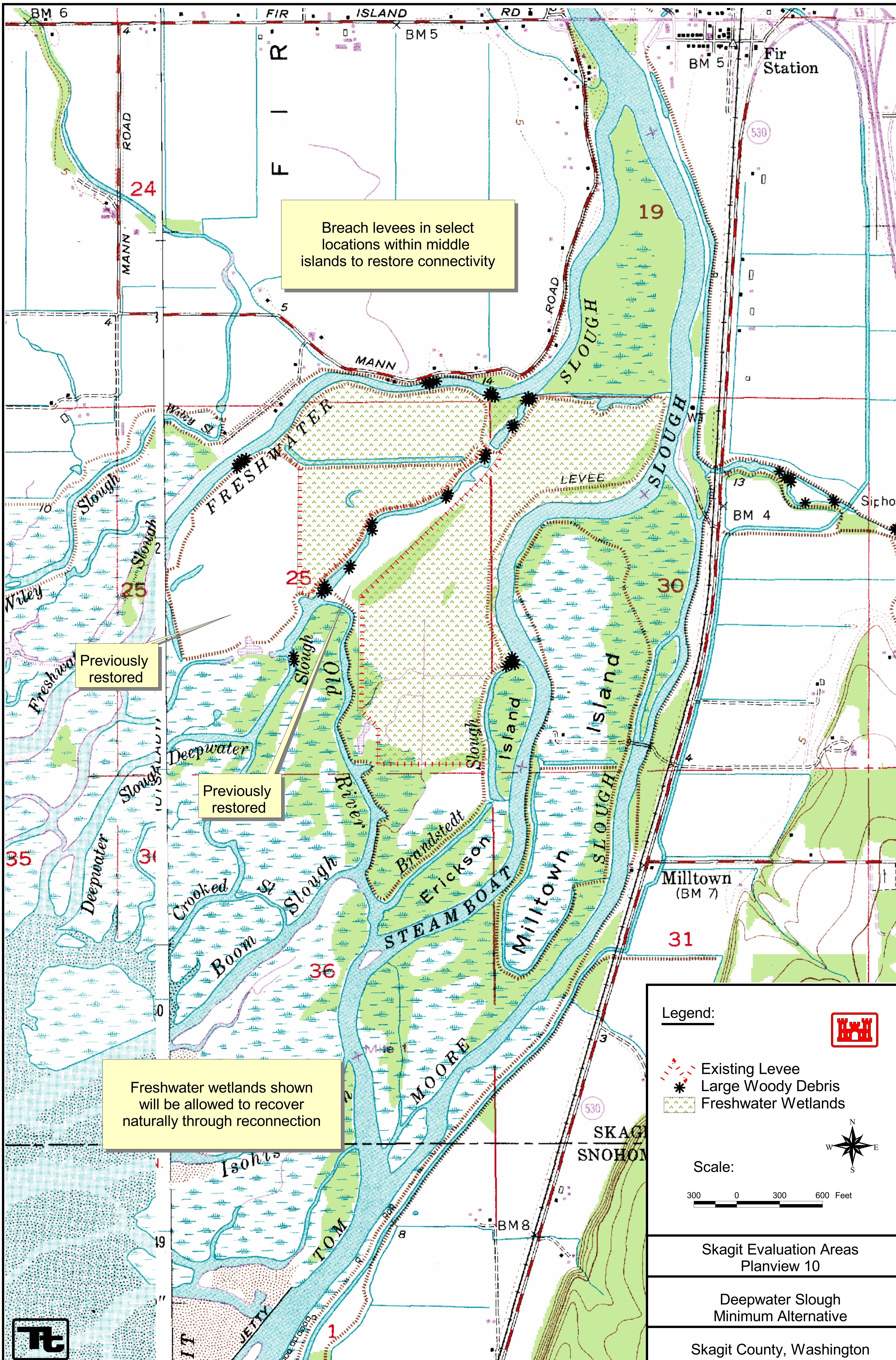

Match Sheet 1
Remove fill material and replace culverts as necessary for fish passage
Grade banks to minimum 2:1 slope where possible
Construct livestock fencing as necessary
Reconfigure tide gates to allow fish passage at low flows
Quarry
LEVEE
BURLINGTON
Fir Station
BM 5
534
530
55
106
Conway Sch
ROAD
HOLMES
ROAD
79
225
20
Siphon
BM 4
13
Legend:
Tide Gate
New Channel
New Levee
Large Woody Debris
Riparian/Upland Revegetation
Freshwater Wetlands
N
W
E
S
Scale:
400 0 400 800 Feet
Skagit Evaluation Areas
Planview 8
Carpenter Creek
Moderate Alternative 2 of 2
Skagit County, Washington



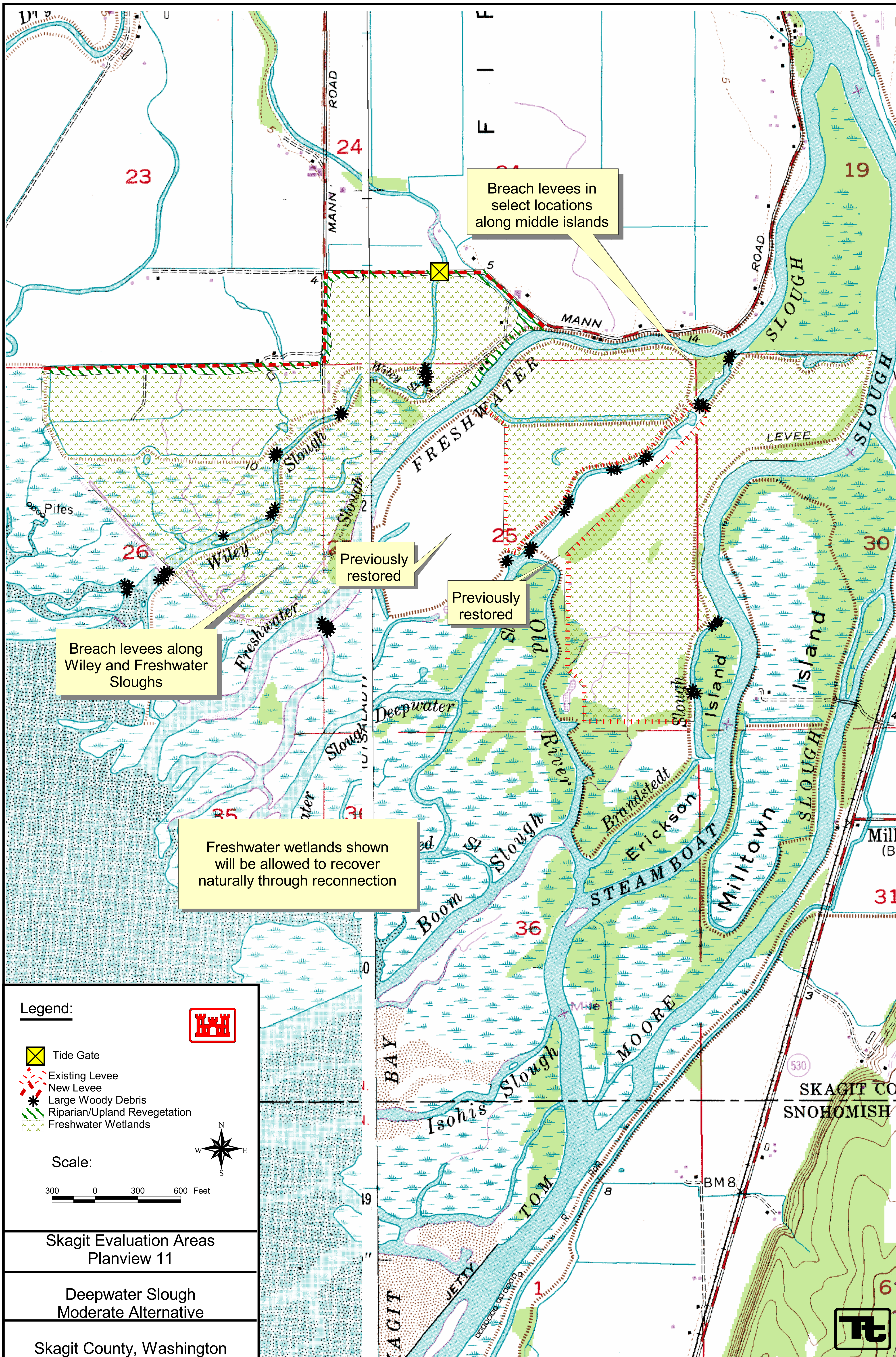
Meadow Grange
Gravel Pit
BURKLAND ROAD
BACON ROAD
Cedardale
Quarry
Sandy
BM 14
BM 7
Construct livestock fencing at headwaters
Realign roads as necessary
Construct livestock fencing as necessary
Grade banks to a minimum 2:1 slope where possible
Realign stream to increase sinuosity
Realign Sandy Creek confluence
Remove fill material and replace culverts as necessary for fish passage
Realign Johnson Creek confluence
Match Sheet 2
Legend:
Tide Gate
New Channel
New Levee
Large Woody Debris
Riparian/Upland Revegetation
Freshwater Wetlands
Scale:
400 0 400 800 Feet
Skagit Evaluation Areas
Planview 9
Carpenter Creek
Maximum Alternative 1 of 2
Skagit County, Washington

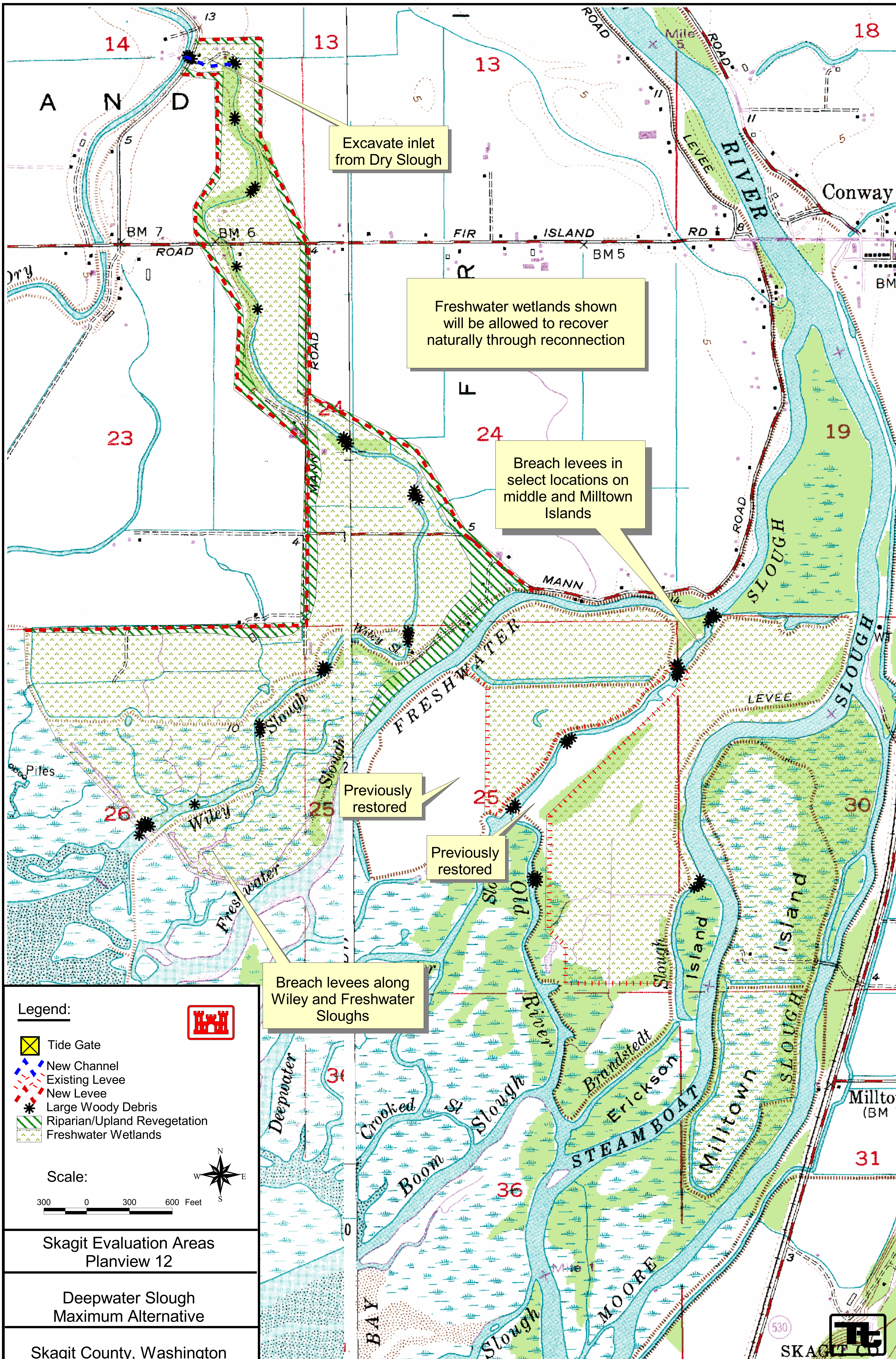


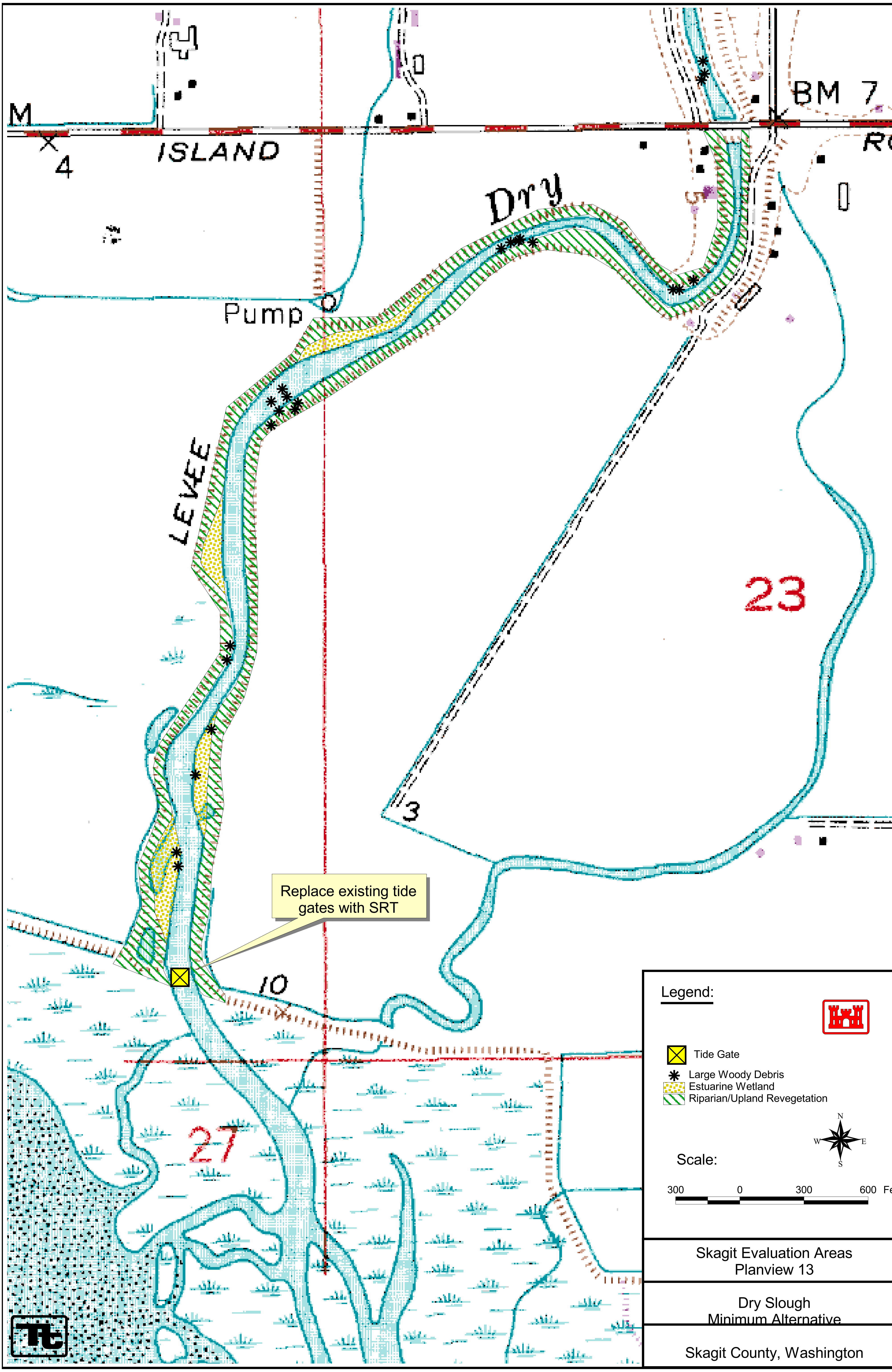
Match Sheet 1
Realign stream to increase sinuosity
Construct livestock fencing as necessary
Remove fill material and replace culverts as necessary for fish passage
Realign roads as necessary
Grade banks to a minimum 2:1 slope where possible
Reconfigure tide gates to allow fish passage at low flows
Quarry
BURLINGTON
Fir Station
BM 5
BM 4
Conway Sch
ROAD
HOLMES
LEVEE
Siphon
17
20
55
534
530
Legend:
Tide Gate
New Channel
New Levee
Large Woody Debris
Riparian/Upland Revegetation
Freshwater Wetlands
Scale:
400 0 400 800 Feet
Skagit Evaluation Areas
Planview 9
Carpenter Creek
Maximum Alternative 2 of 2
Skagit County, Washington



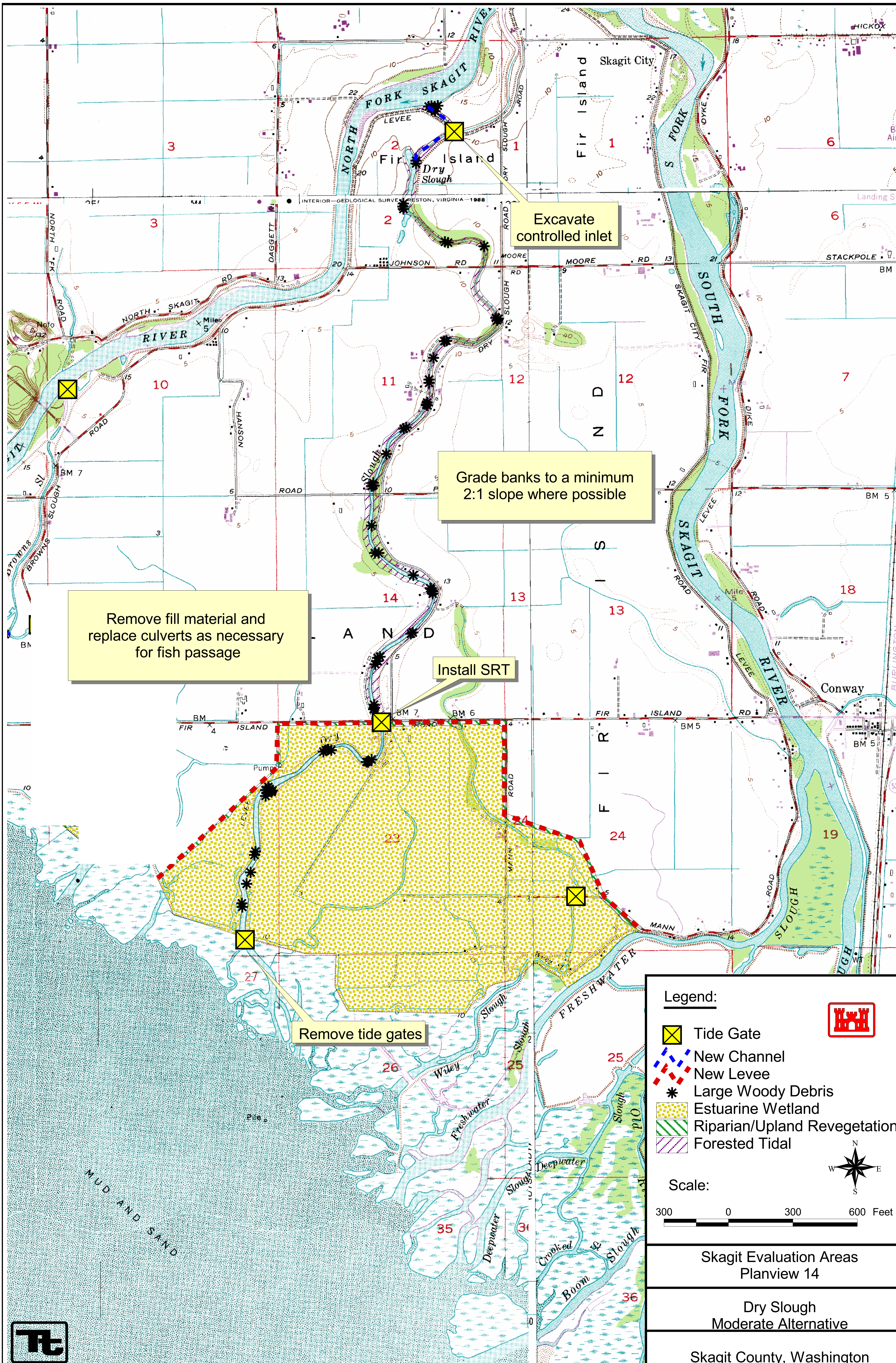
Breach levees in select locations within middle islands to restore connectivity
Previously restored
Previously restored
Freshwater wetlands shown will be allowed to recover naturally through reconnection
Legend:
Existing Levee
Large Woody Debris
Freshwater Wetlands
Scale:
300 0 300 600 Feet
Skagit Evaluation Areas
Planview 10
Deepwater Slough
Minimum Alternative
Skagit County, Washington
FIR ISLAND RD
BM 6
BM 5
Fir Station
MANN ROAD
FRESHWATER SLOUGH
SLOUGH
LEVEE
Old River
Deepwater Slough
Wiley Slough
Steamboat Slough
Brandstedt Slough
Erickson Slough
Milltown Island
Island Slough
Crooked Slough
Boom Slough
MOORE
TOM JETTY
Milltown (BM 7)
BM 4
BM 8
Siphon
SKAGIT
SNOHOMISH
19
24
25
30
31
35
36

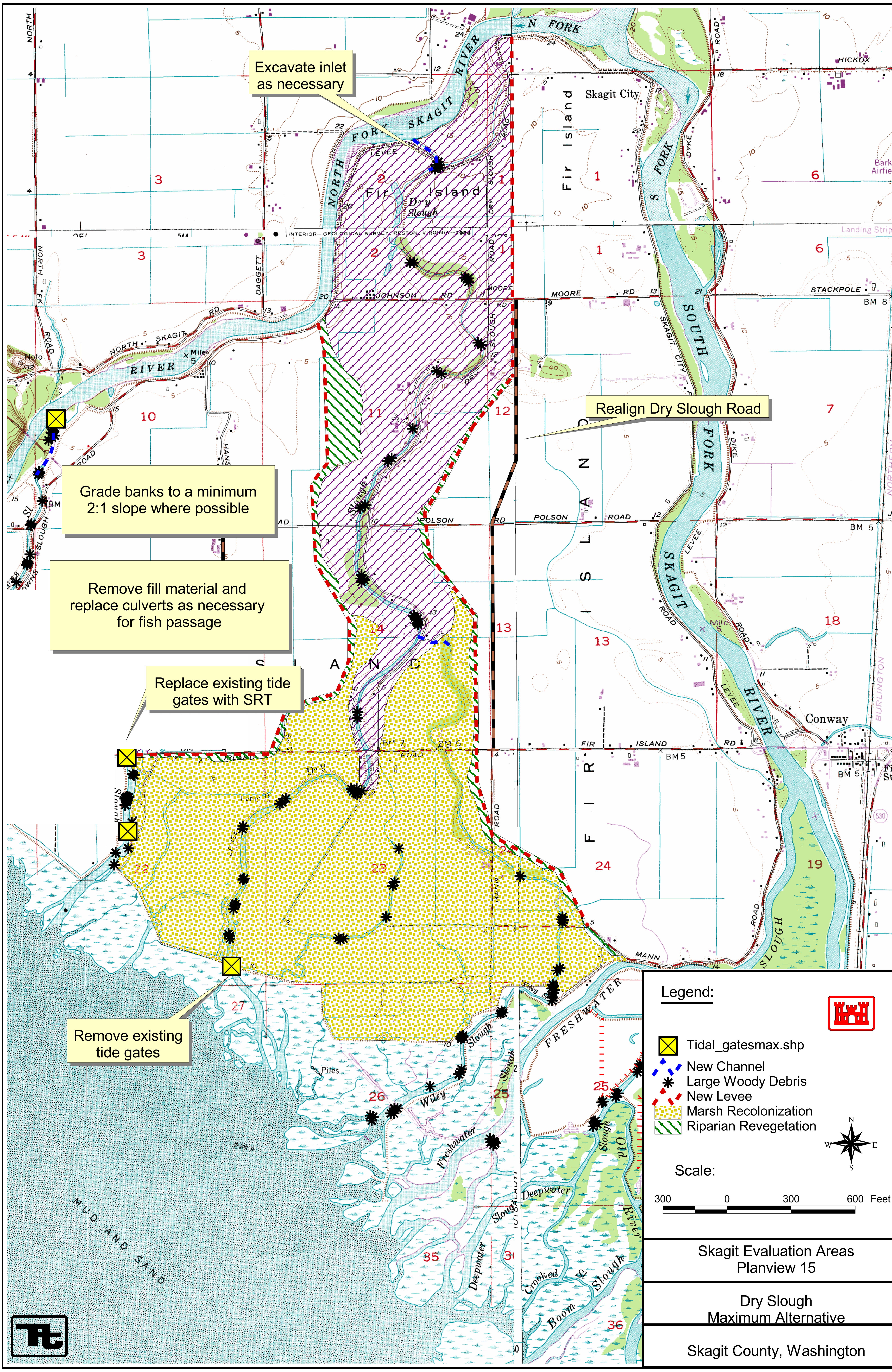

Breach levees in select locations along middle islands
Previously restored
Previously restored
Breach levees along Wiley and Freshwater Sloughs
Freshwater wetlands shown will be allowed to recover naturally through reconnection
Legend:
Tide Gate
Existing Levee
New Levee
Large Woody Debris
Riparian/Upland Revegetation
Freshwater Wetlands
Scale:
300 0 300 600 Feet
Skagit Evaluation Areas
Planview 11
Deepwater Slough
Moderate Alternative
Skagit County, Washington
MANN ROAD
FRESHWATER SLOUGH
Wiley Slough
Freshwater Slough
Deepwater Slough
Old River
Boom Slough
Brandstedt
Erickson
STEAMBOAT SLOUGH
Island Slough
Milltown Island
MOORE
Isohis Slough
TOM
SKAGIT BAY
JETTY
LEVEE
SKAGIT CO
SNOHOMISH

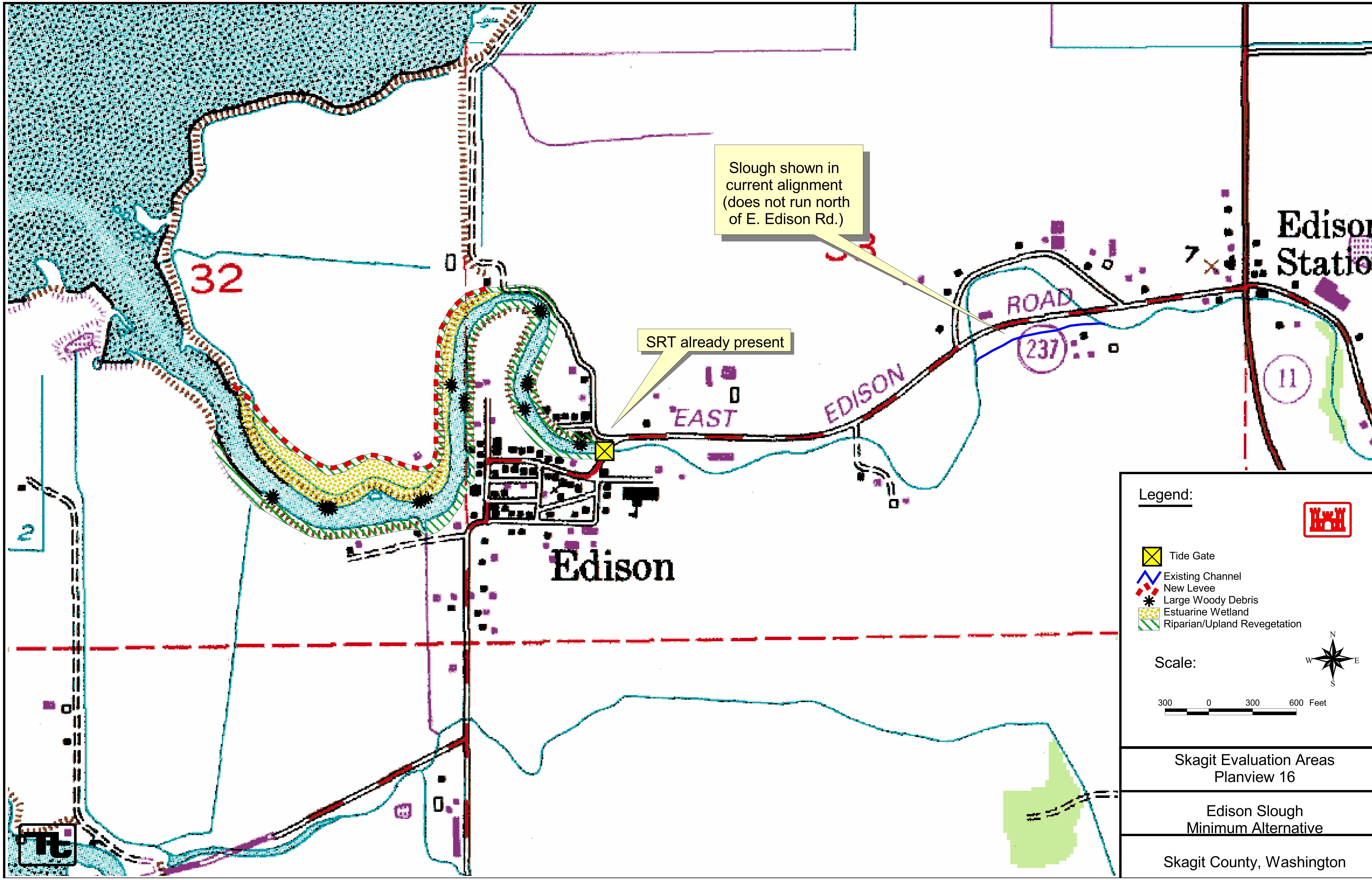

Excavate inlet from Dry Slough
Freshwater wetlands shown will be allowed to recover naturally through reconnection
Breach levees in select locations on middle and Milltown Islands
Previously restored
Previously restored
Breach levees along Wiley and Freshwater Sloughs
Legend:
Tide Gate
New Channel
Existing Levee
New Levee
Large Woody Debris
Riparian/Upland Revegetation
Freshwater Wetlands
Scale:
300 0 300 600 Feet
N
S
E
W
Skagit Evaluation Areas
Planview 12
Deepwater Slough
Maximum Alternative
Skagit County, Washington
Conway
FIR ISLAND RD
MANN ROAD
RIVER
LEVEE
FRESHWATER
SLOUGH
Wiley Slough
Freshwater
Deepwater Slough
Crooked Slough
Boom Slough
Old River
Brandstedt
Erickson Slough
STEAMBOAT SLOUGH
Milltown Island
MOORE
BAY
Piles
BM 7
BM 6
BM 5
14
13
23
24
25
26
19
30
31
36
18



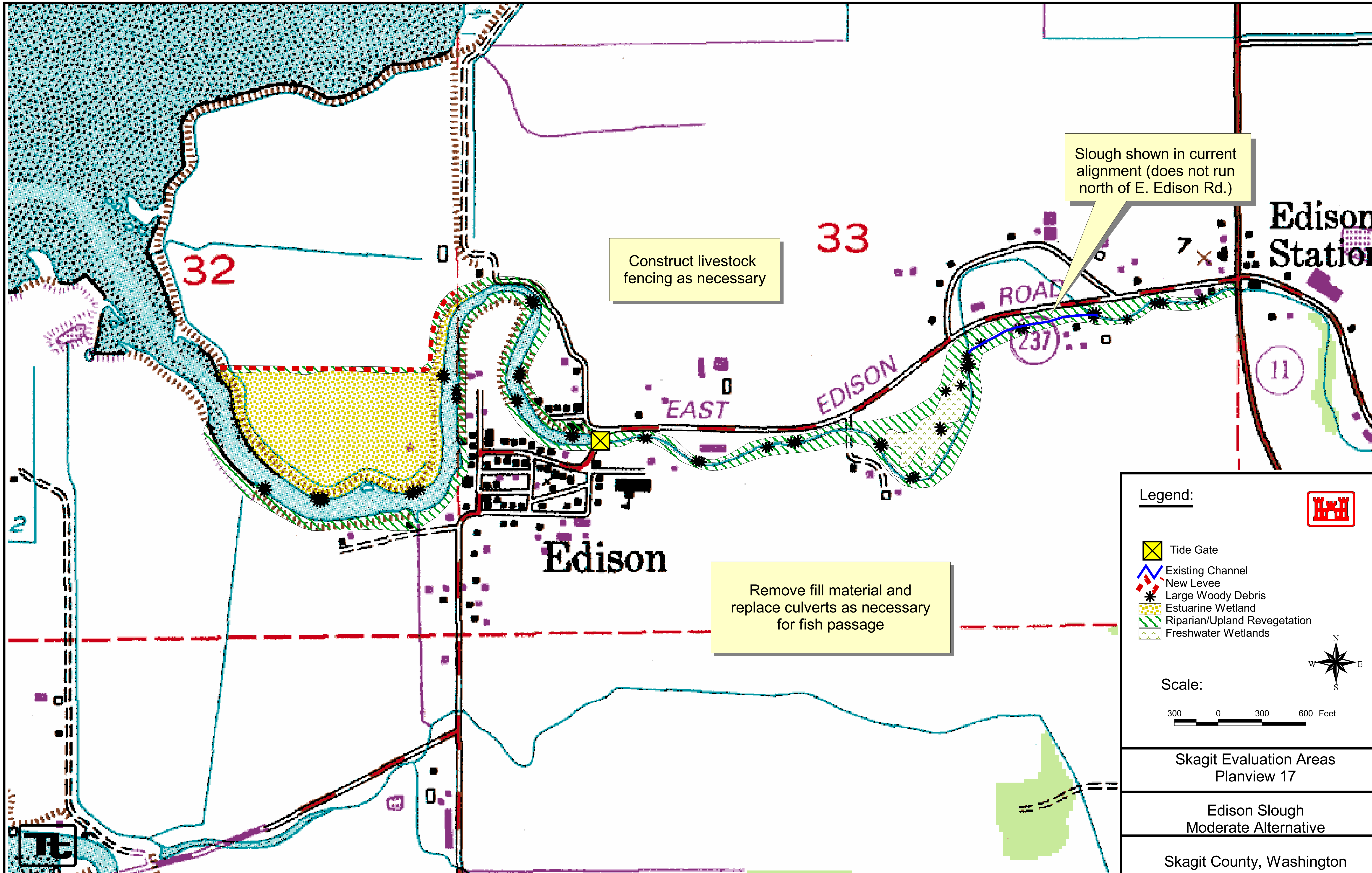
ISLAND
RO
BM 7
Dry
Pump
LEVEE
23
3
10
27
Replace existing tide gates with SRT
Legend:
Tide Gate
Large Woody Debris
Estuarine Wetland
Riparian/Upland Revegetation
N
W
E
S
Scale:
300 0 300 600 Fee
Skagit Evaluation Areas
Planview 13
Dry Slough
Minimum Alternative
Skagit County, Washington


Excavate controlled inlet
Grade banks to a minimum 2:1 slope where possible
Remove fill material and replace culverts as necessary for fish passage
Install SRT
Remove tide gates
Legend:
Tide Gate
New Channel
New Levee
Large Woody Debris
Estuarine Wetland
Riparian/Upland Revegetation
Forested Tidal
Scale:
300 0 300 600 Feet
Skagit Evaluation Areas
Planview 14
Dry Slough
Moderate Alternative
Skagit County, Washington

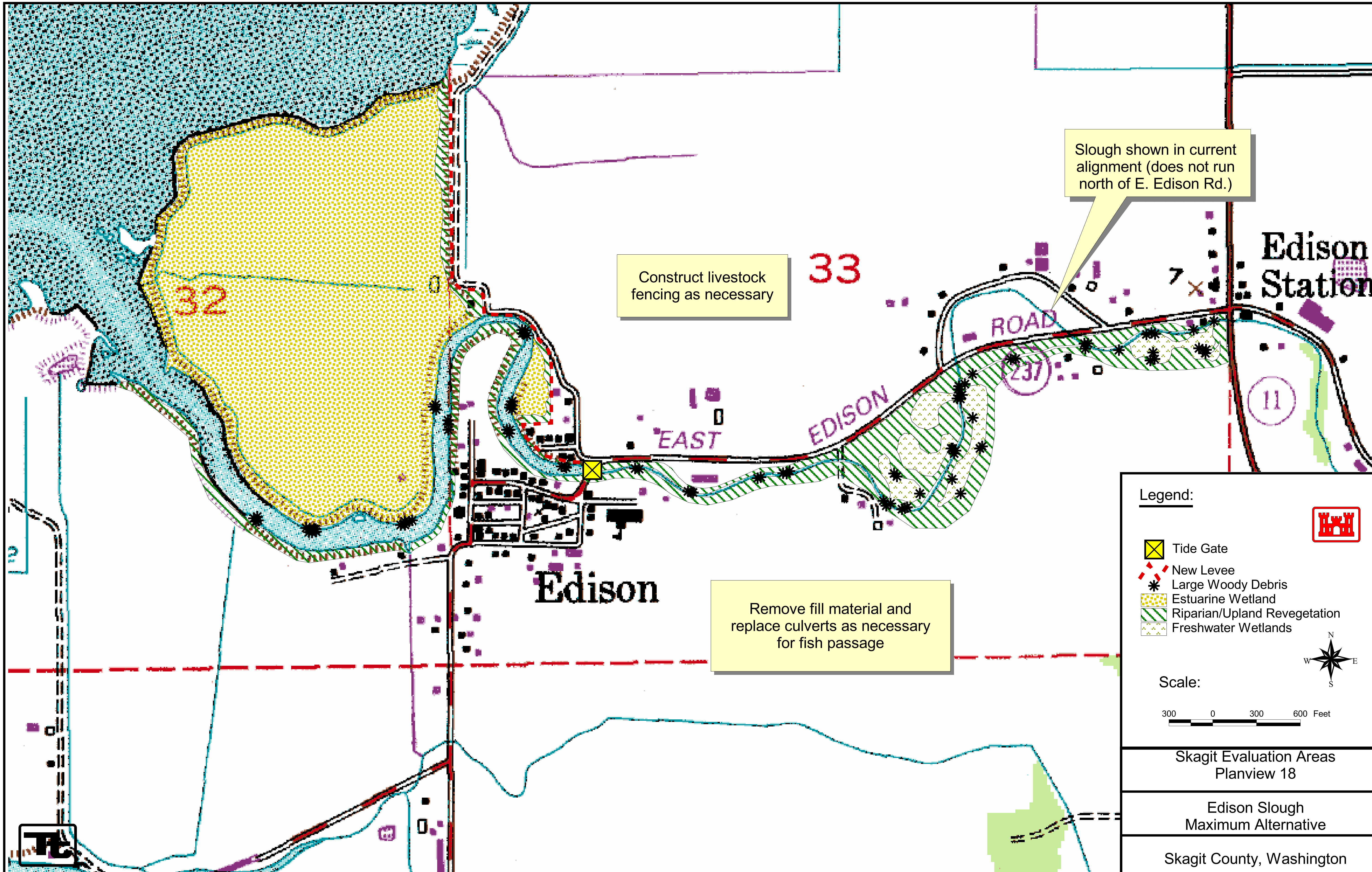

Excavate inlet as necessary
Realign Dry Slough Road
Grade banks to a minimum 2:1 slope where possible
Remove fill material and replace culverts as necessary for fish passage
Replace existing tide gates with SRT
Remove existing tide gates
Legend:
Tidal_gatesmax.shp
New Channel
Large Woody Debris
New Levee
Marsh Recolonization
Riparian Revegetation
Scale:
300 0 300 600 Feet
Skagit Evaluation Areas
Planview 15
Dry Slough
Maximum Alternative
Skagit County, Washington



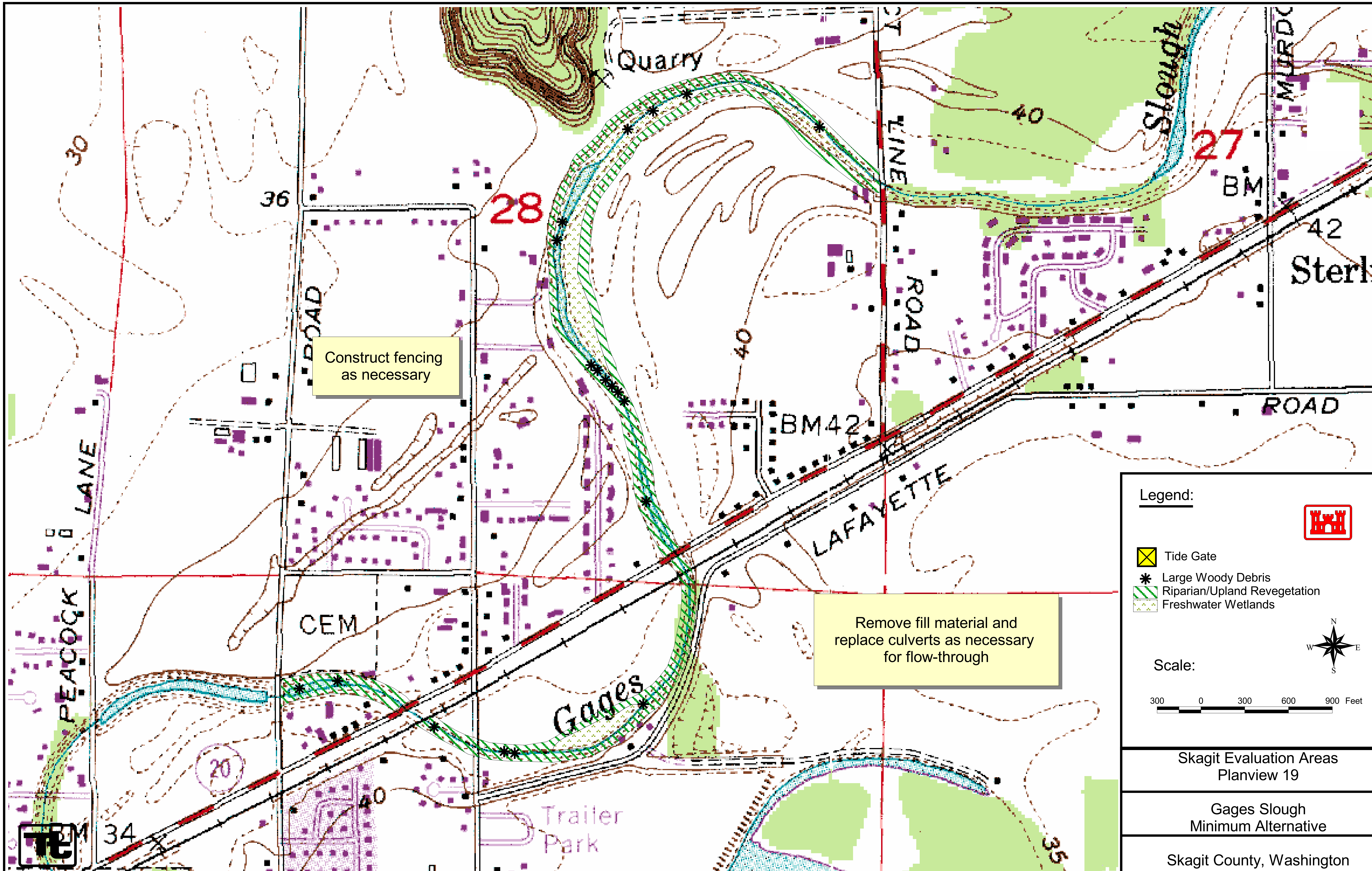
Slough shown in current alignment (does not run north of E. Edison Rd.)
SRT already present
32
EAST
EDISON
ROAD
237
11
Edison
Edison Station
Legend:
Tide Gate
Existing Channel
New Levee
Large Woody Debris
Estuarine Wetland
Riparian/Upland Revegetation
Scale:
300 0 300 600 Feet
N
S
E
W
Skagit Evaluation Areas
Planview 16
Edison Slough
Minimum Alternative
Skagit County, Washington



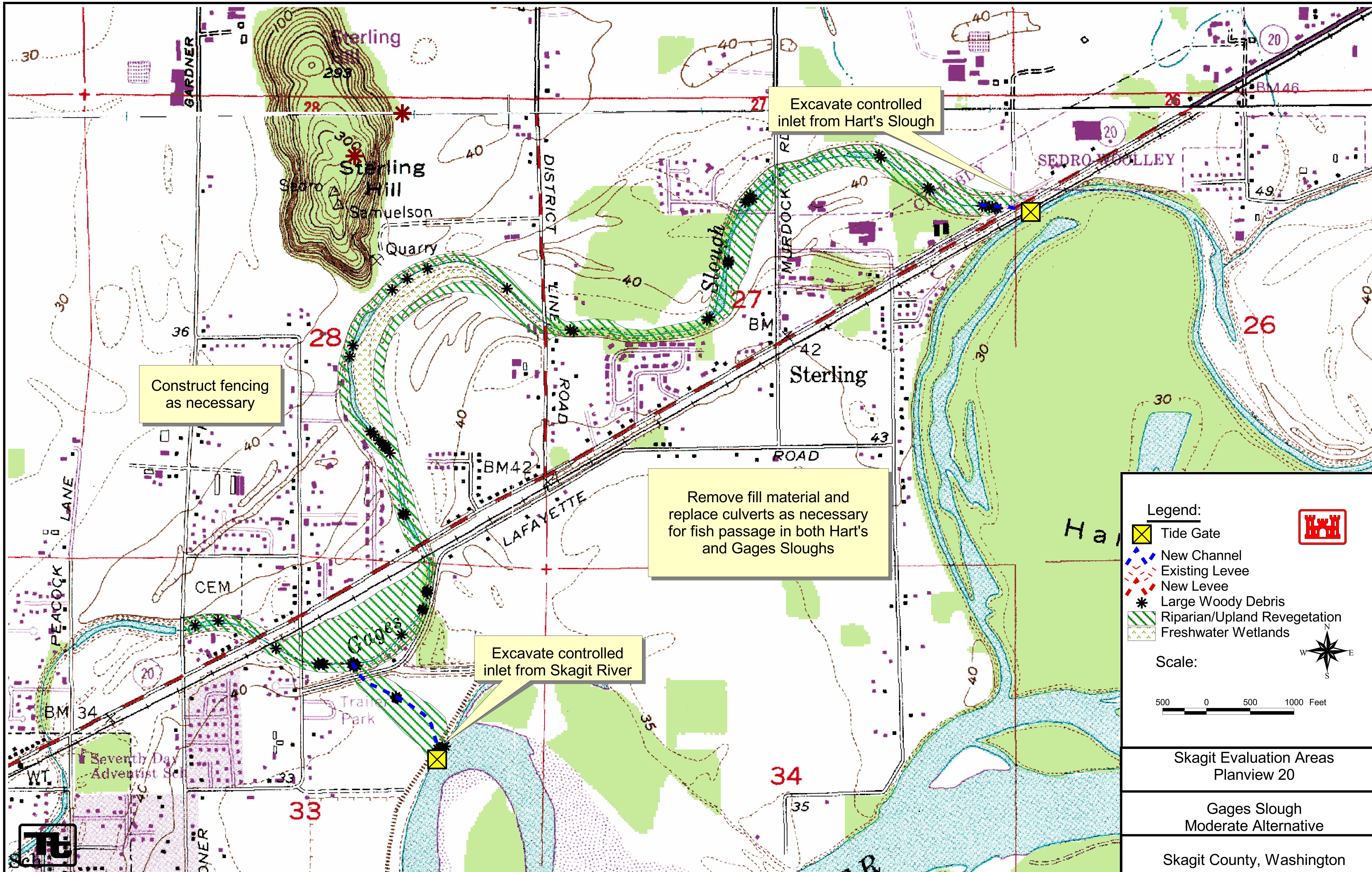
Slough shown in current alignment (does not run north of E. Edison Rd.)
Edison Station
33
32
Construct livestock fencing as necessary
EAST EDISON ROAD
237
11
Edison
Remove fill material and replace culverts as necessary for fish passage
Legend:
Tide Gate
Existing Channel
New Levee
Large Woody Debris
Estuarine Wetland
Riparian/Upland Revegetation
Freshwater Wetlands
N
W
E
S
Scale:
300 0 300 600 Feet
Skagit Evaluation Areas
Planview 17
Edison Slough
Moderate Alternative
Skagit County, Washington

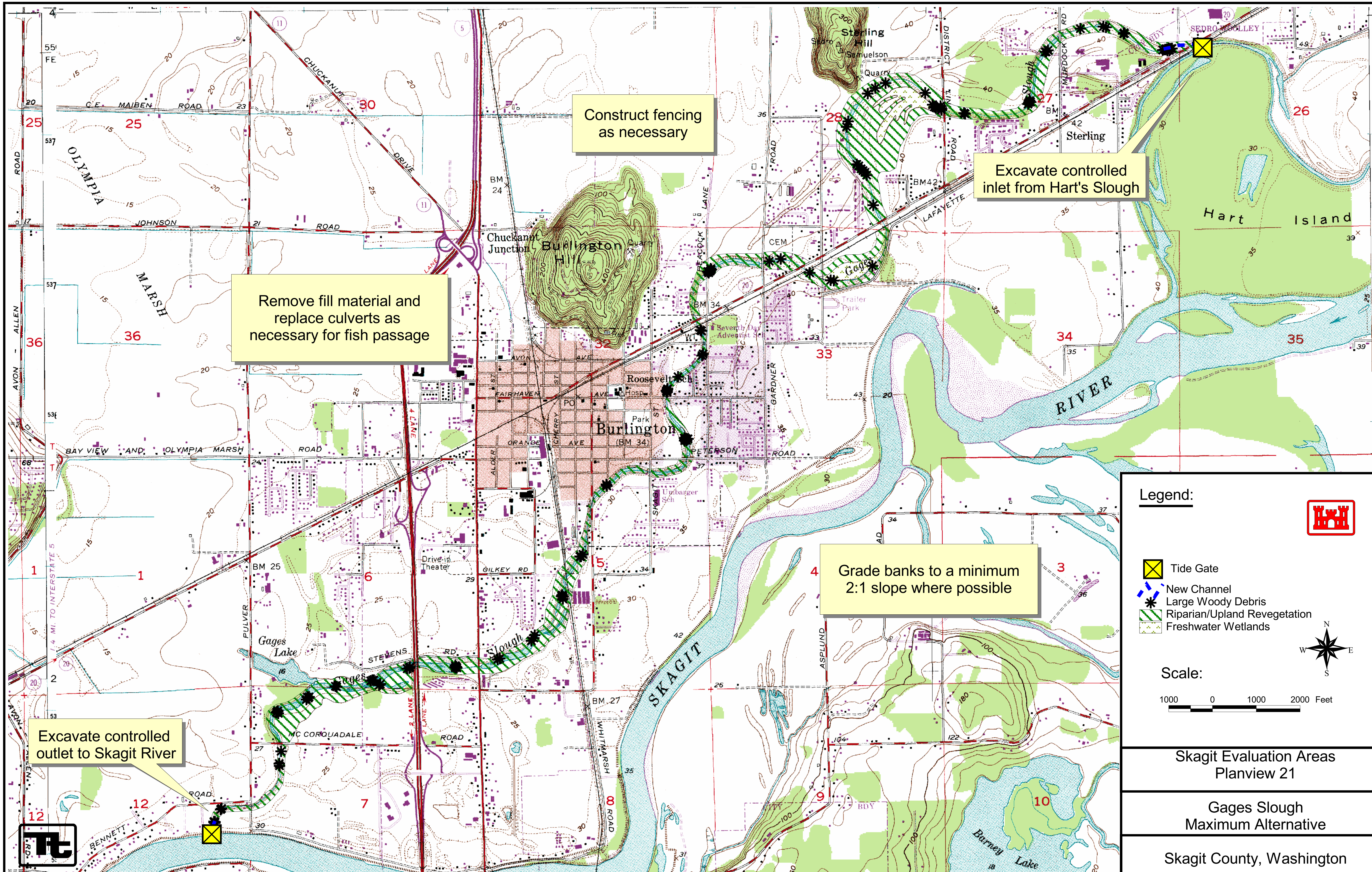


Slough shown in current alignment (does not run north of E. Edison Rd.)
Construct livestock fencing as necessary
Remove fill material and replace culverts as necessary for fish passage
32
33
EAST EDISON ROAD
237
11
Edison
Edison Station
Legend:
Tide Gate
New Levee
Large Woody Debris
Estuarine Wetland
Riparian/Upland Revegetation
Freshwater Wetlands
Scale:
300 0 300 600 Feet
N
E
S
W
Skagit Evaluation Areas
Planview 18
Edison Slough
Maximum Alternative
Skagit County, Washington

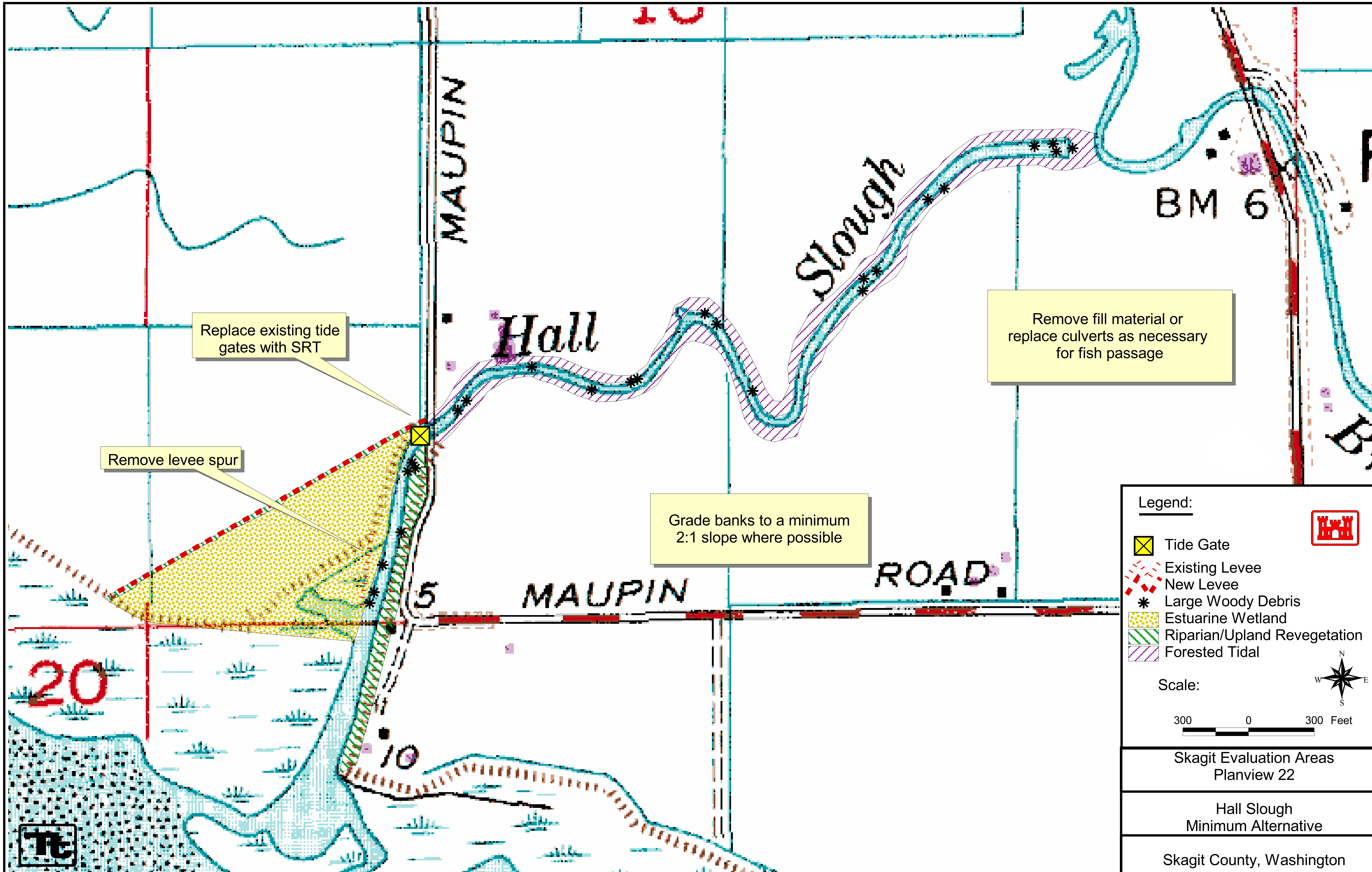


Quarry
Slough
27
28
BM
42
Sterli
36
30
ROAD
LINE
ROAD
40
BM42
LAFAYETTE
ROAD
LANE
PEACOCK
CEM
Gages
20
40
Trailer
Park
BM 34
35
Construct fencing as necessary
Remove fill material and replace culverts as necessary for flow-through
Legend:
Tide Gate
Large Woody Debris
Riparian/Upland Revegetation
Freshwater Wetlands
N
W
E
S
Scale:
300 0 300 600 900 Feet
Skagit Evaluation Areas
Planview 19
Gages Slough
Minimum Alternative
Skagit County, Washington

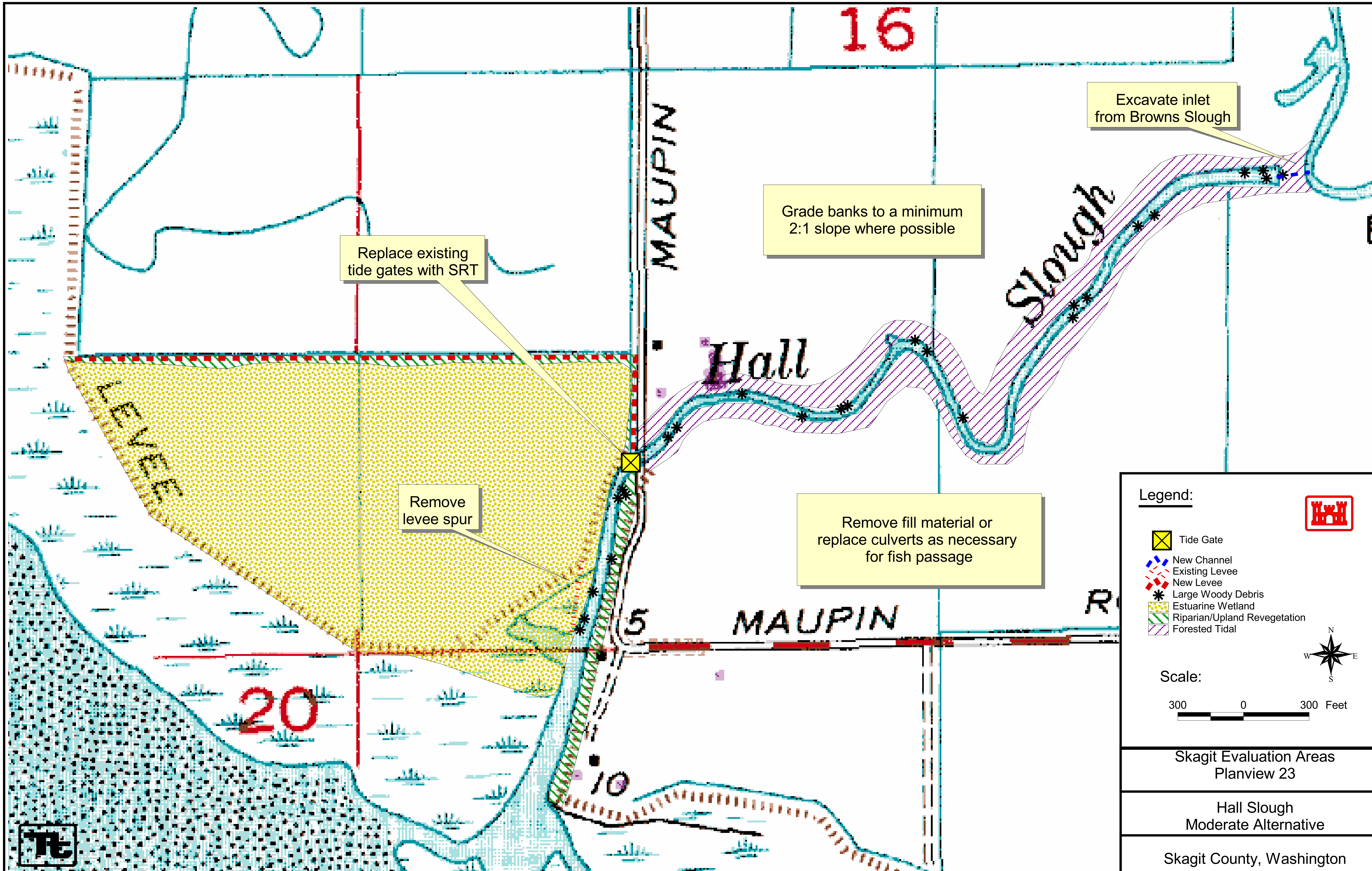

Excavate controlled inlet from Hart's Slough
Construct fencing as necessary
Remove fill material and replace culverts as necessary for fish passage in both Hart's and Gages Sloughs
Excavate controlled inlet from Skagit River
Legend:
Tide Gate
New Channel
Existing Levee
New Levee
Large Woody Debris
Riparian/Upland Revegetation
Freshwater Wetlands
Scale:
500 0 500 1000 Feet
Skagit Evaluation Areas
Planview 20
Gages Slough
Moderate Alternative
Skagit County, Washington
Sterling Hill
SEDRO WOOLLEY
Sterling
DISTRICT LINE ROAD
MURDOCK RD
LAFAYETTE ROAD
PEACOCK LANE
Slough
Gages
CEM
Trailer Park
Seventh Day Adventist Sch
Samuelson
Quarry
28
27
26
33
34

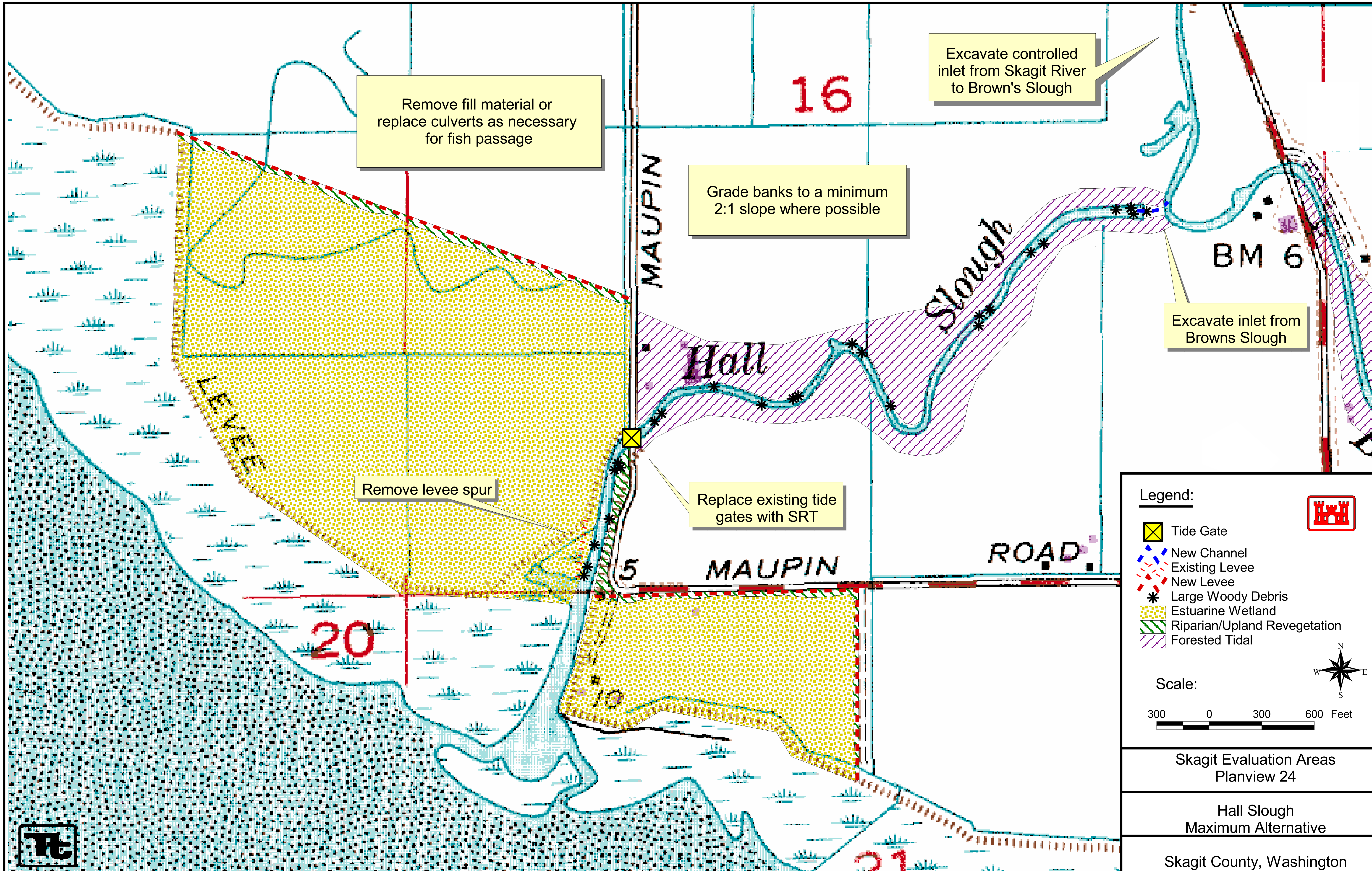


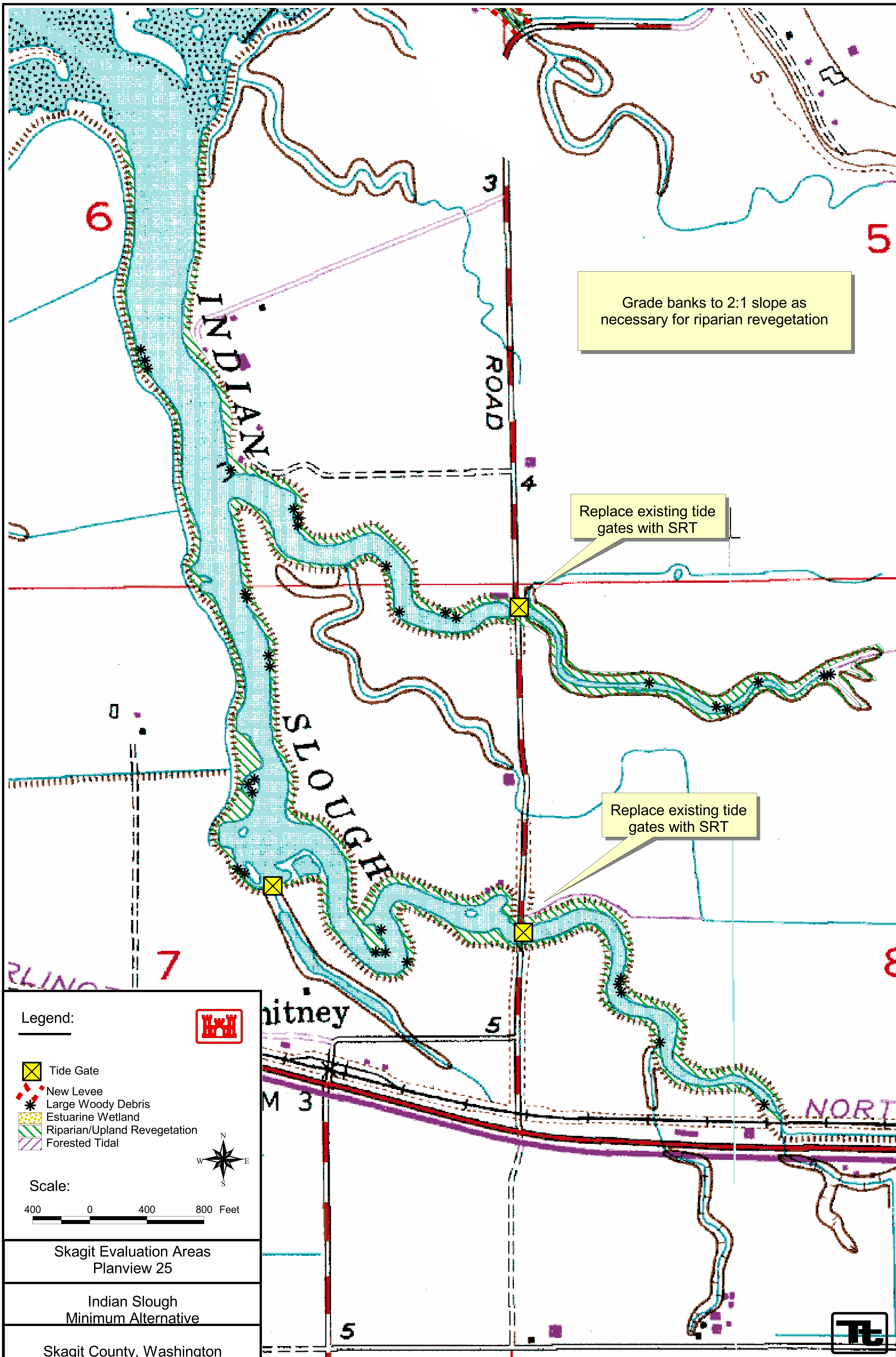
Construct fencing as necessary
Excavate controlled inlet from Hart's Slough
Remove fill material and replace culverts as necessary for fish passage
Grade banks to a minimum 2:1 slope where possible
Excavate controlled outlet to Skagit River
Legend:
Tide Gate
New Channel
Large Woody Debris
Riparian/Upland Revegetation
Freshwater Wetlands
Scale:
1000 0 1000 2000 Feet
Skagit Evaluation Areas
Planview 21
Gages Slough
Maximum Alternative
Skagit County, Washington
Burlington
Burlington Hill
Hart Island
SKAGIT RIVER
Gages Slough
Sterling
Sterling Hill
Gages Lake
Barney Lake

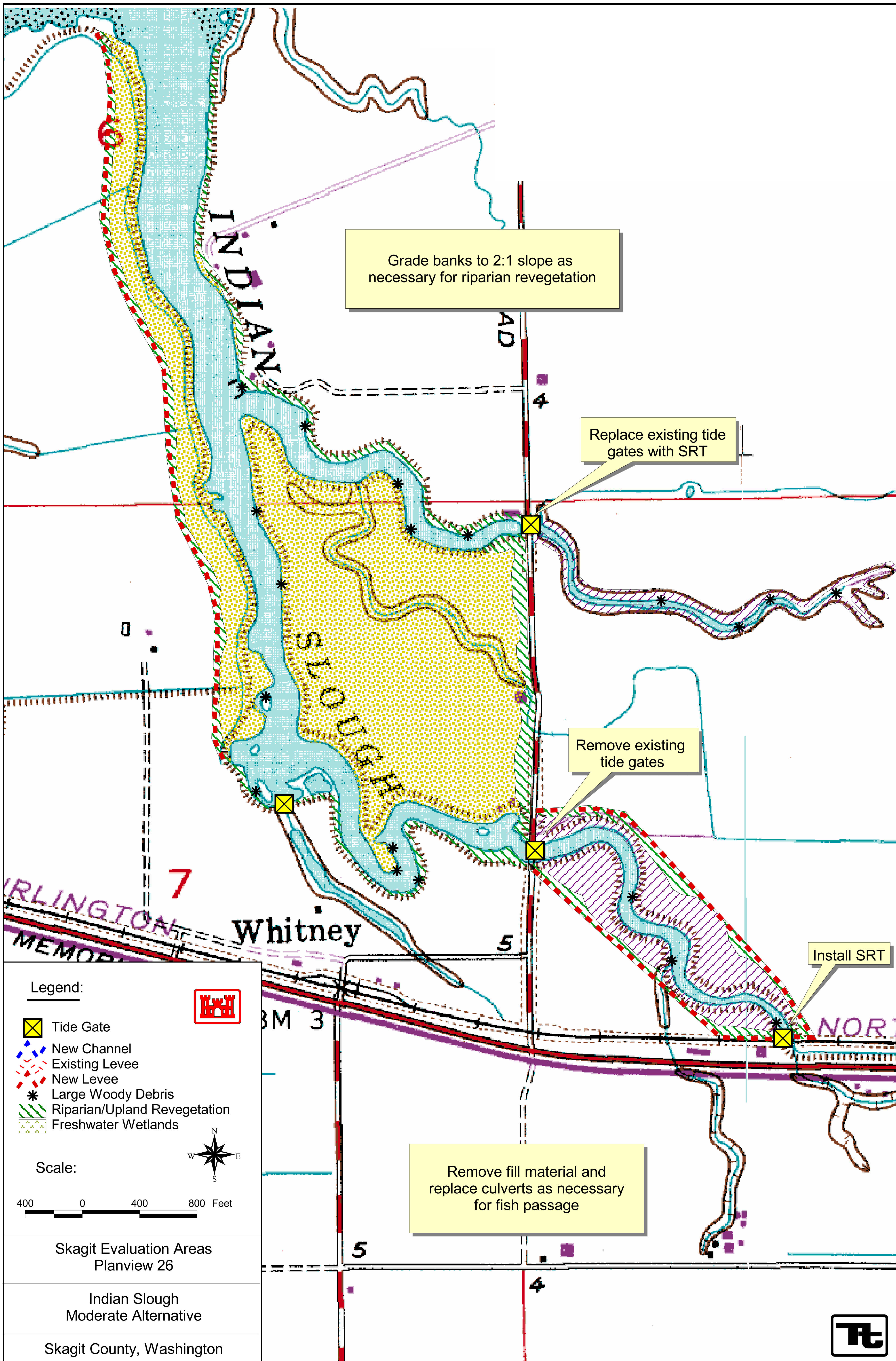


MAUPIN
Hall
Slough
BM 6
Replace existing tide gates with SRT
Remove fill material or replace culverts as necessary for fish passage
Remove levee spur
Grade banks to a minimum 2:1 slope where possible
MAUPIN
ROAD
20
Legend:
Tide Gate
Existing Levee
New Levee
Large Woody Debris
Estuarine Wetland
Riparian/Upland Revegetation
Forested Tidal
Scale:
300 0 300 Feet
Skagit Evaluation Areas
Planview 22
Hall Slough
Minimum Alternative
Skagit County, Washington

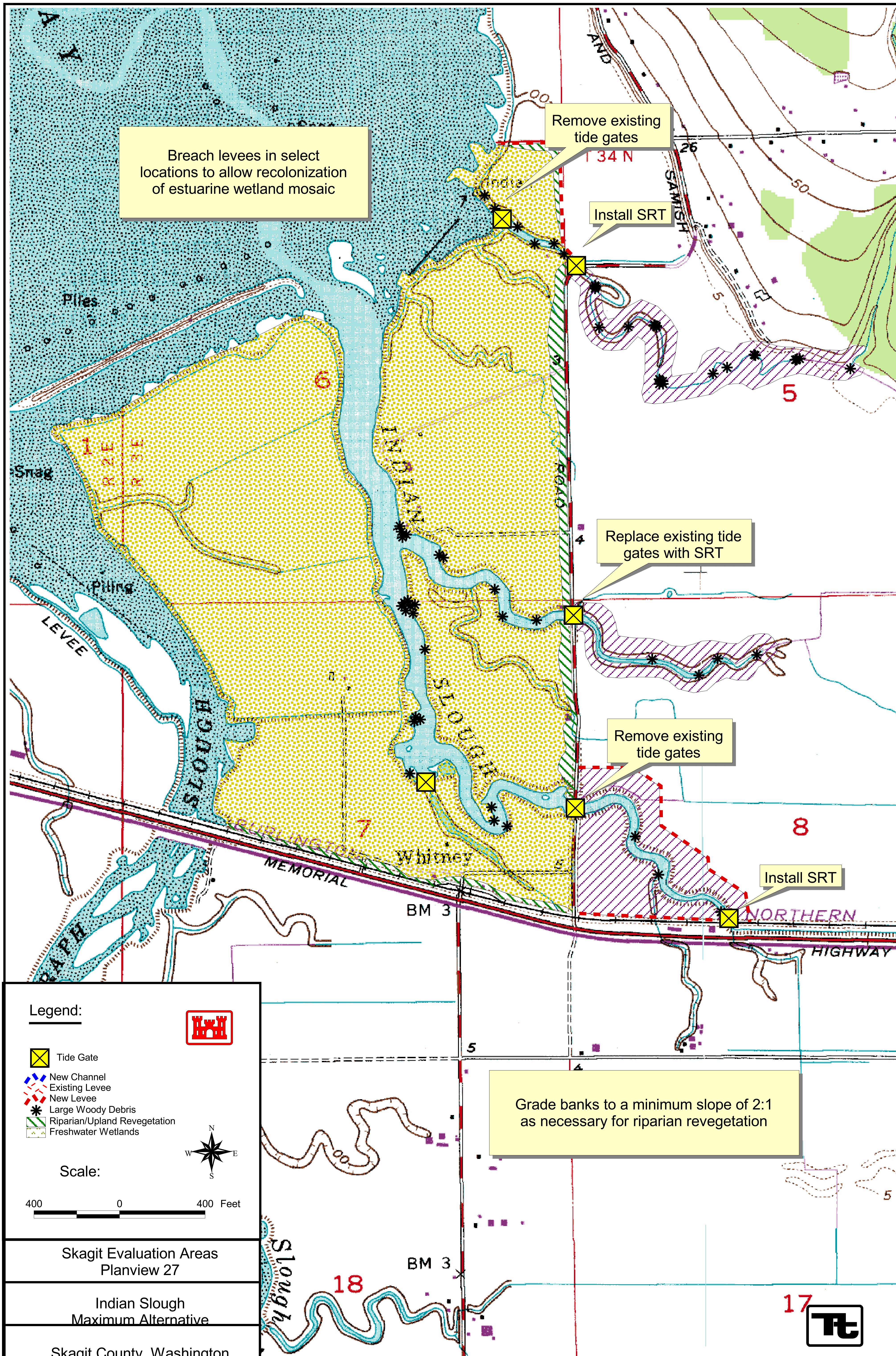

16
20
MAUPIN
MAUPIN
Hall
Slough
LEVEE
Replace existing tide gates with SRT
Grade banks to a minimum 2:1 slope where possible
Excavate inlet from Browns Slough
Remove levee spur
Remove fill material or replace culverts as necessary for fish passage
Legend:
Tide Gate
New Channel
Existing Levee
New Levee
Large Woody Debris
Estuarine Wetland
Riparian/Upland Revegetation
Forested Tidal
Scale:
300 0 300 Feet
Skagit Evaluation Areas
Planview 23
Hall Slough
Moderate Alternative
Skagit County, Washington


Remove fill material or replace culverts as necessary for fish passage
Grade banks to a minimum 2:1 slope where possible
Excavate controlled inlet from Skagit River to Brown's Slough
Excavate inlet from Browns Slough
Remove levee spur
Replace existing tide gates with SRT
16
20
21
5
10
MAUPIN
MAUPIN ROAD
LEVEE
Hall Slough
BM 6
Legend:
Tide Gate
New Channel
Existing Levee
New Levee
Large Woody Debris
Estuarine Wetland
Riparian/Upland Revegetation
Forested Tidal
Scale:
300 0 300 600 Feet
N
S
E
W
Skagit Evaluation Areas
Planview 24
Hall Slough
Maximum Alternative
Skagit County, Washington


Grade banks to 2:1 slope as necessary for riparian revegetation
Replace existing tide gates with SRT
Replace existing tide gates with SRT
INDIAN SLOUGH
ROAD
6
5
7
Legend:
Tide Gate
New Levee
Large Woody Debris
Estuarine Wetland
Riparian/Upland Revegetation
Forested Tidal
N
S
E
W
Scale:
400 0 400 800 Feet
Skagit Evaluation Areas
Planview 25
Indian Slough
Minimum Alternative
Skagit County, Washington



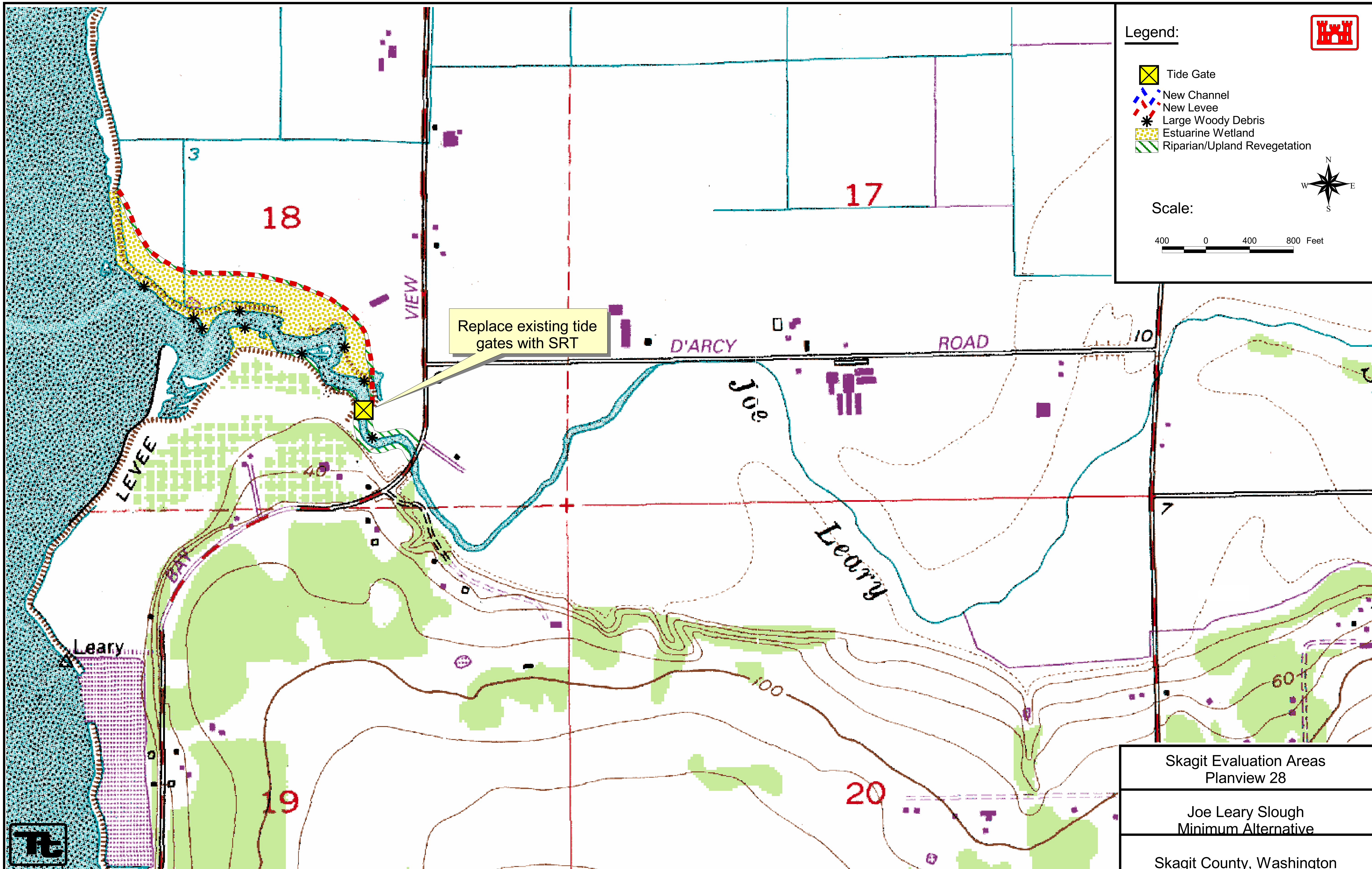
Grade banks to 2:1 slope as necessary for riparian revegetation
Replace existing tide gates with SRT
Remove existing tide gates
Install SRT
Remove fill material and replace culverts as necessary for fish passage
INDIAN
SLOUGH
Whitney
Legend:
Tide Gate
New Channel
Existing Levee
New Levee
Large Woody Debris
Riparian/Upland Revegetation
Freshwater Wetlands
Scale:
400 0 400 800 Feet
N
S
E
W
Skagit Evaluation Areas
Planview 26
Indian Slough
Moderate Alternative
Skagit County, Washington




Skagit Evaluation Areas
Planview 27

Indian Slough
Maximum Alternative

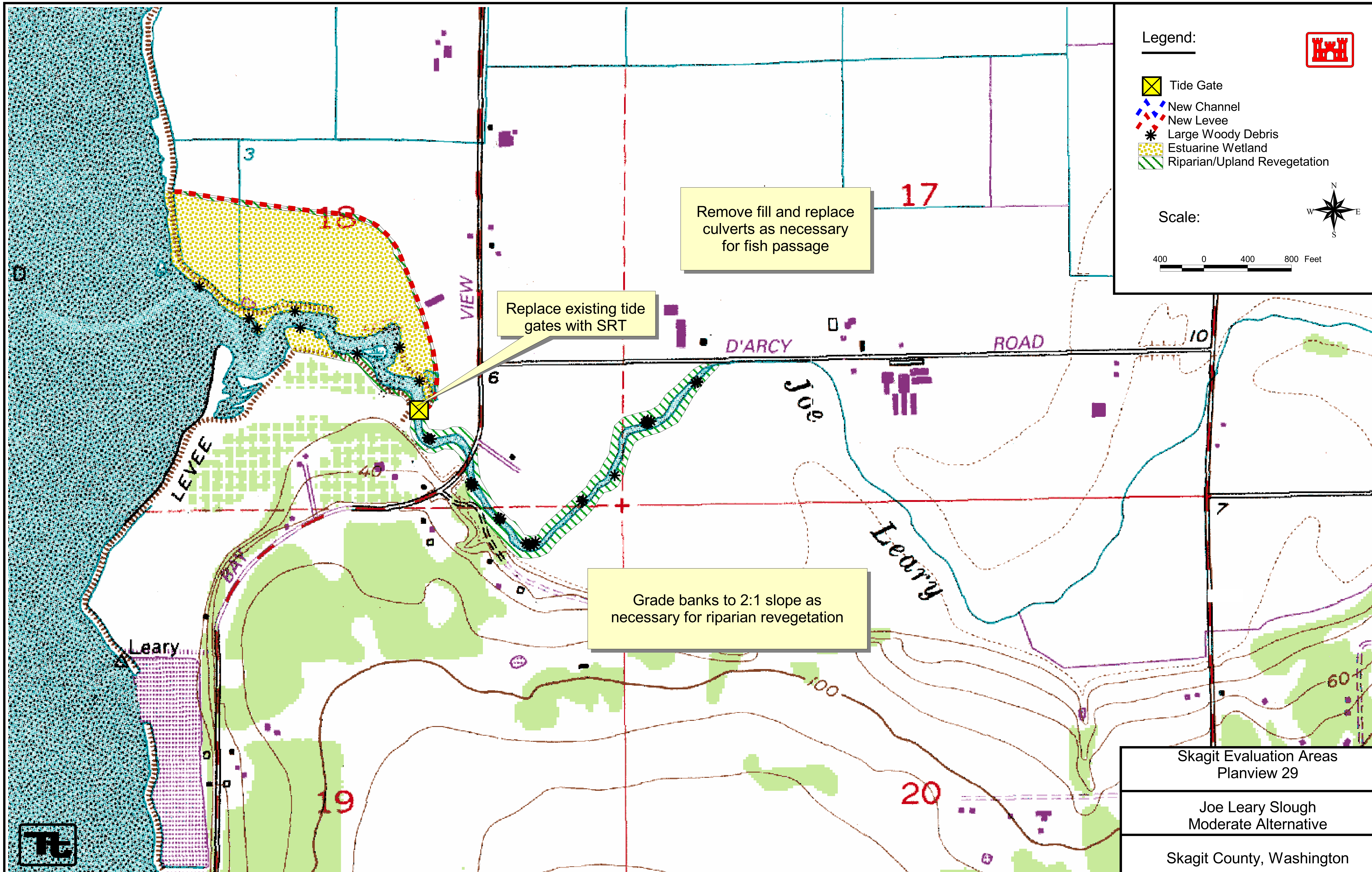
Skagit County, Washington



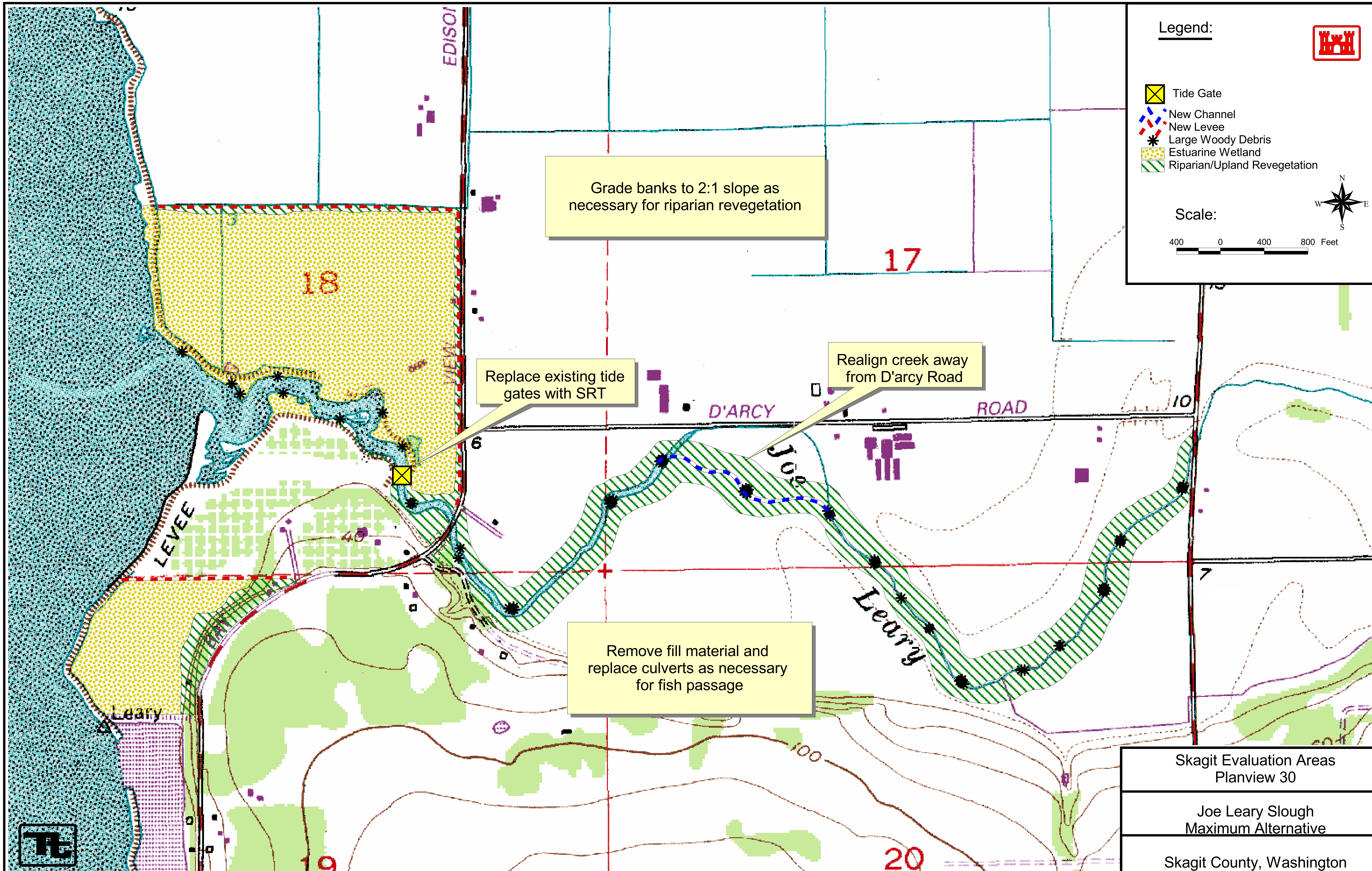

Skagit Evaluation Areas
Planview 28

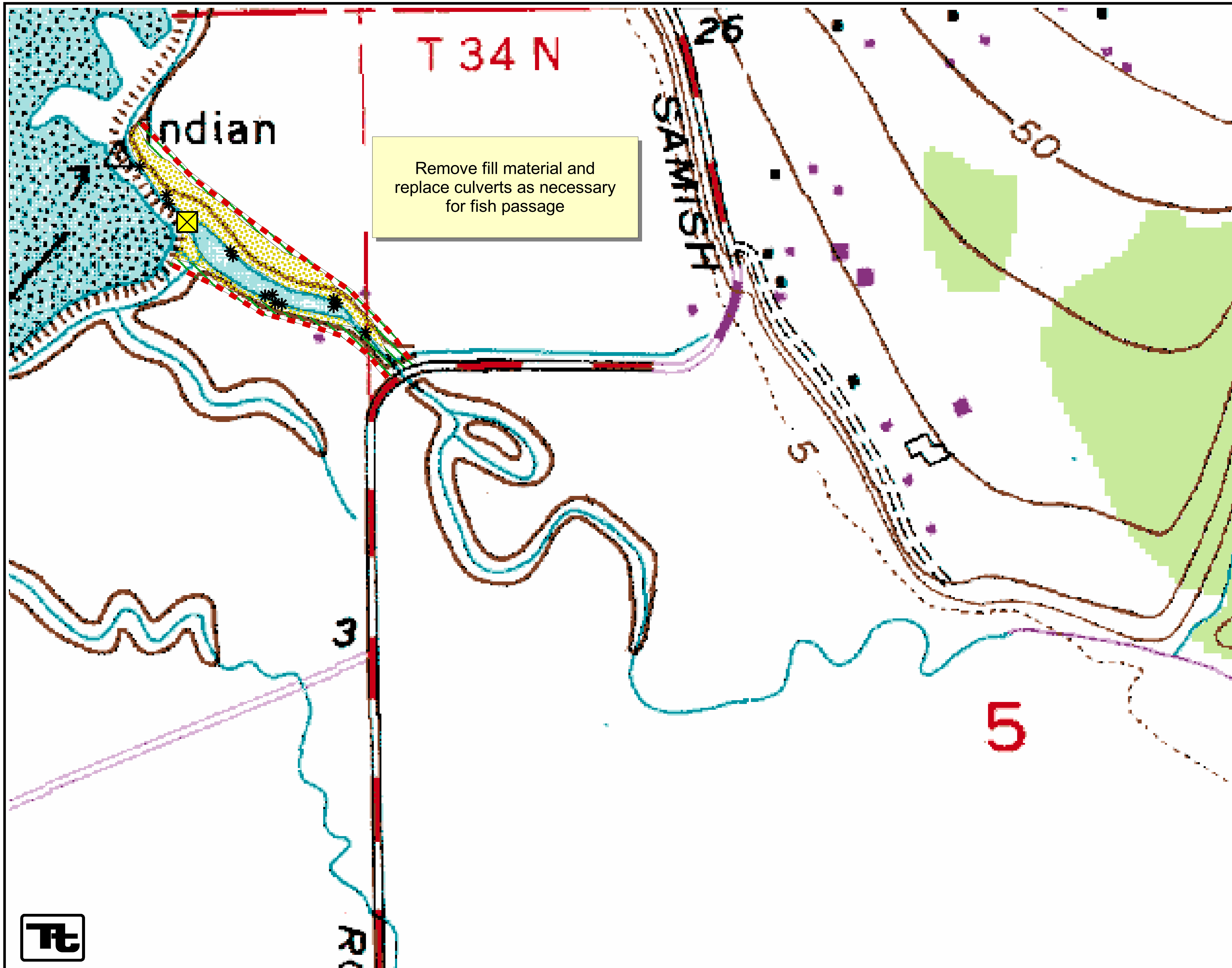
Joe Leary Slough
Minimum Alternative

Skagit County, Washington



Legend:
Tide Gate
New Channel
New Levee
Large Woody Debris
Estuarine Wetland
Riparian/Upland Revegetation
Scale:
400 0 400 800 Feet
Remove fill and replace culverts as necessary for fish passage
Replace existing tide gates with SRT
Grade banks to 2:1 slope as necessary for riparian revegetation
D'ARCY ROAD
VIEW
LEVEE
Joe Leary
Leary
Skagit Evaluation Areas
Planview 29
Joe Leary Slough
Moderate Alternative
Skagit County, Washington

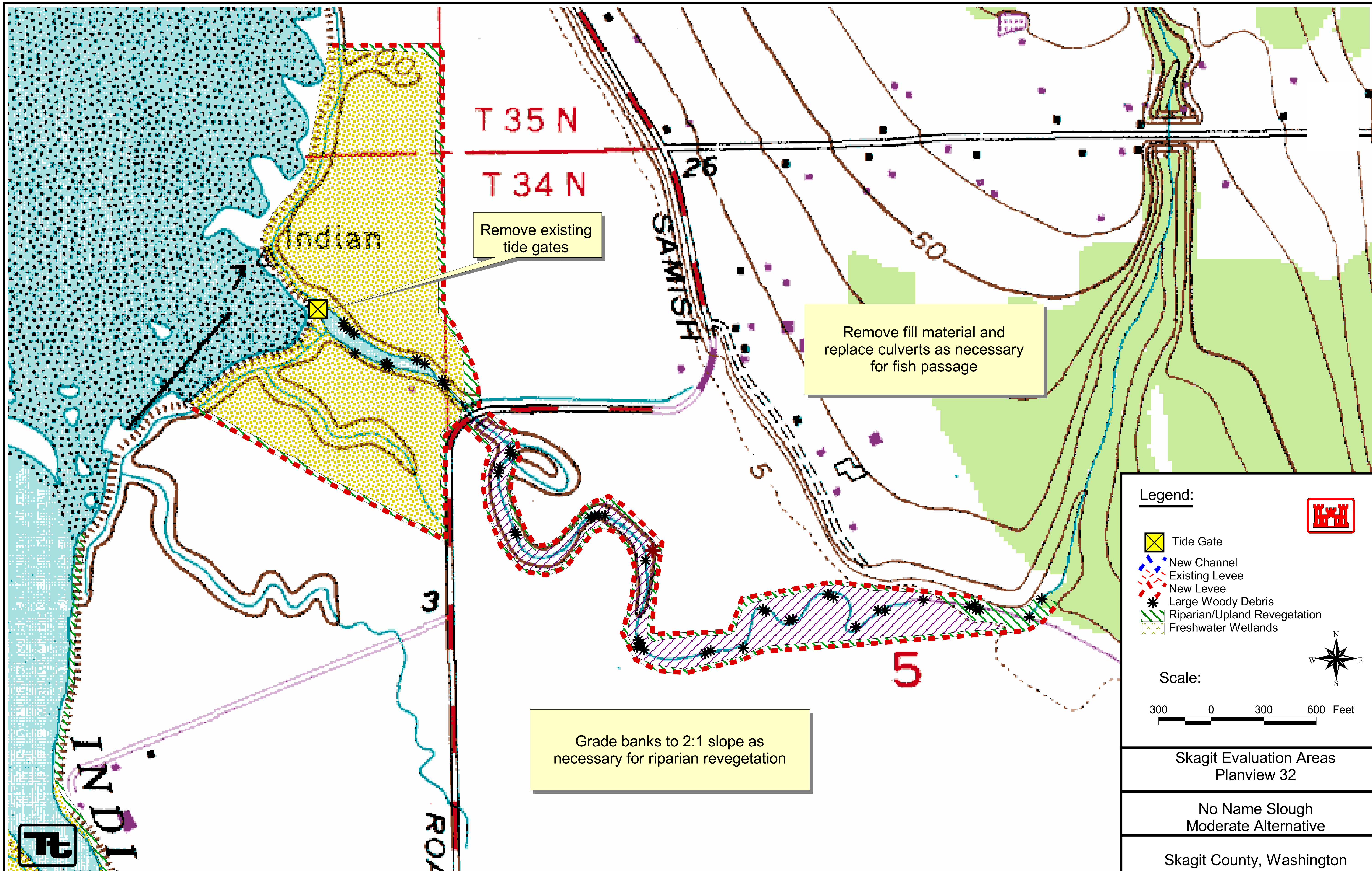

Legend:
Tide Gate
New Channel
New Levee
Large Woody Debris
Estuarine Wetland
Riparian/Upland Revegetation
Scale:
400
0
400
800
Feet
N
S
E
W
Grade banks to 2:1 slope as necessary for riparian revegetation
Replace existing tide gates with SRT
Realign creek away from D'arcy Road
Remove fill material and replace culverts as necessary for fish passage
D'ARCY
ROAD
LEVEE
Joe
Leary
Leary
EDISO
18
17
19
20
Skagit Evaluation Areas
Planview 30
Joe Leary Slough
Maximum Alternative
Skagit County, Washington



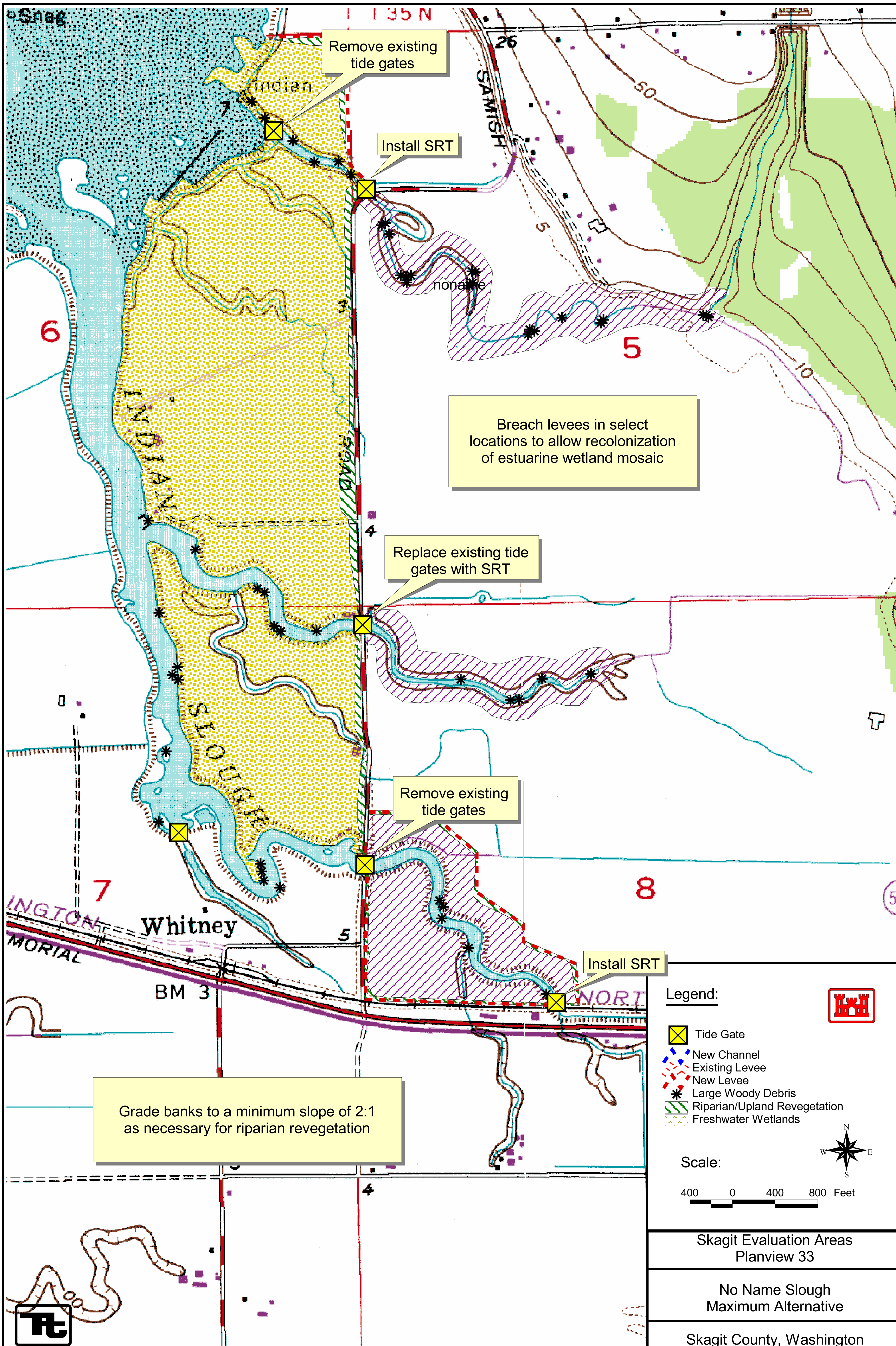

Skagit Evaluation Areas
Planview 31

No Name Slough
Minimum Alternative

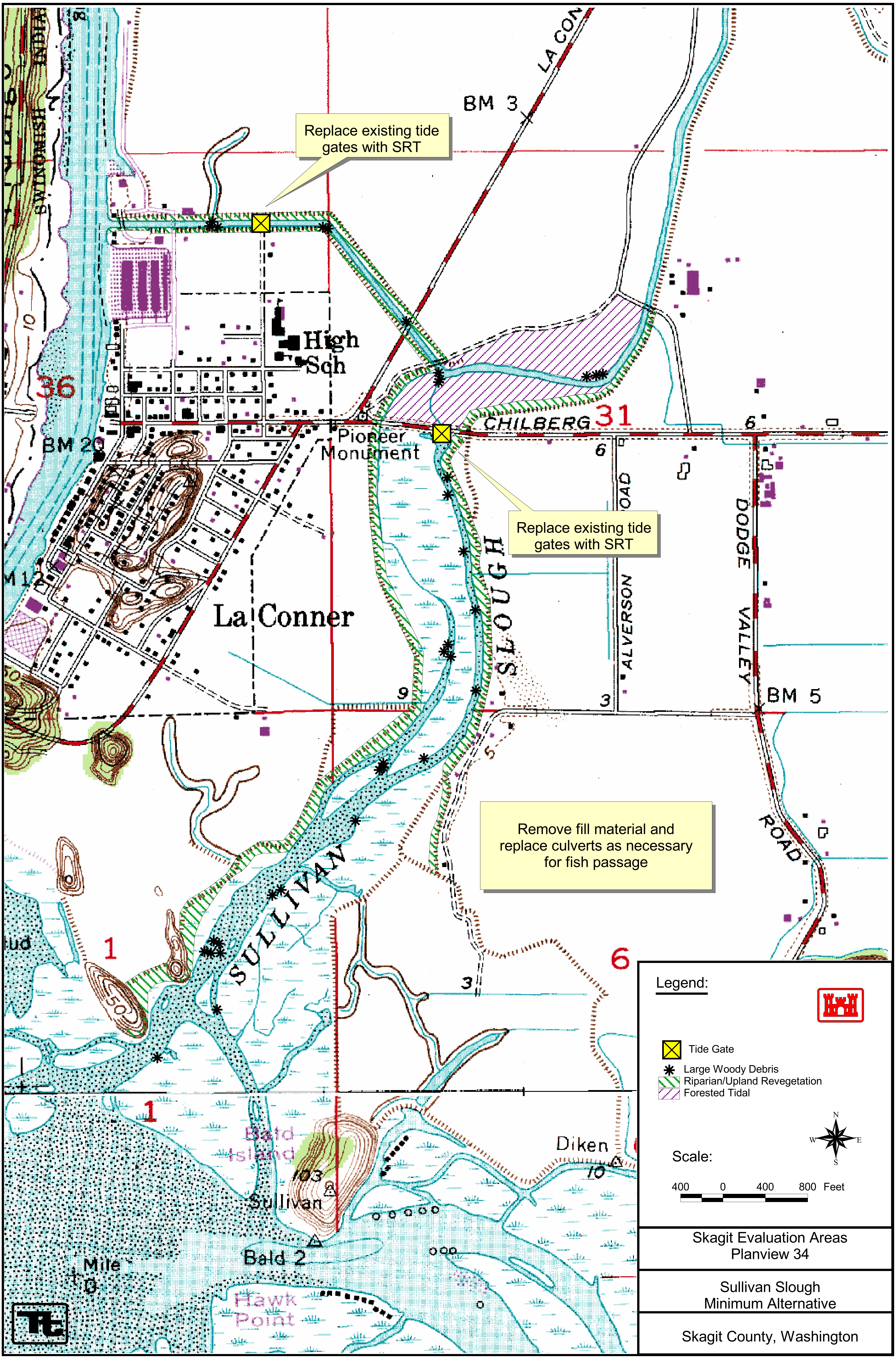
Skagit County, Washington

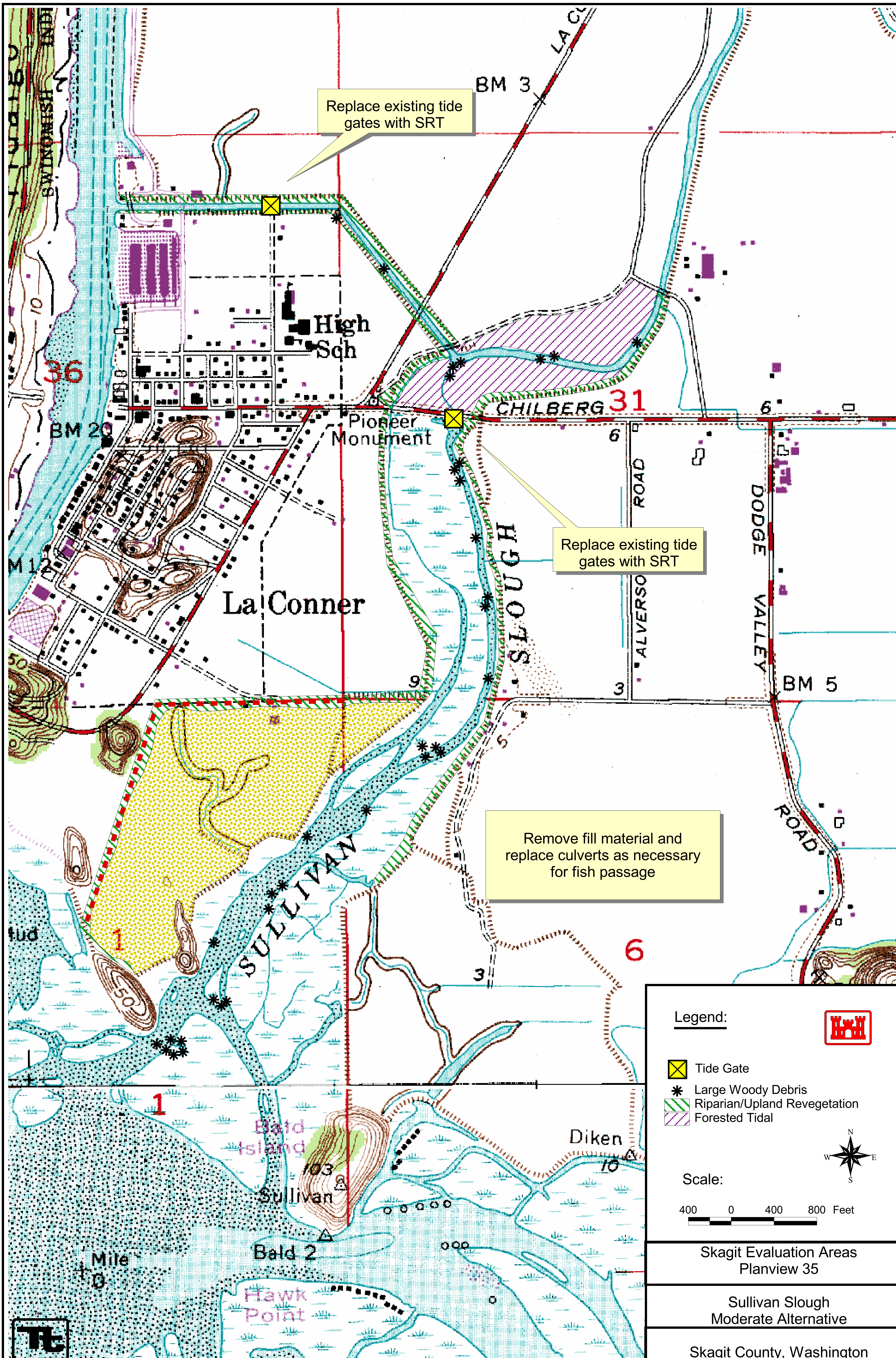


T 35 N
T 34 N
Indian
26
SAMISH
50
5
3
5
INDI
ROA
Remove existing tide gates
Remove fill material and replace culverts as necessary for fish passage
Grade banks to 2:1 slope as necessary for riparian revegetation
Legend:
Tide Gate
New Channel
Existing Levee
New Levee
Large Woody Debris
Riparian/Upland Revegetation
Freshwater Wetlands
N
W
E
S
Scale:
300 0 300 600 Feet
Skagit Evaluation Areas
Planview 32
No Name Slough
Moderate Alternative
Skagit County, Washington

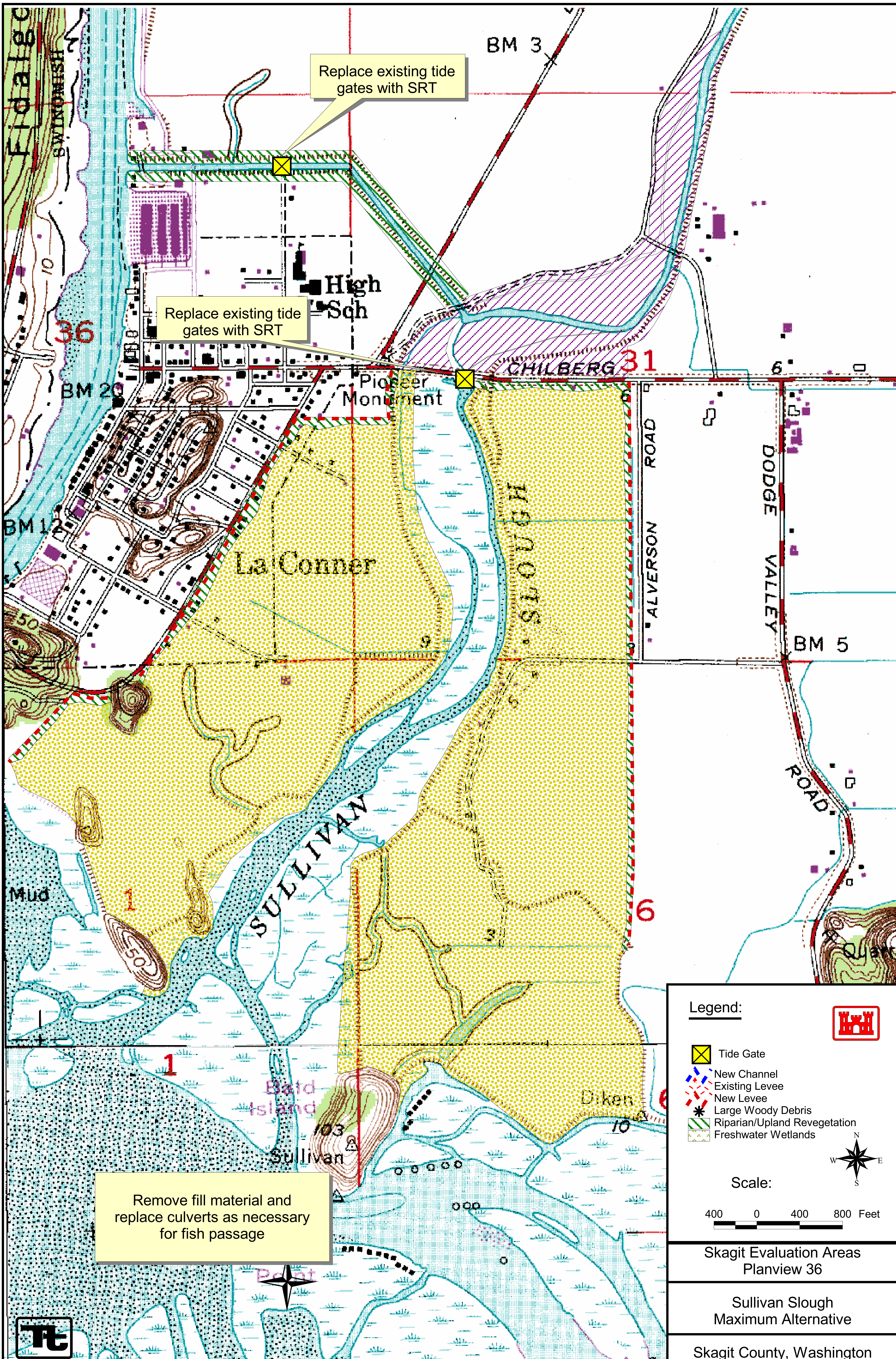


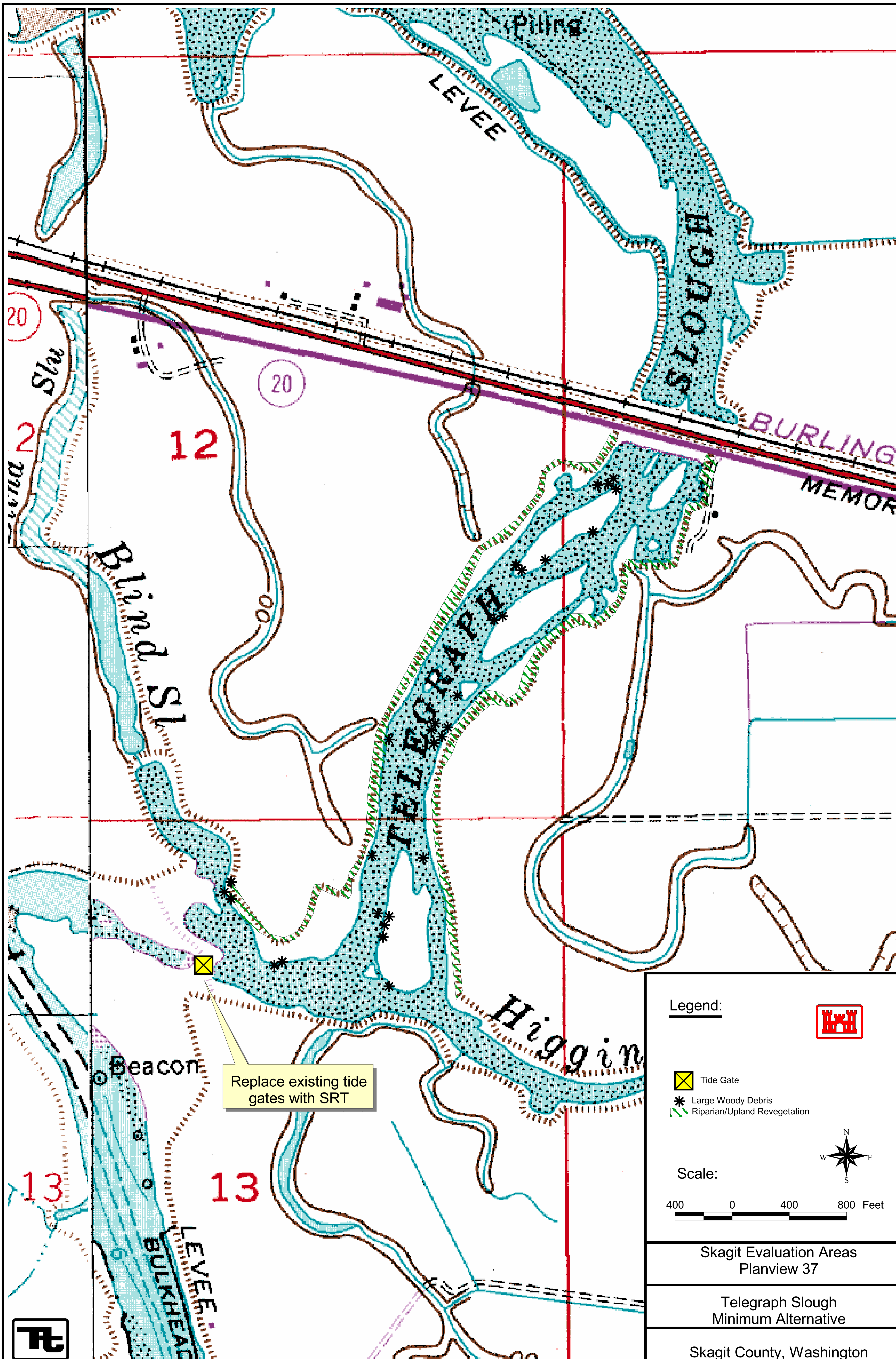
Remove existing tide gates
Install SRT
Breach levees in select locations to allow recolonization of estuarine wetland mosaic
Replace existing tide gates with SRT
Remove existing tide gates
Install SRT
Grade banks to a minimum slope of 2:1 as necessary for riparian revegetation
T 35 N
Snag
Indian
INDIAN SLOUGH
SAMISH
ROAD
Whitney
BM 3
none
6
5
7
8
Legend:
Tide Gate
New Channel
Existing Levee
New Levee
Large Woody Debris
Riparian/Upland Revegetation
Freshwater Wetlands
Scale:
400 0 400 800 Feet
N
S
E
W
Skagit Evaluation Areas
Planview 33
No Name Slough
Maximum Alternative
Skagit County, Washington

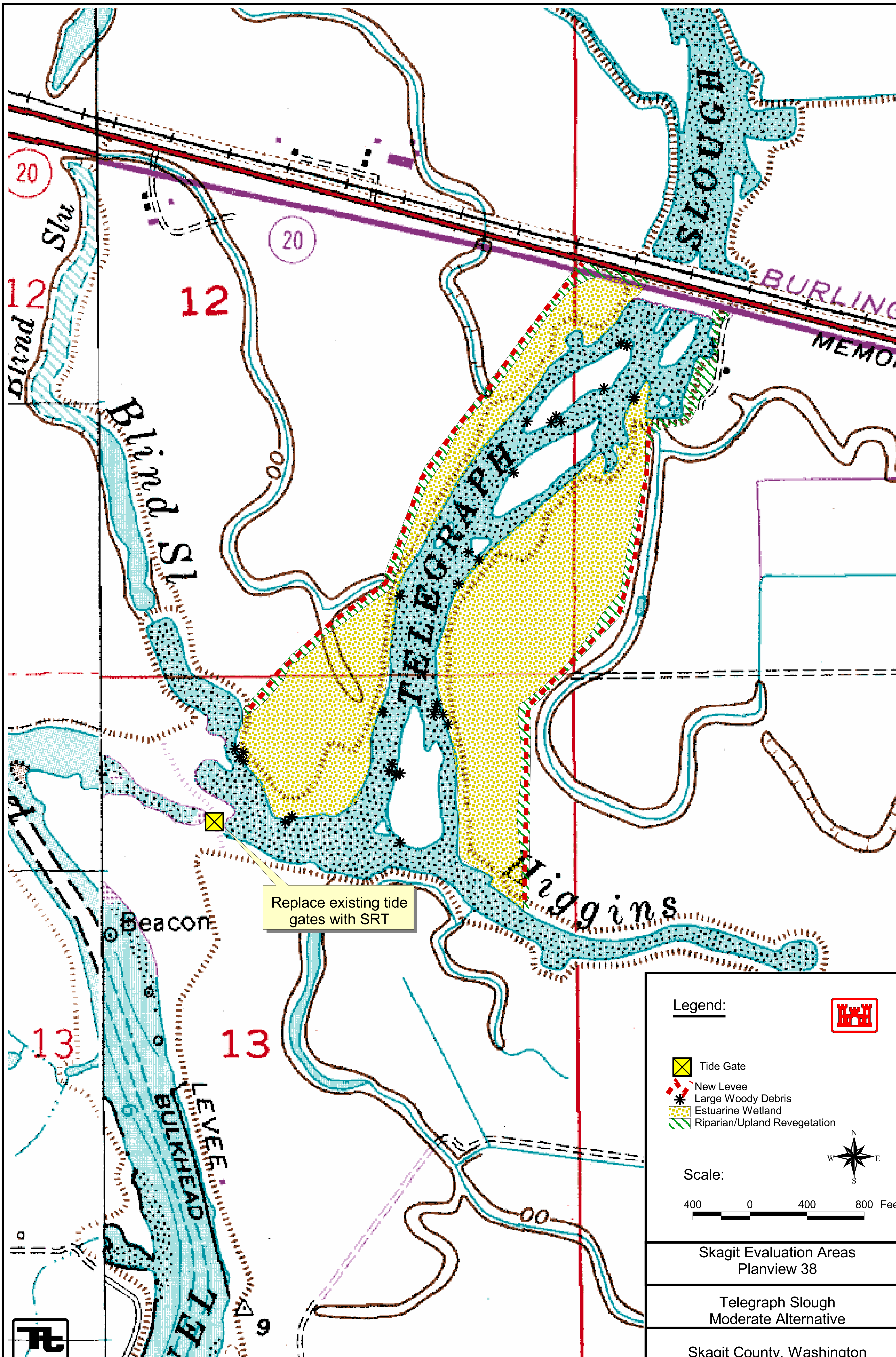

Replace existing tide gates with SRT
Replace existing tide gates with SRT
Remove fill material and replace culverts as necessary for fish passage
BM 3
LA CON
High Sch
La Conner
Pioneer Monument
CHILBERG
ALVERSON ROAD
DODGE VALLEY ROAD
SLOUGH
SULLIVAN
SWINOMISH
BM 20
BM 5
36
31
1
6
Bald Island
Sullivan
Bald 2
Diken
Hawk Point
Legend:
Tide Gate
Large Woody Debris
Riparian/Upland Revegetation
Forested Tidal
Scale:
400 0 400 800 Feet
Skagit Evaluation Areas
Planview 34
Sullivan Slough
Minimum Alternative
Skagit County, Washington



Replace existing tide gates with SRT
Replace existing tide gates with SRT
Remove fill material and replace culverts as necessary for fish passage
BM 3
High Sch
Pioneer Monument
CHILBERG
La Conner
SULLIVAN
SLOUGH
ALVERSON ROAD
DODGE VALLEY ROAD
BM 5
BM 20
36
31
6
1
Bald Island
Sullivan
Bald 2
Hawk Point
Diken
Mile 0
Legend:
Tide Gate
Large Woody Debris
Riparian/Upland Revegetation
Forested Tidal
Scale:
400 0 400 800 Feet
Skagit Evaluation Areas
Planview 35
Sullivan Slough
Moderate Alternative
Skagit County, Washington


Replace existing tide gates with SRT
Replace existing tide gates with SRT
Remove fill material and replace culverts as necessary for fish passage
La Conner
SULLIVAN
SLOUGH
CHILBERG
ALVERSON ROAD
DODGE VALLEY ROAD
Pioneer Monument
High Sch
SWINOMISH
BM 3
BM 20
BM 12
BM 5
Mud
Bald Island
Sullivan
Diken
Legend:
Tide Gate
New Channel
Existing Levee
New Levee
Large Woody Debris
Riparian/Upland Revegetation
Freshwater Wetlands
Scale:
400 0 400 800 Feet
Skagit Evaluation Areas
Planview 36
Sullivan Slough
Maximum Alternative
Skagit County, Washington

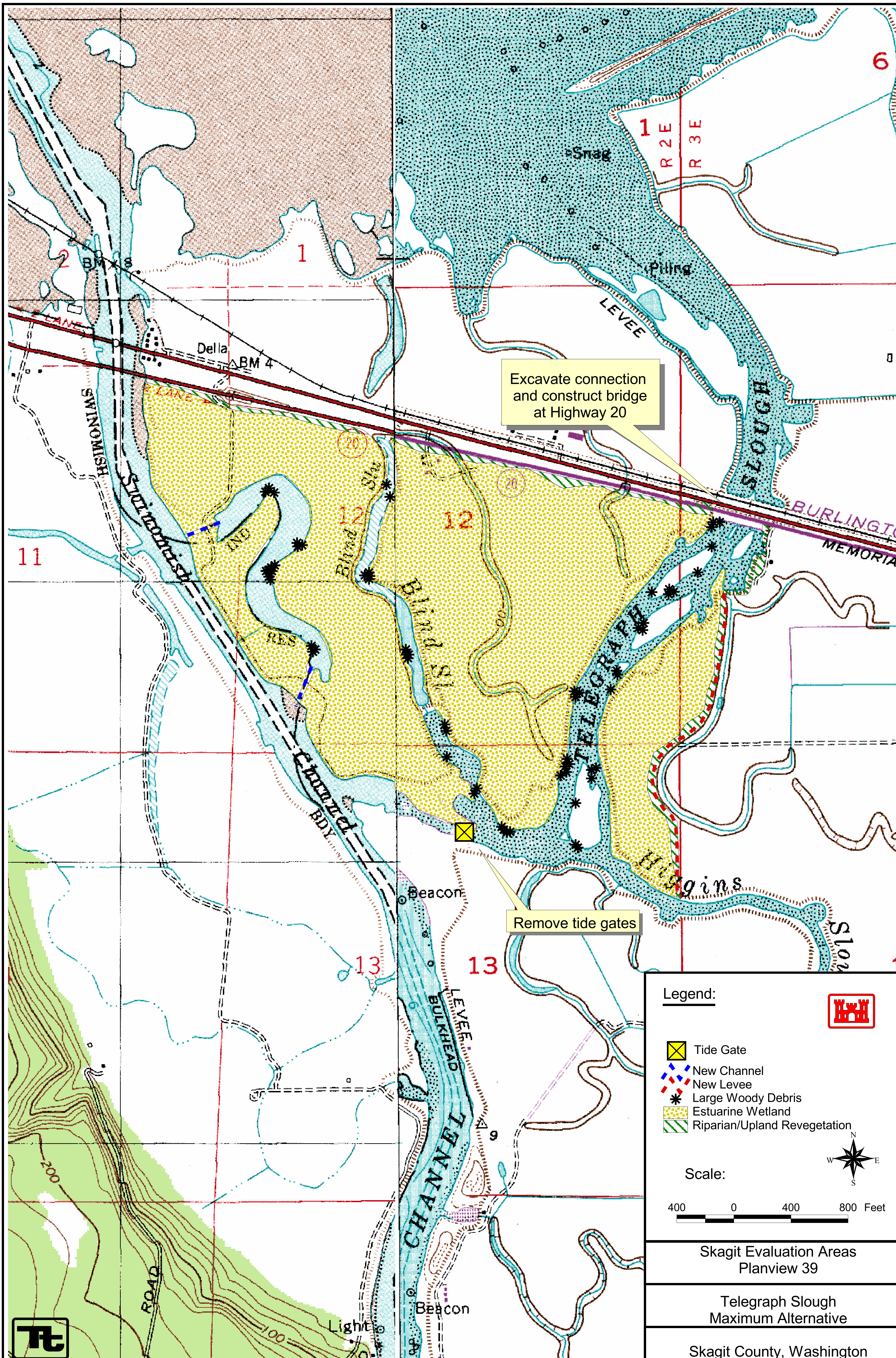

Piling
LEVEE
SLOUGH
BURLING
MEMOR
20
20
Slu
2
12
Blind Sl
TELEGRAPH
Higgin
Beacon
Replace existing tide gates with SRT
13
13
LEVEE
BULKHEAD
Legend:
Tide Gate
Large Woody Debris
Riparian/Upland Revegetation
N
W
E
S
Scale:
400
0
400
800
Feet
Skagit Evaluation Areas
Planview 37
Telegraph Slough
Minimum Alternative
Skagit County, Washington

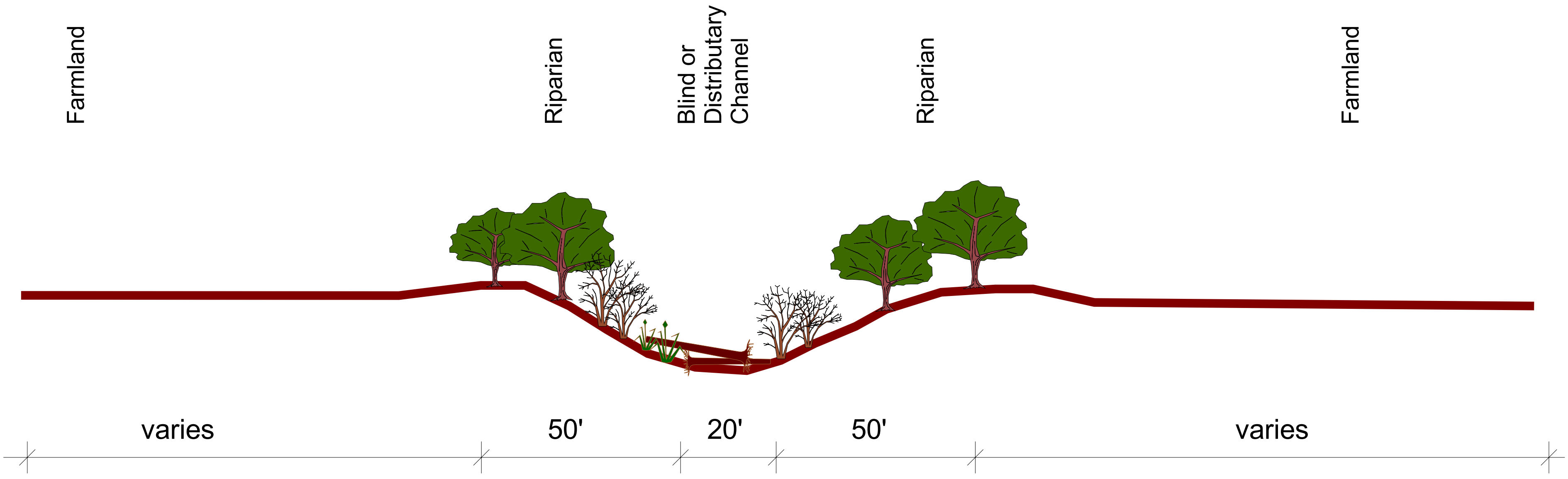



Skagit Evaluation Areas
Planview 38

Telegraph Slough
Moderate Alternative

Skagit County, Washington

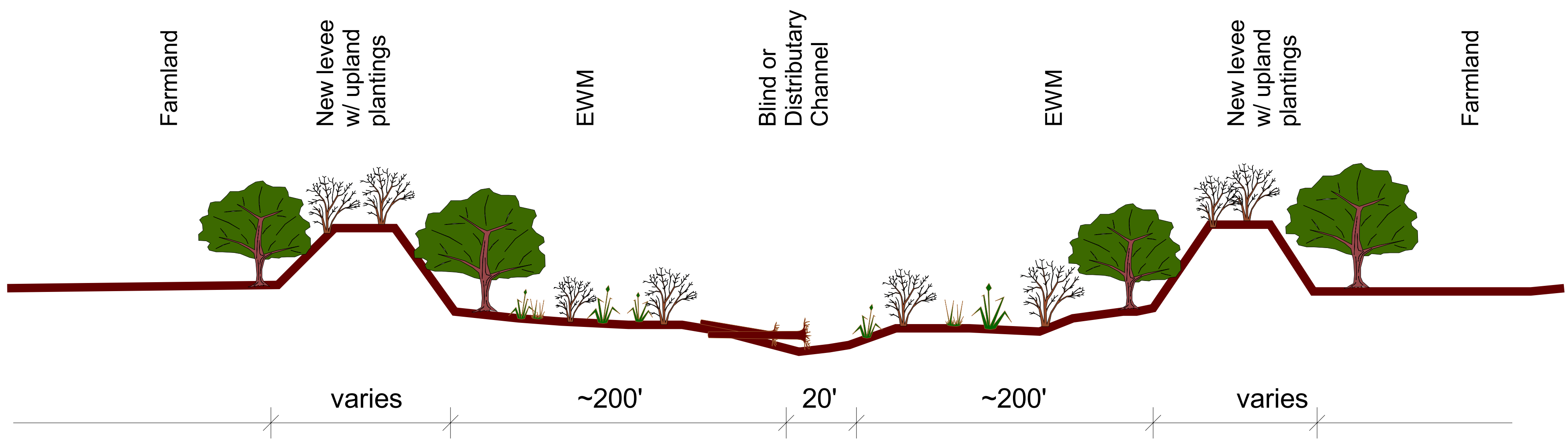

Excavate connection and construct bridge at Highway 20
Remove tide gates
Legend:
Tide Gate
New Channel
New Levee
Large Woody Debris
Estuarine Wetland
Riparian/Upland Revegetation
Scale:
400 0 400 800 Feet
Skagit Evaluation Areas
Planview 39
Telegraph Slough
Maximum Alternative
Skagit County, Washington
Swinomish Channel
TELEGRAPH
SLOUGH
Higgins
Blind Sl
CHANNEL
LEVEE
BULKHEAD
Della
BM 4
Snag
Piling
Beacon
Light
BURLINGTON
MEMORIAL
R 2 E
R 3 E




## CROSS SECTION A: MINIMUM ALTERNATIVE

Estuarine Blind or Distributory Channel with Riparian/Upland Plantings

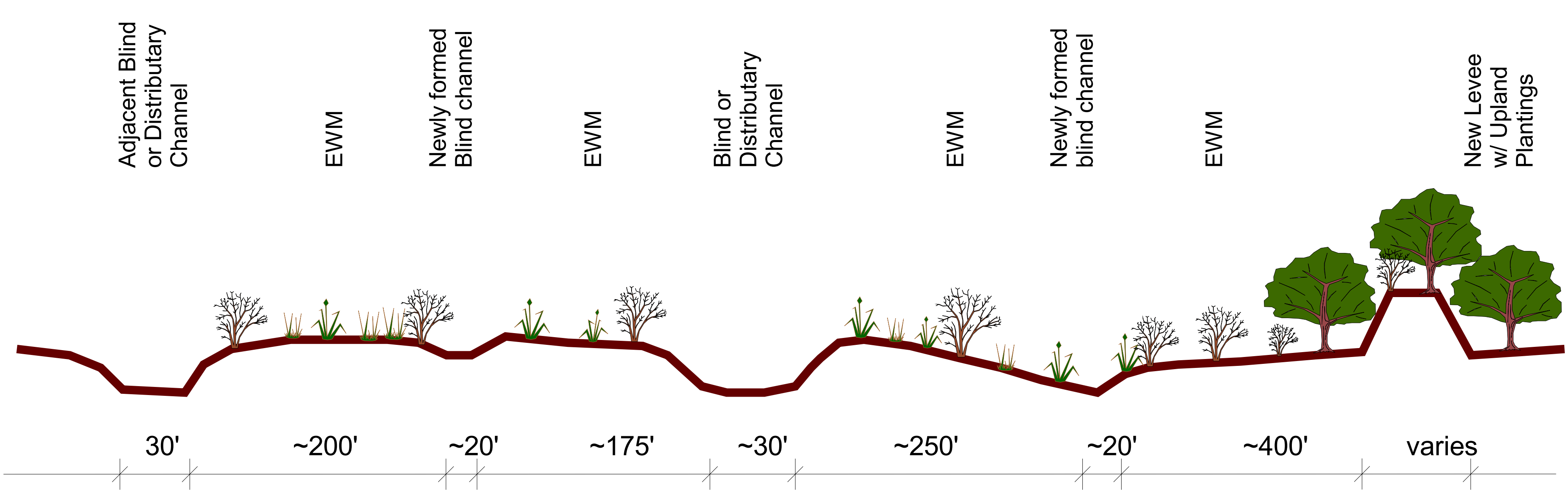
Notes: This example is from Dry Slough Minimum Alternative, downstream of SRT.
Habitat widths are conceptual and will vary for differing alternatives.
These drawings are not to scale, elevations are exaggerated for comparison




## CROSS SECTION B: MODERATE ALTERNATIVE

Estuarine Blind or Distributory Channel with newly opened Estuarine Wetlands, new or setback Levees, and Riparian/Upland Plantings

Notes: This example is from Dry Slough Moderate Alternative, downstream of SRT.
EWM (estuarine emergent and scrub-shrub wetland mosaic) will be allowed to recover naturally and will require no plantings.
Some alternatives may only have a single levee setback (e.g. Edison Slough, north levee only).
Habitat widths are conceptual and will vary for differing alternatives.
These drawings are not to scale, elevations are exaggerated for comparison.




## CROSS SECTION C: MAXIMUM ALTERNATIVE

Estuarine Blind or Distributory Channel with newly opened Estuarine Wetlands, new or setback levees, and Riparian/Upland Plantings

Notes: This example is from the Dry Slough Maximum Alternative, downstream of SRT.
Habitat widths are conceptual and will vary for differing alternatives.
These drawings are not to scale, elevations are exaggerated for comparison

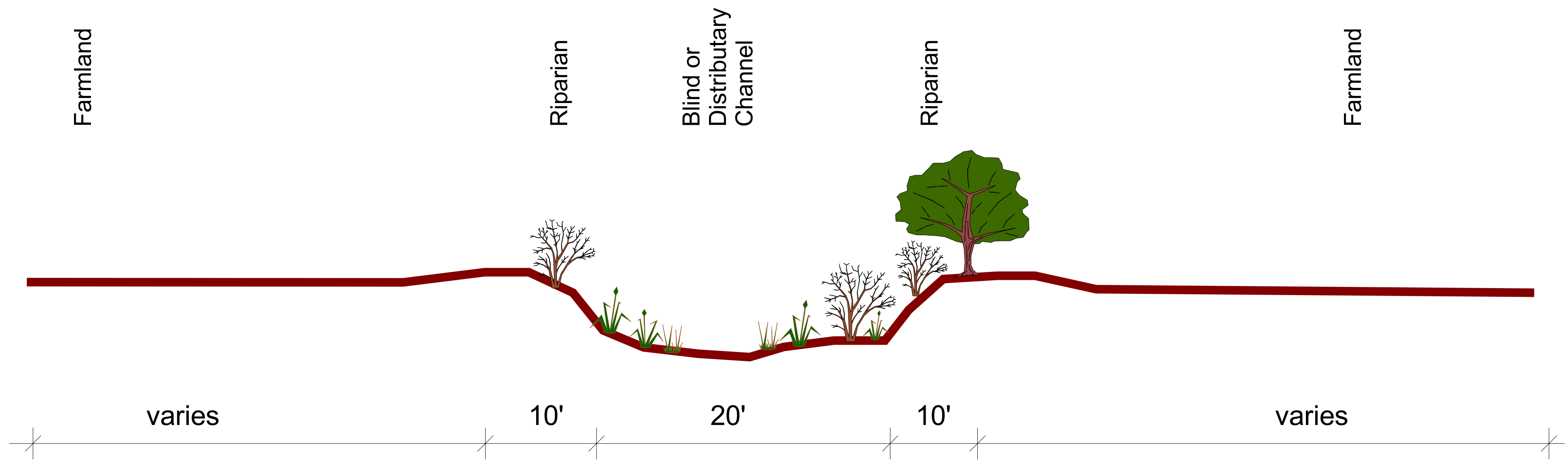
NOT TO SCALE

LEGEND:
- Deciduous Tree
- Coniferous Tree
- Large Woody Debris
- Freshwater or Estuarine Emergent Plant
- Freshwater or Estuarine Shrub

Skagit Evaluation Areas
Cross Sections

Sections
A, B, and C

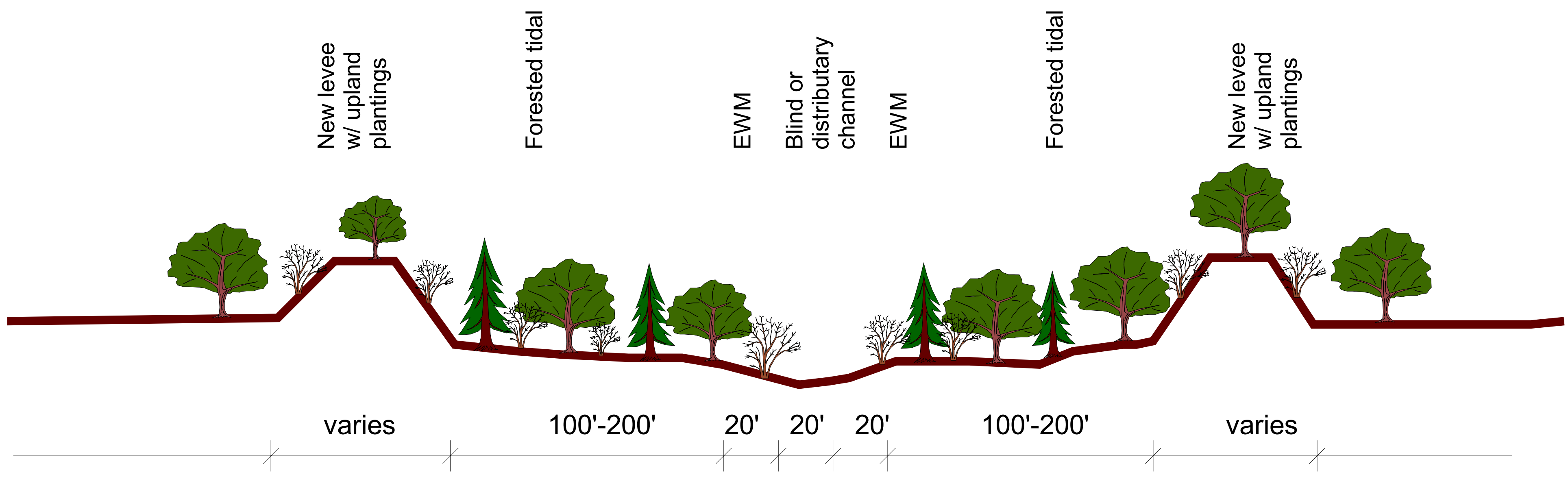
Skagit County, Washington




## CROSS SECTION D: MINIMUM ALTERNATIVE (EXISTING)

Estuarine Blind or Distributory Channel with Riparian/Upland Plantings

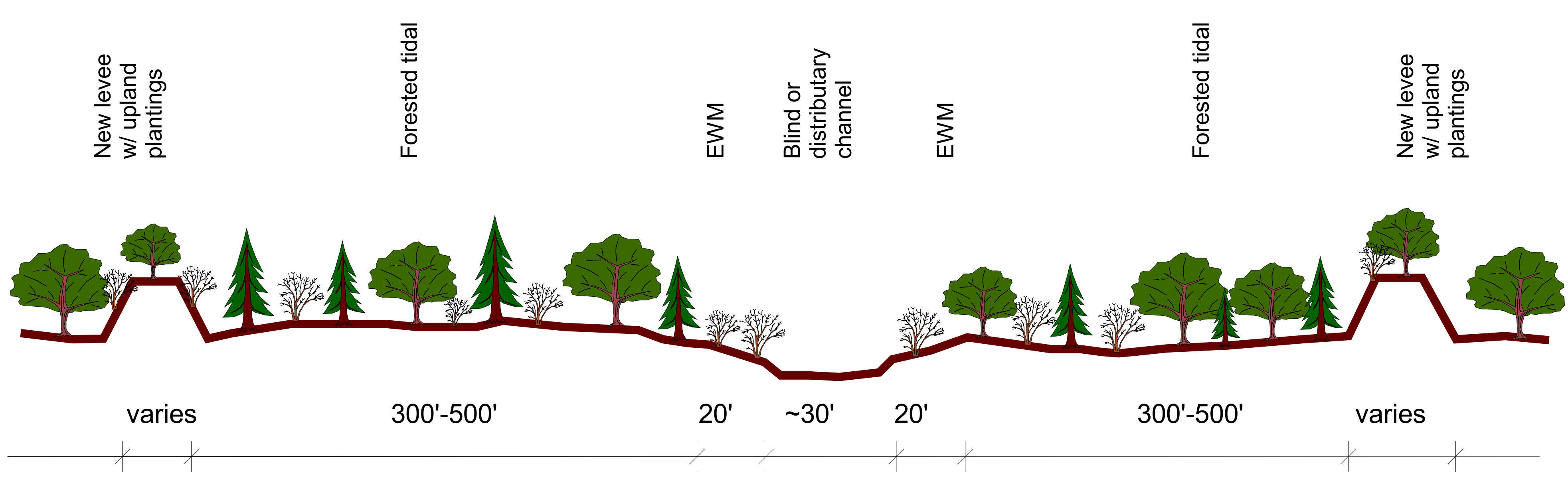
Notes: This example is from Dry Slough Minimum Alternative, upstream of SRT.
Habitat widths are conceptual and will vary for differing alternatives.
These drawings are not to scale, elevations are exaggerated for comparison




## CROSS SECTION E: MODERATE ALTERNATIVE

Estuarine Blind or Distributory Channel with Forested Tidal Plantings and New or Setback Levees

Notes: This example is from Dry Slough Moderate Alternative, upstream of SRT.
EWM (estuarine emergent and scrub-shrub wetland mosaic) will be allowed to recover naturally and will require no plantings.
Some alternatives may only have a single levee setback (e.g. Edison Slough, north levee only).
Habitat widths are conceptual and will vary for differing alternatives.
These drawings are not to scale, elevations are exaggerated for comparison.




## CROSS SECTION F: MAXIMUM ALTERNATIVE

Estuarine Blind or Distributory Channel with Forested Tidal Plantings and New or Setback Levees

Notes: This example is from the Dry Slough Maximum Alternative, upstream of SRT.
Habitat widths are conceptual and will vary for differing alternatives.
These drawings are not to scale, elevations are exaggerated for comparison

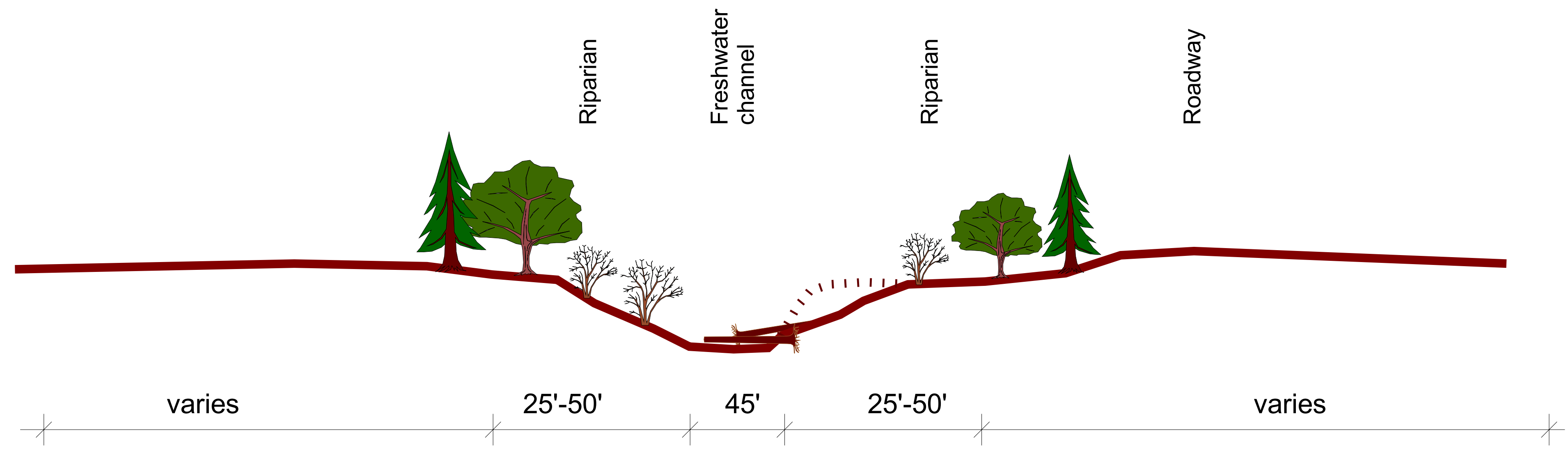
NOT TO SCALE

LEGEND:
- Deciduous Tree
- Coniferous Tree
- Large Woody Debris
- Freshwater or Estuarine Emergent Plant
- Freshwater or Estuarine Shrub

Skagit Evaluation Areas
Cross Sections

Sections
D, E, and F

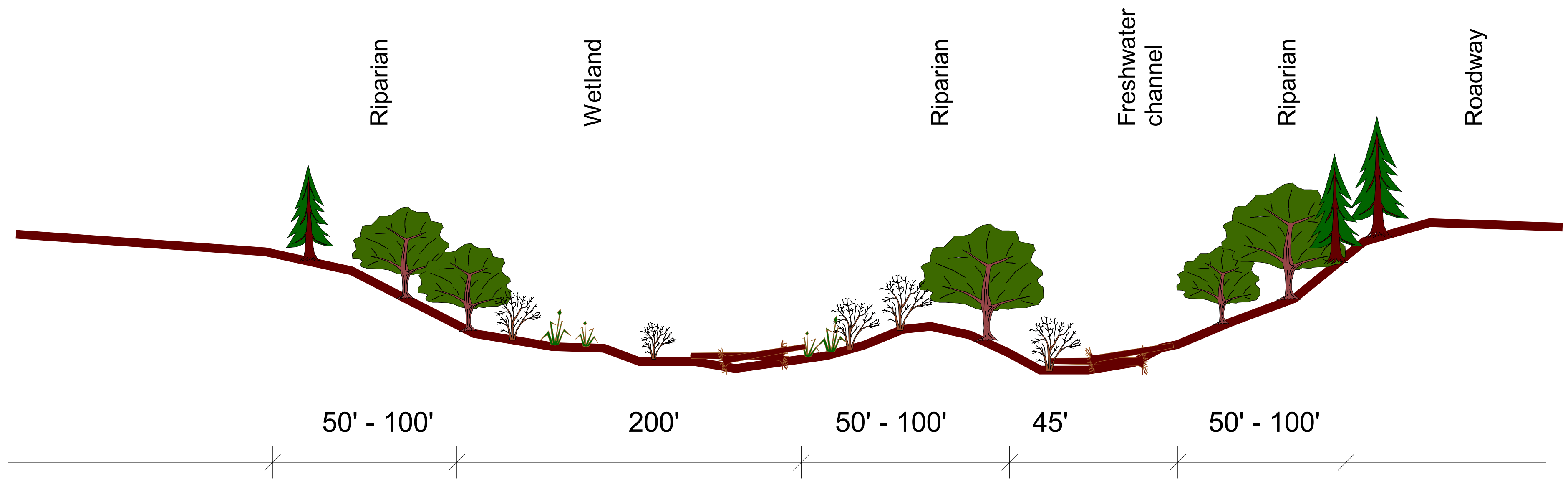
Skagit County, Washington




## CROSS SECTION G: MINIMUM ALTERNATIVE

Freshwater Mainstem, Side Channel or Slough with Riparian/Upland Plantings

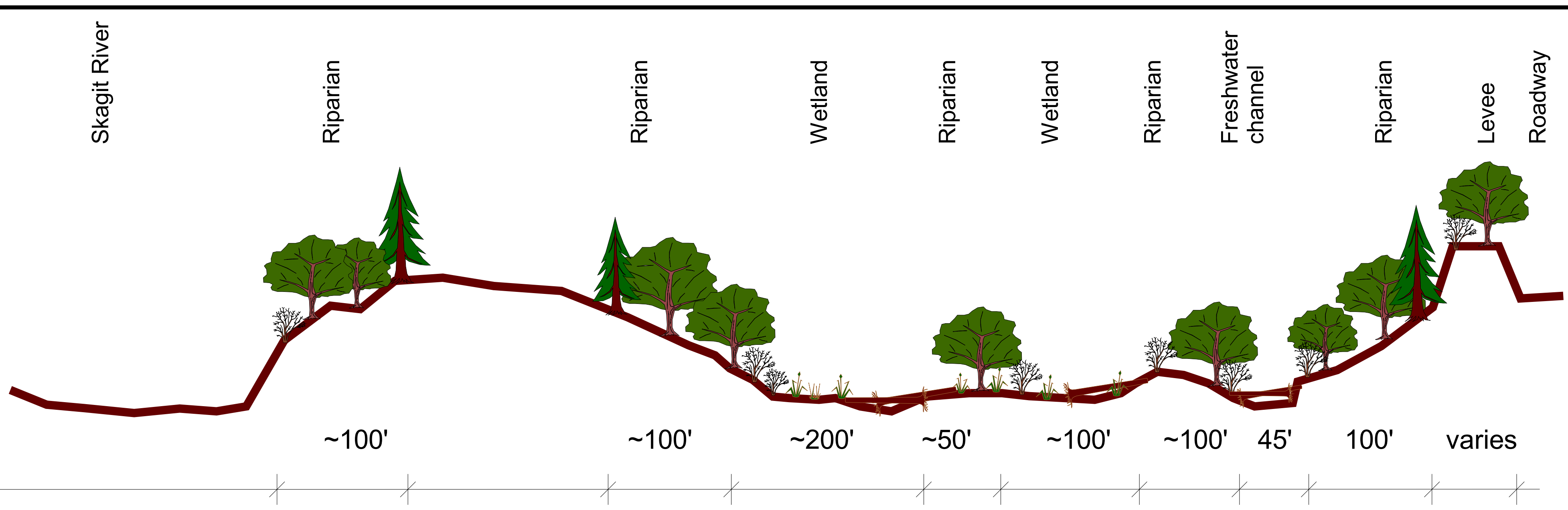
Notes: This example is from Britt Slough Minimum Alternative.
Habitat widths are conceptual and will vary for differing alternatives.
These drawings are not to scale, elevations are exaggerated for comparison




## CROSS SECTION H: MODERATE ALTERNATIVE

Freshwater Mainstem, Side Channel or Slough with Riparian/Upland Plantings, Levee Setbacks, and Wetland Creation

Notes: This example is from Britt Slough Moderate Alternative.
EWM (estuarine emergent and scrub-shrub wetland mosaic) will be allowed to recover naturally and will require no plantings.
Some alternatives may only have a single levee setback (e.g. Edison Slough, north levee only).
Habitat widths are conceptual and will vary for differing alternatives.
These drawings are not to scale, elevations are exaggerated for comparison.




## CROSS SECTION I: MAXIMUM ALTERNATIVE

Freshwater Mainstem, Side Channel or Slough with Riparian/Upland Plantings, Levee Setbacks, and Wetland Creation

Notes: This example is from the Britt Slough Maximum Alternative.
Habitat widths are conceptual and will vary for differing alternatives.
These drawings are not to scale, elevations are exaggerated for comparison

NOT TO SCALE

LEGEND:
- Deciduous Tree
- Coniferous Tree
- Large Woody Debris
- Freshwater or Estuarine Emergent Plant
- Freshwater or Estuarine Shrub

Skagit Evaluation Areas
Cross Sections

Sections
G, H, and I

Skagit County, Washington

## 5.0 SCREENING AND EVALUATION METHODOLOGY, PREFERRED ALTERNATIVE(S), AND RECOMMENDATIONS

This screening and evaluation methodology will be used to develop numerical scores for each of the alternatives described above based on their expected habitat benefits. Each of the alternatives, including the no action alternative, will be rated for both existing and proposed future conditions. These numerical ratings will then be used to conduct an incremental cost and cost effectiveness analysis to determine which projects provide significant habitat benefits for relatively low cost. Several alternatives may provide a reasonable level of benefits for the cost, and a second phase of ranking the alternatives will rate the highest priority projects. There are four major steps to the scoring process:

| | |
|---|---|
| **1** | ***Initial Scoring Process*** uses evaluation parameters and habitat type weighting to provide numerical Habitat Output Units (Habitat Units or HUs). |
| **2** | HUs are then used with conceptual costs for the ***Cost Effectiveness and Incremental Cost Analysis*** to determine which alternatives are the most cost effective. |
| **3** | The most cost effective alternatives are put through a ***Second Screening*** to determine their actual feasibility for implementation. |
| **4** | The most cost effective and implementable alternatives are then *R**ecommended for Implementation***. |

### 5.1 Initial Scoring Process

#### *5.1.1 Identification of Evaluation Parameters*

The evaluation parameters were selected based on several recent studies of chinook, and other species in the Skagit River, and on the habitat needs of fish and wildlife in estuarine or lower river habitats, particularly chinook. Parameters are described in Table 4.

A score is given to each alternative (and also the existing conditions) based on the definitions. Scores may range from 1 to 4 and decimal scores are allowed at quarter intervals. The scores for each parameter are summed, and then divided by the maximum possible score (20 points) to yield an index score for each alternative. The index score is then multiplied by the estimated acreage of each major habitat type that exists or will be restored as follows (Table 5), and then summed to provide total habitat units. Habitat types are weighted based on their relative importance to chinook salmon.

**Table 4. Scoring criteria definitions for the evaluation framework.**

| ***Score*** | ***Description*** |
|---|---|
| | **Hydrology** |
| **4** | Natural (or uncontrolled) tidal exchange and upstream freshwater inflow occurs within the channels and wetlands in the majority of the evaluation area, and channel formation and migration is unconstrained. (This definition recognizes that dams are present upstream that control flood flows and low flows.) |
| **3** | Either uncontrolled tidal exchange or freshwater inflow and outflow occurs within the channels and wetlands in the majority of the evaluation area (can include SRTs that allow tidal exchange), and channel formation and migration may be constrained in portions of the evaluation area by levees, culverts, etc. |
| **2** | No natural or uncontrolled tidal exchange or freshwater flows occur in the evaluation area. Controlled tidal exchange or freshwater inflow/outflow occurs in all or some portions of the evaluation area (i.e. controlled via sized culverts, levees, etc.). Channel formation and migration is limited due to levees, culverts, etc. |
| **1** | No hydrologic connections to river, streams or bays exist in the evaluation area, except during flood flows (>25 year flood) or via pump stations and gated culverts. No channel formation or migration is occurring. |
| | ***Riparian Buffers*** |
| **4** | Riparian zone or other appropriate native buffer averages 100 feet or more on both banks of sloughs or other channels throughout the evaluation area and is dominated by native species. |
| **3** | Riparian zone or other appropriate native buffer averages between 50 and 100 feet on both banks throughout the evaluation area, and is dominated by native species. |
| **2** | Riparian zone or other appropriate native buffer averages approximately 25 feet on either bank throughout the evaluation area, and/or non-native species are dominant. |
| **1** | Riparian zone or other appropriate native buffer averages less than 25 ft throughout the evaluation area and is dominated by non-native species in many areas. |

| | |
|---|---|
| ***Fish Passage/Accessibility*** | |
| **4** | Aquatic habitats within the evaluation area are fully accessible to fish as expected for geomorphic setting, and tidal cycles. |
| **3** | Aquatic habitats are accessible to fish, but may have seasonal barriers due to low or high flows, closure of tide gates, etc. |
| **2** | Aquatic habitats are infrequently accessible to fish, due to tide gate operation, low flows, etc. |
| **1** | Aquatic habitats within the evaluation area are not accessible to fish, except during high flood flows. |
| ***Salmon Rearing Habitat*** | |
| **4** | Habitat within the evaluation area provides a diversity of rearing and refuge opportunities, and has all aquatic habitat types expected to be present for its geomorphic setting (i.e. distributary channels, blind channels, sloughs, emergent marsh). |
| **3** | Habitat within the evaluation area provides one or more aquatic habitat types expected to be present for its geomorphic setting, but is only moderately diverse or is missing at least one habitat type, and is somewhat degraded. |
| **2** | Only one aquatic habitat type that would naturally occur based on geomorphic setting is present, and is moderately or highly degraded. |
| **1** | No naturally occuring aquatic habitat types are present or accessible that would be expected based on geomorphic setting (i.e. habitat that would naturally be estuarine marsh or channel has been converted entirely to freshwater or upland). |
| ***Proximity of Habitat to Native Chinook Populations*** | |
| **4** | Habitat is adjacent to and accessible from $1^{st}$ or $2^{nd}$ order distributary channel(s) with native chinook stocks (per Beamer, *et al*, 2001 classification of distributary channel bifurcation). |
| **3** | Habitat is adjacent to and accessible from $3^{rd}$ or $4^{th}$ order distributary channel(s) with native chinook stocks. |
| **2** | Habitat is adjacent to and accessible from $5^{th}$ or $6^{th}$ order distributary channels, or between 1/2 and 5 miles distant from higher order channels, with native chinook stocks, or is seasonally or partially inaccessible from closer stocks. |
| **1** | Habitat is not adjacent to distributary channels with native chinook stocks (isolated or more than 5 miles distant), or is completely inaccessible. |

**Table 5. Habitat types used for weighting of scores.**

| Major Habitat Types | Weighted Value |
|---|---|
| Estuarine Distributary Channels<br>Estuarine Blind Channels | **3** |
| Estuarine Emergent Wetland<br>Estuarine Scrub-Shrub Wetland<br>Freshwater Mainstem or Side Channel | **2** |
| Forested Tidal<br>Freshwater Slough<br>Freshwater Wetlands<br>Riparian/Upland Buffer | **1** |

As an example, a site with an overall score of 12 points yields an index of 12/20 = 0.6. The site has 2.0 acres of estuarine channels, and 5.0 acres of forested tidal habitat. The index score would be multiplied by each habitat type, and the value weighting to yield:

[(2.0 acres * 3) + (5.0 acres * 1)] = 11 total weighted acres * 0.6
= 6.6 Habitat Units (HUs)

The acreage used for the existing condition is the area of existing slough or other habitat (not including farmlands or otherwise developed lands). The HUs are then compared between the existing condition and the proposed condition. The change between existing and proposed is the net habitat benefit. This change in HUs value is utilized in the cost effectiveness and incremental cost analyses.

#### *5.1.2 HU Outputs for Each Alternative*

The following table (Table 6) shows the raw scores given to each evaluation parameter, the resulting index score, and total HUs. It also includes the change in HUs from existing conditions, which is the value used for the cost effectiveness and incremental cost analyses computations. This value is calculated by substracting the existing condition score from the final HU output. The change in HUs is used to show the improvements made as a result of restoration.

**Table 6. Alternative index scores, resulting Habitat Unit Outputs (HU), and change in HUs from existing conditions.**

| Evaluation Area | Alternatives | Hydrology | Riparian | Fish Passage | Rearing | Proximity | Index Score | Total HU Outputs | Change in HUs from Existing Conditions[1] |
|---|---|---|---|---|---|---|---|---|---|
| Britt | Existing | 1 | 1 | 1 | 1 | 1 | 0.2 | 4.62 | - |
| | Minimum | 3 | 2.5 | 3 | 2 | 4 | 0.58 | 19.62 | 15 |
| | Moderate | 3 | 3 | 3 | 2 | 4 | 0.6 | 83.59 | 78.97 |
| | Maximum | 4 | 4 | 4 | 3 | 4 | 0.76 | 353.91 | 349.29 |
| Browns | Existing | 1.5 | 1.5 | 1.5 | 2 | 2 | 0.34 | 10.09 | - |
| | Minimum | 3 | 2.5 | 3.5 | 2.5 | 3 | 0.58 | 26.87 | 16.78 |
| | Moderate | 3.5 | 3 | 3.5 | 3 | 3 | 0.64 | 181.54 | 171.45 |
| | Maximum | 4 | 4 | 4 | 4 | 4 | 0.8 | 980.04 | 969.95 |
| Carpenter | Existing | 2.5 | 1.5 | 3 | 2.5 | 4 | 0.54 | 40.71 | - |
| | Minimum | 3 | 3 | 3 | 3 | 4 | 0.64 | 68.99 | 28.28 |
| | Moderate | 3 | 4 | 3 | 3 | 4 | 0.68 | 357.31 | 316.6 |
| | Maximum | 3 | 4 | 3 | 3 | 4 | 0.68 | 650.54 | 609.83 |
| Deepwater | Existing | 2.5 | 2.5 | 2 | 2.5 | 4 | 0.54 | 123.14 | - |
| | Minimum | 3 | 3 | 3 | 3 | 4 | 0.64 | 590.71 | 467.57 |
| | Moderate | 3 | 3.5 | 3.5 | 3.5 | 4 | 0.7 | 1211.69 | 1088.55 |
| | Maximum | 4 | 4 | 4 | 4 | 4 | 0.8 | 1705.34 | 1582.2 |
| Dry | Existing | 1 | 1 | 1 | 1.2 | 1.2 | 0.216 | 4.15 | - |
| | Minimum | 3 | 2 | 3 | 2 | 3 | 0.52 | 12.3 | 8.15 |
| | Moderate | 3.5 | 4 | 3.5 | 3 | 4 | 0.72 | 1623.86 | 1619.71 |
| | Maximum | 4 | 4 | 4 | 4 | 4 | 0.8 | 3147.4 | 3143.25 |
| Edison | Existing | 3 | 1.5 | 3 | 2.5 | 1 | 0.44 | 25.48 | - |
| | Minimum | 3 | 2.5 | 3 | 2.5 | 1 | 0.48 | 35.85 | 10.37 |
| | Moderate | 3 | 3 | 3 | 3 | 1 | 0.52 | 64.84 | 39.36 |
| | Maximum | 3 | 4 | 3 | 3.5 | 1 | 0.58 | 179.97 | 154.49 |
| Gages | Existing | 1 | 1 | 1 | 1 | 1 | 0.2 | 3.4 | - |
| | Minimum | 1 | 2 | 1 | 1 | 1 | 0.24 | 11.03 | 7.63 |
| | Moderate | 3 | 3 | 3 | 3 | 4 | 0.64 | 100.3 | 96.9 |
| | Maximum | 3 | 3.5 | 3 | 3 | 4 | 0.66 | 260.15 | 256.75 |
| Hall | Existing | 1.5 | 1 | 1.1 | 1.7 | 1.5 | 0.272 | 2.19 | - |
| | Minimum | 3 | 3 | 3 | 2 | 2 | 0.52 | 22.59 | 20.4 |
| | Moderate | 3 | 3.5 | 3 | 3 | 2 | 0.58 | 88.31 | 86.12 |
| | Maximum | 3.5 | 4 | 3 | 4 | 4 | 0.74 | 244.9 | 242.71 |
| Indian | Existing | 1.5 | 2.5 | 2 | 2 | 1 | 0.36 | 35.86 | - |
| | Minimum | 3 | 2 | 3 | 3 | 1 | 0.48 | 65.76 | 29.9 |
| | Moderate | 3 | 3 | 3 | 4 | 1 | 0.56 | 199.9 | 164.04 |
| | Maximum | 4 | 4 | 3 | 4 | 1 | 0.64 | 998.49 | 962.63 |
| Joe Leary | Existing | 1.5 | 2 | 1.2 | 1.5 | 1 | 0.288 | 5.37 | - |
| | Minimum | 3 | 2.5 | 3 | 2 | 1 | 0.46 | 30.61 | 25.24 |
| | Moderate | 3 | 3 | 3 | 3 | 1 | 0.52 | 73.78 | 68.41 |
| | Maximum | 3 | 4 | 3 | 4 | 1 | 0.6 | 235.15 | 229.78 |

**Table 6 continued**

| Evaluation Area | Alternatives | Hydrology | Riparian | Fish Passage | Rearing | Proximity | Index Score | Total HU Outputs | Change in HUs from Existing Conditions[1] |
|---|---|---|---|---|---|---|---|---|---|
| No Name | Existing | 1.1 | 1 | 1.2 | 1.2 | 1 | 0.22 | 2.23 | - |
| | Minimum | 3 | 2.5 | 3 | 2 | 1 | 0.46 | 6.8 | 4.57 |
| | Moderate | 3 | 3 | 3 | 3.5 | 1 | 0.54 | 68.66 | 66.43 |
| | Maximum | 3 | 4 | 3 | 4 | 1 | 0.6 | 408.39 | 406.16 |
| Sullivan | Existing | 2 | 2.5 | 2.5 | 2.5 | 2.5 | 0.48 | 92.39 | - |
| | Minimum | 3 | 2.5 | 3 | 3 | 4 | 0.62 | 151.06 | 58.67 |
| | Moderate | 3 | 4 | 3 | 3.5 | 4 | 0.7 | 215.3 | 122.91 |
| | Maximum | 3.5 | 4 | 3.5 | 4 | 4 | 0.76 | 895.11 | 802.72 |
| Telegraph | Existing | 2 | 2.5 | 2.5 | 3 | 2 | 0.48 | 45.46 | - |
| | Minimum | 3 | 3 | 3 | 3 | 2 | 0.56 | 56.45 | 10.99 |
| | Moderate | 3 | 4 | 3 | 4 | 2 | 0.64 | 148.86 | 103.4 |
| | Maximum | 4 | 4 | 4 | 4 | 2 | 0.72 | 905.45 | 859.99 |

[1]Values used for cost effectiveness and incremental cost analyses.

## 5.2 Cost Effectiveness and Incremental Cost Analyses

The habitat units developed as described above will be used with preliminary cost estimates for each site to conduct cost effectiveness and incremental cost analyses. The purpose of the analyses will be to compare habitat benefits with costs and to screen out projects with relatively low habitat benefit for high costs. Cost effective projects provide high levels of habitat benefits for lower costs. Typically, several projects will be considered cost effective. Because the analyses only evaluates habitat benefits, there may be other issues that should be considered after conducting the cost analyses. The cost estimate for each alternative is provided in Appendix

### *5.2.1 Cost Effectiveness and Incremental Cost Analyses Results*

A cost effectiveness and incremental cost analysis was conducted to evaluate the relative effectiveness and efficiency of alternative restoration measures to address the environmental objectives of this study. The analyses provide a framework for comparing the differences in output across alternatives and the associated changes in cost. The analysis was conducted in the following steps:

- Tabulate average annual cost and environmental ouputs of each restoration alternative
- Identify any alternative whose implementation is dependent upon implementation of another alternative
- Identify combinations of alternatives
- Calculate cost and output estimates for each alternative
- Identify any measures that provide the same output at greater cost than other individual or combination alternatives

- Identify any measures that provide less output at the same or greater cost as other individual or combination alternatives
- Evaluate changes in incremental costs for remaining combinations
- Identify the most efficient set of remaining combinations ("best-buys")
- Display changes in incremental cost for best-buy combinations

Preliminary costs were developed for each alternative restoration plan that included mobilization/demobilization, construction, contingency, engineering design, construction management, real estate, and operation and maintenance. For this study, the real estate cost estimates were obtained from Skagit County's assessed land values for each parcel that was within the various project footprints (with the exception of Deepwater Slough which was based on the actual land value assigned to WDFW lands for the previously constructed Corps project). The total value of each parcel was used in this comparison, which most certainly overestimates the real estate costs for the projects because in many cases the project footprint only encompasses a small portion of a parcel. However, for the purposes of comparing the relative habitat outputs with the relative costs for each alternative, this error is acceptable.

Each alternative was given an identification code letter for use in entering the data into IWR-PLAN, a Corps of Engineers software program developed specifically for conducting these analyses. Table 7 displays the 39 alternatives with their identifier code, preliminary costs, and habitat units of output.

**Table 7. Preliminary costs and HUs for each restoration alternative.**

| ID Code | | Evaluation Area | Alternatives | HU | Cost |
|---|---|---|---|---|---|
| A | 1 | Britt | Minimum | 15.0 | $12,528,740 |
| A | 2 | Britt | Moderate | 79.0 | $26,030,250 |
| A | 3 | Britt | Maximum | 349.3 | $57,714,460 |
| B | 1 | Browns | Minimum | 16.8 | $1,693,930 |
| B | 2 | Browns | Moderate | 171.5 | $5,126,370 |
| B | 3 | Browns | Maximum | 970.0 | $17,132,380 |
| C | 1 | Carpenter | Minimum | 28.3 | $11,662,620 |
| C | 2 | Carpenter | Moderate | 316.6 | $27,192,820 |
| C | 3 | Carpenter | Maximum | 609.8 | $37,199,590 |
| D | 1 | Deepwater | Minimum | 467.6 | $1,156,130 |
| D | 2 | Deepwater | Moderate | 1,088.6 | $2,126,020 |
| D | 3 | Deepwater | Maximum | 1,582.2 | $3,617,590 |
| E | 1 | Dry | Minimum | 8.2 | $2,184,740 |
| E | 2 | Dry | Moderate | 1,619.7 | $16,741,780 |
| E | 3 | Dry | Maximum | 3,143.3 | $46,583,810 |
| F | 1 | Edison | Minimum | 10.4 | $4,190,140 |
| F | 2 | Edison | Moderate | 39.4 | $5,571,680 |
| F | 3 | Edison | Maximum | 154.5 | $10,779,880 |
| G | 1 | Gages | Minimum | 7.6 | $8,125,770 |
| G | 2 | Gages | Moderate | 96.9 | $16,064,870 |
| G | 3 | Gages | Maximum | 256.8 | $56,197,670 |
| H | 1 | Hall | Minimum | 20.4 | $3,139,190 |
| H | 2 | Hall | Moderate | 86.1 | $3,862,530 |
| H | 3 | Hall | Maximum | 242.7 | $5,006,710 |
| I | 1 | Indian | Minimum | 29.9 | $4,624,030 |
| I | 2 | Indian | Moderate | 164.0 | $5,895,100 |
| I | 3 | Indian | Maximum | 962.6 | $12,385,390 |
| J | 1 | Joe Leary | Minimum | 25.2 | $1,495,410 |
| J | 2 | Joe Leary | Moderate | 68.4 | $4,075,640 |
| J | 3 | Joe Leary | Maximum | 229.8 | $7,084,440 |
| K | 1 | No Name | Minimum | 4.6 | $746,100 |
| K | 2 | No Name | Moderate | 66.4 | $2,455,470 |
| K | 3 | No Name | Maximum | 406.2 | $4,326,410 |
| L | 1 | Sullivan | Minimum | 58.7 | $6,089,900 |
| L | 2 | Sullivan | Moderate | 122.9 | $6,431,920 |
| L | 3 | Sullivan | Maximum | 802.7 | $8,393,770 |
| M | 1 | Telegraph | Minimum | 11.0 | $1,445,250 |
| M | 2 | Telegraph | Moderate | 103.4 | $2,214,330 |
| M | 3 | Telegraph | Maximum | 860.0 | $3,419,830 |

A vast array of combinations are possible and these combinations are compared to determine which combinations provide more habitat output for each level of cost. Appendix C describes the cost effective combinations. The cost effective combinations are then analyzed to determine which of those plans provides the most increase in output for the least increase in cost (lowest incremental cost per habitat unit produced). The set of plans are considered “best-buys.” Table 8 lists the cost effective plans with the lowest incremental costs and Figure 3 is a graphic representation of the table which shows the relative increase in habitat output versus the increase in incremental cost.

**Table 8. Incremental cost analysis ("Best-Buy Combinations") for the top 15 restoration alternatives**

| Plan | | Incremental Cost | Incremental HUs | Total HUs | Incremental Cost Per HU |
|---|---|---|---|---|---|
| 0 | A0 B0 C0 D0 E0 F0 G0 H0 I0 J0 K0 L0 M0 | $0 | - | - | $0 |
| 1 | A0 B0 C0 D2 E0 F0 G0 H0 I0 J0 K0 L0 M0 | $2,126,020 | 1,088.6 | 1,088.6 | $1,950 |
| 2 | A0 B0 C0 D3 E0 F0 G0 H0 I0 J0 K0 L0 M0 | $1,491,570 | 493.6 | 1,582.2 | $3,020 |
| 3 | A0 B0 C0 D3 E0 F0 G0 H0 I0 J0 K0 L0 M3 | $3,419,830 | 860.0 | 2,442.2 | $3,980 |
| 4 | A0 B0 C0 D3 E2 F0 G0 H0 I0 J0 K0 L0 M3 | $16,741,780 | 1,619.7 | 4,061.9 | $10,340 |
| 5 | A0 B0 C0 D3 E2 F0 G0 H0 I0 J0 K0 L3 M3 | $8,393,770 | 802.7 | 4,864.6 | $10,460 |
| 6 | A0 B0 C0 D3 E2 F0 G0 H0 I0 J0 K3 L3 M3 | $4,326,410 | 406.2 | 5,270.8 | $10,650 |
| 7 | A0 B0 C0 D3 E2 F0 G0 H0 I3 J0 K3 L3 M3 | $12,385,390 | 962.6 | 6,233.4 | $12,870 |
| 8 | A0 B3 C0 D3 E2 F0 G0 H0 I3 J0 K3 L3 M3 | $17,132,380 | 970.0 | 7,203.4 | $17,660 |
| 9 | A0 B3 C0 D3 E3 F0 G0 H0 I3 J0 K3 L3 M3 | $29,842,030 | 1,523.6 | 8,727.0 | $19,590 |
| 10 | A0 B3 C0 D3 E3 F0 G0 H3 I3 J0 K3 L3 M3 | $5,006,710 | 242.7 | 8,969.7 | $20,630 |
| 11 | A0 B3 C0 D3 E3 F0 G0 H3 I3 J3 K3 L3 M3 | $7,084,440 | 229.8 | 9,199.5 | $30,830 |
| 12 | A0 B3 C3 D3 E3 F0 G0 H3 I3 J3 K3 L3 M3 | $37,199,590 | 609.8 | 9,809.3 | $61,000 |
| 13 | A0 B3 C3 D3 E3 F3 G0 H3 I3 J3 K3 L3 M3 | $10,779,880 | 154.5 | 9,963.8 | $69,770 |
| 14 | A3 B3 C3 D3 E3 F3 G0 H3 I3 J3 K3 L3 M3 | $57,714,460 | 349.3 | 10,313.1 | $165,230 |
| 15 | A3 B3 C3 D3 E3 F3 G2 H3 I3 J3 K3 L3 M3 | $16,064,870 | 96.9 | 10,410.0 | $165,790 |
| 16 | A3 B3 C3 D3 E3 F3 G3 H3 I3 J3 K3 L3 M3 | $40,132,800 | 159.9 | 10,569.9 | $250,990 |

**LEGEND:**

| | | | |
|---|---|---|---|
| A = Britt<br>B = Browns<br>C = Carpenter<br>D = Deepwater<br>E = Dry | F = Edison<br>G = Gages<br>H = Hall<br>I = Indian | J = Joe Leary<br>K = No Name<br>L = Sullivan<br>M = Telegraph | 0 = No Action<br>1 = Minimum Scale<br>2 = Moderate Scale<br>3 = Maximum Scale |

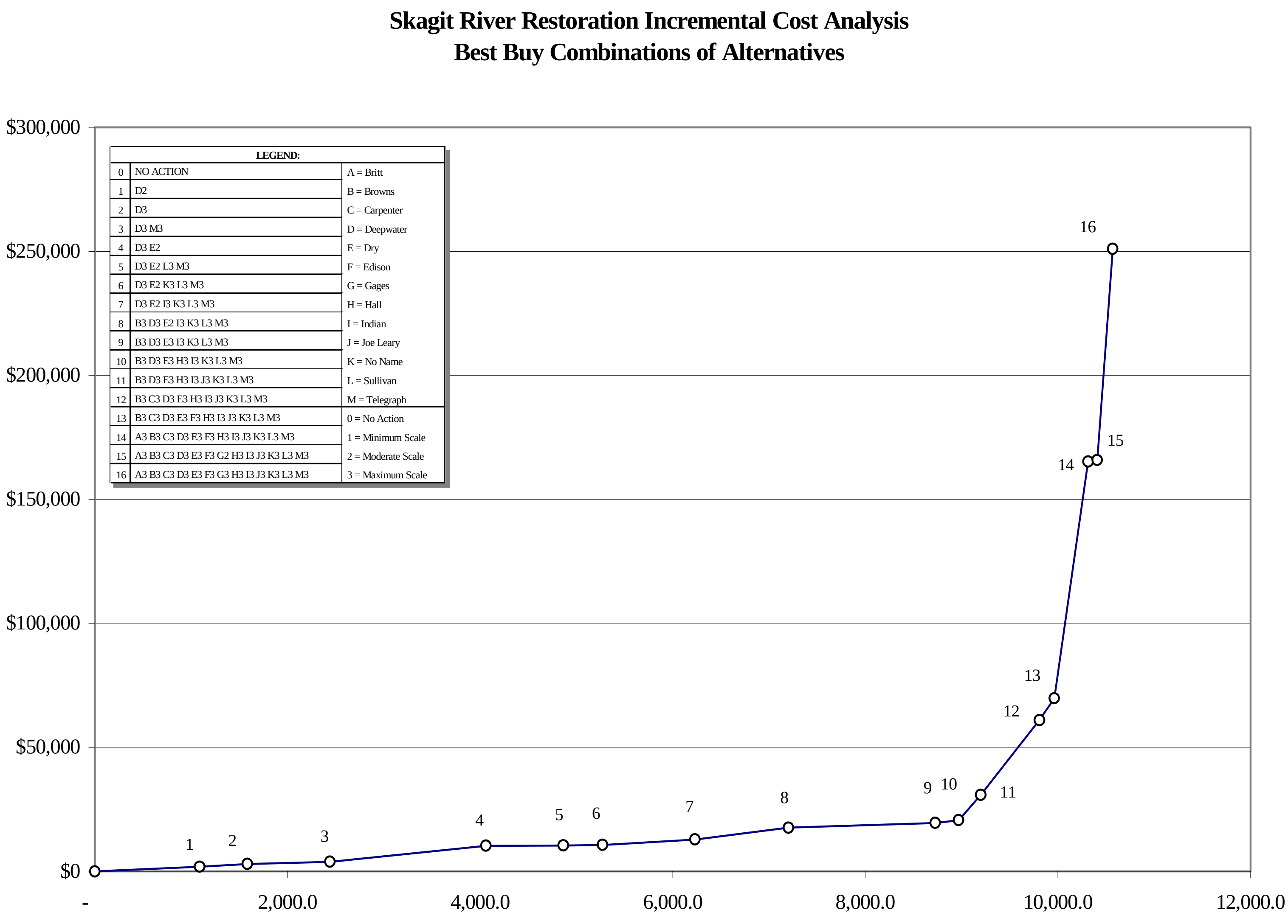



**Figure 3. Cost and HU comparison for Skagit River restoration alternative combinations.**

The graph in Figure 3 shows the "best-buy" combination plans starting with the most cost effective individual project (Deepwater moderate). If it is determined that the level of output provided by implementing that first plan is worth the cost, then the next decision becomes whether the additional output provided by the next plan (Deepwater maximum) is worth its extra cost, and so on. Plans 2 through 10 (Plan 1 being the No Action alternative) each show a significant increase in habitat output over the previous plan at a relatively low increase in incremental cost. Starting with plan 11, the cost increases more rapidly versus the habitat gains. This is illustrated by the rapid upward break of the graph line occurring between Plan 10 and 11 on Figure 3.

There is no precise selection criterion that identifies the optimal restoration plan using the cost effectiveness and incremental cost analyses. Instead the study sponsors must consider the results of the analyses and determine which plans are most desirable and worth the costs. It is easier to justify implementation of plans up through plan 10 because they clearly show significant habitat gains at a relatively low cost.

We have used the results of these analyses to recommend that plans 1 through 10 be evaluated in the secondary screening, presented in the following section.

### 5.3 Secondary Screening

The plans that are the most cost effective are screened further in this section. The second phase of screening includes political and social parameters such as the number of landowners affected and risk of negative impacts to adjacent properties. Feasibility of the projects will be rated with parameters including the sustainability of the project over the long term. Projects in areas of greater landownership may result in lengthy and complicated real estate or easement obtainments. Projects that require frequent maintenance of levees, culverts, SRTs, or plantings indicate that functioning conditions cannot be achieved through natural processes and are therefore less appropriate to undertake. The cost effective projects will be rated low, medium, or high for each of the parameters as shown in Table 9 below, and then listed in order of priority.

**Table 9. Secondary screening criteria and ratings.**

| ***Parameter and Definition*** | ***Rating*** |
|---|---|
| **Number of Landowners Affected** | |
| 0-10 landowners | High |
| 10-20 landowners | Medium |
| 20+ landowners | Low |
| **Negative Impacts to Adjacent Properties** | |
| No measureable negative impacts expected to adjacent unrestored properties | High |
| Project will cause minor negative impacts to adjacent properties (such as elevated groundwater table or saltwater intrusion in a small portion of the properties) | Medium |
| Project will cause significant negative impacts to adjacent properties (saltwater intrusion or groundwater table rise to within the rootzone of crops on more than 25% of the property) | Low |
| **Project Complete and Sustainable** | |
| Project can function over time with minimal expected maintenance and habitats will continue to form and reform freely because the project is not constrained in a majority of the evaluation area by levees, culverts or other structures. | High |
| Project will function with minimal to moderate levels of maintenance and can freely form habitats within the area of restoration. Habitats may be constrained in overall area by levees. | Medium |
| Project is highly controlled by levees, culverts and controlled inlets/outlets so that maintenance is expected to be moderate to frequent. Habitats cannot naturally form because they are constrained to specific channels or wetlands surrounded by other land uses. | Low |

#### *5.3.1 Secondary Screening Results*

The top 10 best-buy combinations were taken through the secondary screening process and the results are presented in Table 10. Screening was completed through the use of parcel maps and professional judgement. Plans 1, 2, 3, 5, 6, 7, and 8 were found to have the least negative impacts to landowners and/or other limits to implementation. Plans with 2 or more Low rankings (or high impact) were ranked the lowest and are not recommended for implementation. Plans found to have identical second screening rankings, such as Plans 1, 2 and 3, were ranked out based on the previous incremental cost analysis results.

**Table 10. Second screening results for cost effective alternatives.**

| Cost Effective Plans | | Number of Landowners Affected | Negative Impacts to Adjacent Properties | Project Complete and Sustainable | Overall Rank | Recommended |
|---|---|---|---|---|---|---|
| 1 | Deepwater moderate | H | H | H | 1 | Y |
| 2 | Deepwater maximum | H | H | H | 2 | Y |
| 3 | Deepwater maximum + Telegraph maximum | H | H | H | 3 | Y |
| 4 | Deepwater maximum + Dry moderate | L | M | L | 10 | |
| 5 | Plan 4 + Sullivan maximum + Telegraph maximum | L* | M | M | 4 | Y |
| 6 | Plan 5 + No Name maximum | L* | M | M | 5 | Y |
| 7 | Plan 6 + Indian maximum | L* | M | M | 6 | Y |
| 8 | Plan 7 + Browns maximum | L | M | M | 7 | Y |
| 9 | Plan 8 with Dry maximum instead of moderate | L | L | H | 8 | |
| 10 | Plan 9 + Hall maximum | L | L | H | 9 | |

*****Plan would be high or moderate ranked for number of landowners without the Dry Slough project included.

### 5.4 Recommendations for Implementation

Plans 1, 2, 3, 5, 6, 7, and 8 appear to provide significant habitat benefits and are also more feasible for implementation based on criteria in Table 9. The evaluation areas represented in these plans include Deepwater, Telegraph, Dry, Sullivan, No Name, Indian and Brown’s Sloughs. Each of these plans, or a similar combination of alternatives from these top rated evaluation areas, could be suitable for implementation.

We recommend that these areas be studied in more detail for a few reasons. First, restoration designs are conceptual at this stage and it will be necessary to identify specific project features, such as project boundary and feature locations. Second, it will be necessary to fine tune costs over time and as restoration features are tweaked. Real estate costs especially require additional investigation. Finally, the second screening phase was completed without data gathering regarding landowner willingness to participate in restoration which may impact private property. Considerations of the needs of drainage and diking districts must be evaluated prior to selection of a final restoration package.

## 6.0 MONITORING PLAN FOR PREFERRED ALTERNATIVE(S)

This monitoring plan provides a method for evaluating the implemented alternative to determine if project objectives are being met, if restoration actions are having the desired effects, and if the original assumptions made were correct. It also provides guidelines for response actions in the event that objectives are not met, actions have not had the desired effect, or assumptions were false.

Objectives for this restoration plan are to implement projects that restore ecosystem functions and processes, as feasible, that will naturally maintain and create key habitat for fish and wildlife habitat over time, as well as projects that restore localized habitats in the Skagit River delta region that are currently lacking and critically limit fish and wildlife production. Restoration measures proposed to achieve these objectives include setting back levees, reconfiguration of fish passage barriers, riparian revegetation, wetland creation, placement of LWD, and construction of livestock fencing. Our assumption is that, together, these restoration measures will result in the restoration of increasingly more natural hydroregimes, native vegetation communities, and sediment supply and transport, while also improving salmonid access and productivity, habitat diversity and connectivity, floodplain connectivity, and water quality.

The goal of monitoring is to set guidelines and account for the management, operation, and reporting of mitigation values over the life of the project. Three primary monitoring tasks will be employed, including those intended to monitor processes, those for conditions and functions, and those for biological response. Three phases of monitoring will be necessary and throughout each phase, each of the three monitoring tasks will be used. Monitoring phases include pre-project baseline, construction and post-project. The monitoring tasks and phases are defined below.

### 6.1 Monitoring Tasks

*Process Monitoring*: This task is designed for evaluating the success of process restoration. Processes that may be restored include tidal inundation or sediment supply and transport.

*Conditions Monitoring*: Conditions and functions are evaluated for success using this task. Conditions include the physical characteristics of the project site, such as percent cover of vegetation or sediment accumulation.

*Biological Monitoring*: This task is intended to monitor the biological response in the project area, including, for example, increase or decrease in population or diversity of fish and wildlife species.

### 6.2 Monitoring Phases

*Baseline Monitoring*: This monitoring occurs prior to project implementation for all monitoring tasks. Baseline monitoring is conducted to determine the existing conditions of processes, conditions, and biological communities. Determining existing conditions can be done through a combination of field studies and literature review. These conditions will be compared to post-project monitoring as a means of determining changes that have resulted from implementation of the alternatives.

*Construction Monitoring*: As the preferred alternative or alternatives are implemented, construction practices, results, and impacts on surrounding environments are monitored to ensure that the alternative is built according to design and that all conservation measures are being met.

*Post-Project Monitoring*: This phase is designed to allow ecologists and engineers to determine if the as-built project has achieved its restoration goals. Post-project monitoring begins immediately after construction and can continue for several years or decades. In this phase, adaptive management is employed in the event that goals are not being met and/or assumptions were false.

### 6.3 Adaptive Management

Adaptive management may be defined as the decision-making process to optimize the success long-term implementation of restoration alternatives. The objective of adaptive management is to ensure that ecological functions and habitat values affected by the project are restored and that overall project effects continue to be positive for the natural environment. Key components of adaptive management are identifying indicators for ecological functions and habitat values, monitoring the indicators, setting measurable objectives for the indicators, and planning and implementing remedial actions. The adaptive management process provides a mechanism by which remedial actions can be implemented if a measurable objective is not achieved.

An Adaptive Management Team (AMT) convened by Skagit County would direct and implement the adaptive management process during project construction and post-project monitoring. The AMT would consist of members with appropriate technical expertise representing Skagit County, the Corps, Department of Ecology, U.S. Fish and Wildlife Service, Washington State Department of Fish and Wildlife, and (tribe). The AMT would have the authority to address the failure to meet project objectives, if necessary, on the basis of the monitoring results and through a majority or consensus process subject to any necessary regulatory approvals. Project features could ultimately be reconfigured through these processes. For example, if a wetland does not meet the performance standards, potential adaptive management actions could include rerouting hydrologic inputs, replacing vegetation, or further grading work (excavation or fill). Decision-making would include the following response actions:

- No Action
- Maintenance
- Project or Objectives Modification
- Adaptive Management: Reconfiguration of Project Features
- Documentation and Reporting
- Dissemination of Results

An annual monitoring report should be prepared on or before March 31 by the monitoring entity and submitted to the AMT for review. Annual reports would summarize monitoring data collected during the previous water year (October 1-September 31). This report would be the primary tool by which the AMT would make determinations for response actions.

### 6.4 Monitoring Task Indicators

Determining the success of the restoration alternatives will require monitoring of processes, conditions, and biological responses both prior to construction and for several years following implementation. Monitoring processes, conditions, and biological responses can be conducted through physical and biological surveys. These surveys allow several indicator species or conditions to be evaluated both before and after project completion and will provide the data required for the AMT to determine if objectives are being met or how best to respond to failed objectives. Common monitoring indicators include physical measurements of riparian vegetation cover or water temperature, as well as biological surveys for wildlife species. A number of monitoring indicators have been proposed in the following section. However, additional indicators or their numeric targets may be identified or modified by the AMT at any time during the monitoring period. The following monitoring tasks will be further specified following the design phase of the selected project. In addition, cost estimates and detailed timelines will need to be developed. The following is a list of potential monitoring indicators, their definition and, if appropriate, their numeric targets for this monitoring plan.

*Tidal Inundation – Process Indicator*: Prior to construction, the current extent of tidal inundation of the project area would be determined in acres. The project area would be mapped, showing extent of tidal inundation and locations currently isolated from tides and rivers, using latest DNR or Corps orthorectified aerial photos. In selected years following construction (years 1, 3, and 5 for example), identical mapping procedures will again be conducted to determine the change in extent of tidal inundation. Specific numeric targets for increase in acres of inundation should be developed, based on the projected footprint as described in the project planview. Salinity studies in freshwater slough or creeks may also assist in determining the frequency and extent of tidal inundation.

*Sediment Accretion – Process Indicator*: Both prior to and after construction, several locations will be selected within the project area where cross-sectional surveys will be conducted. In addition, elevation surveys may be concurrently conducted within marsh or mudflat areas to further augment sediment accumulation data. Monitoring could potentially be scheduled for years 1, 3, and 5, but may include years

7 and 10 if necessary. Numeric targets would need to be developed following the design phase for the project.

*Riparian or Marsh Community – Condition Indicator*: In freshwater communities, for selected years (typically years 1, 2, 5 and 10) after construction, the riparian vegetation plantings should be evaluated for percent cover, canopy cover over the river and overall percent survival. Percent cover should generally be in the range of 40-60% in year 1, 75% in year 2, and 80-90% in year 5. Irrigation of plantings can be necessary for up to 3 years. Monitoring should occur during the August-September timeframe to encompass the maximum growth of each season. A possible numeric target may be the extent of mortality. If greater than 20% of plantings fail within the first year, replanting may be the action response of the AMT. In marsh communities there will be no new plantings. It will be necessary to determine the marsh vegetation coverage prior to and after construction via transect surveys. Numeric targets may be identified as percentage growth in coverage per year. Failure to meet those numeric targets could potentially result in the AMT taking action to plant marsh species.

*Water Quality – Condition Indicator*: Potential water quality indicators are numerous, but the most appropriate indicators for the project area include temperature, fecal coliform counts, turbidity, pH, and dissolved oxygen. Numeric targets for these parameters should be set according to Washington State surface water quality standards (WAC 173-201). Monitoring should occur prior to and after construction and may occur in years 1, 3, 5, and 10.

*Salmonid Use – Biological Response Indicator*: There are many approaches to assessing fish use of the project area. Trapping, seining, or visual surveys for presence of adults, juveniles or redds are possibilities. Surveys for chinook should occur between February and July. Surveys should occur prior to and after construction in selected years (1, 2, 4, 7, and 10). Sampling should be done in locations that fish would be expected to use and in areas recently opened to fish access through implementation of the restoration project.

*Wildlife Use – Biological Response Indicator*: As with monitoring of fish, there are several methods for monitoring wildlife species, but in this case there are also several different taxa that may be surveyed. Breeding birds, small mammals, amphibians, and macroinvertebrates are all possible indicator species for the project area. Scat surveys and trapping are possible for determining populations for small mammals, while point counts and mist netting are options for bird surveying. Macroinvertebrates are typically assessed using an index of biotic integrity and visual surveys are conducted for amphibians. Specific survey methods, numeric targets, and survey species will be selected following the design phase.

## 7.0 DISCUSSION AND SUMMARY

Based on the cost effectiveness and incremental cost analyses, it appears that plans that include alternatives from Deepwater, Telegraph, Dry, Sullivan, No Name, Indian, and Browns Sloughs provide the most habitat benefits at the lowest relative cost. In addition, these areas are the most feasible for implementation based on landowner constraints and long term sustainability. The maximum alternative described for these areas typically provided the most habitat benefits and was also typically the most costly alternative. However, because of the significant habitat benefits gained by providing a large and sustainable project, the incremental costs were lower.

The maximum alternatives as shown on the planviews would require the purchase of significant acreages of existing farm or pasture lands. This is likely beyond the financial capabilities of Skagit County, and it may not be possible to acquire these lands due to landowner resistance. For these reasons, we recommend that at least the five highest-ranking evaluation areas be considered in more detail to determine a more realistic preferred alternative for each area (Deepwater, Telegraph, Dry, Sullivan and No Name). All readers should note, however, that providing less habitat restoration in these areas will likely increase the incremental costs and make any modified alternatives somewhat less cost effective than the maximum alternatives shown in this report.

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# Appendix A: Vegetation Species and Densities for Estuarine and Freshwater Riparian Plantings and Wetland Plantings

| Community | Species | Common Name | Density | Size(s) |
|---|---|---|---|---|
| **Riparian** | *Acer macrophyllum* | Big-leaf maple | 50' o.c. | 2-5 gal. |
| | *Alnus rubra* | Red alder | 15' o.c. | 2-5 gal. |
| | *Picea sitchensis* | Sitka spruce | 20' o.c. | 2-5 gal. |
| | *Populus balsamifera* | Black cottonwood | 20' o.c. | 2-5 gal. |
| | *Thuja plicata* | Western red cedar | 20' o.c. | 2-5 gal. |
| | *Cornus sericea* | Red-osier dogwood | 10' o.c. | 1 gal. |
| | *Lonicera involucrata* | Twinberry | 15' o.c. | 2 gal. |
| | *Malus fusca* | Pacific crabapple | 15' o.c. | 3 gal. |
| | *Myrica gale* | Sweetgale | 10' o.c. | 4 gal. |
| | *Oemleria cerasiformis* | Indian plum | 15' o.c. | 5 gal. |
| | *Physocarpus capitatus* | Pacific ninebark | 15' o.c. | 6 gal. |
| | *Rosa pisocarpa* | Peafruit rose | 10' o.c. | 7 gal. |
| | *Rubus spectabilis* | Salmonberry | 10' o.c. | 8 gal. |
| | *Salix hookeriana* | Hooker willow | 3' o.c. | cuttings |
| | *Salix sitchensis* | Sitka willow | 3' o.c. | cuttings |
| | *Sambucus racemosa* | Red elderberry | 20' o.c. | 1 gal. |
| | | | | |
| **Forested Tidal** | *Picea sitchensis* | Sitka spruce | 30' o.c. | 2-5 gal. |
| | *Alnus rubra* | Red alder | 15' o.c. | 2-5 gal. |
| | *Salix sitchensis* | Sitka willow | 3' o.c. | cuttings |
| | *Salix hookeriana* | Hooker willow | 3' o.c. | cuttings |
| | *Physocarpus capitatus* | Pacific ninebark | 15' o.c. | 6 gal. |
| | *Malus fusca* | Pacific crabapple | 15' o.c. | 3 gal. |
| | | | | |
| **Upland** | *Acer macrophyllum* | Big-leaf maple | 30' o.c. | 2-5 gal. |
| | *Picea sitchensis* | Sitka spruce | 30' o.c. | 2-5 gal. |
| | *Pseudotsuga menziesii* | Douglas fir | 20' o.c. | 2-5 gal. |
| | *Taxus brevifolia* | Pacific yew | 30' o.c. | 2-5 gal. |
| | *Thuja plicata* | Western red cedar | 20' o.c. | 2-5 gal. |
| | *Tsuga heterophylla* | Western hemlock | 20' o.c. | 2-5 gal. |
| | *Crataegus douglasii* | Black hawthorn | 15' o.c. | 1 gal. |
| | *Gaultheria shallon* | Salal | 5' o.c. | 2 gal. |
| | *Rhamnus purshiana* | Cascara | 15' o.c. | 3 gal. |
| | *Rubus parviflorus* | Thimbleberry | 10' o.c. | 4 gal. |
| | *Symphoricarpos albus* | Snowberry | 10' o.c. | 5 gal. |
| | | | | |
| **Freshwater Wetland** | *Angelica genuflexa* | Kneeling angelica | 5' o.c. | 4" |
| | *Carex lenticularis* | Lenticular sedge | 1' o.c. | seed |
| | *Carex obnupta* | Slough sedge | 1' o.c. | 4" |
| | *Carex vulpinoidea* | Fox sedge | 1' o.c. | 4" |
| | *Deschampsia cespitosa* | Tufted hairgrass | 1' o.c. | seed |
| | *Juncus acuminatus* | Tapertip rush | 1' o.c. | 4" |
| | *Juncus gerardii* | Mud rush | 1' o.c. | 4" |
| | *Oenanthe sarmentosa* | Water parsley | 1' o.c. | 4" |
| | *Scirpus acutus* | Tule | 1' o.c. | 4" |
| | *Scirpus microcarpus* | Small-fruited bulrush | 1' o.c. | seed |

# Appendix B: Cost Estimate for Each Restoration Alternative

| | | | Britt Minimum | | Britt Moderate | | Britt Maximum | | Brown's Minimum | | Brown's Moderate | | Brown's Maximum | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **unit** | **unit cost** | **qt.** | **cost** | **qt.** | **cost** | **qt.** | **cost** | **qt.** | **cost** | **qt.** | **cost** | **qt.** | **cost** |
| *Mobilization/Demobilization* | LS | 4% | 1 | $152,129 | 1 | $205,761 | 1 | $532,566 | 1 | $26,989 | 1 | $76,603 | 1 | $271,339 |
| *Erosion control & SMWP (exc. silt fence)* | LS | 1% | 1 | $38,032 | 1 | $51,440 | 1 | $133,141 | 1 | $6,747 | 1 | $19,151 | 1 | $67,835 |
| *Place silt fence* | LF | $5 | 5850 | $29,250 | 7510 | $37,550 | 7510 | $37,550 | 1700 | $8,500 | 3600 | $18,000 | 9950 | $49,750 |
| *Remove non-native plants* | AC | $5,800 | 2.1 | $12,447 | 9.6 | $55,460 | 39.9 | $231,211 | 1.3 | $7,598 | 1.0 | $5,794 | 4.3 | $24,789 |
| *Excavate new channel* | CY | $20 | 1738 | $34,756 | 18707 | $374,133 | 18707 | $374,133 | 0 | $0 | 0 | $0 | 17633 | $352,667 |
| *Place LWD* | EA | $750 | 0 | $0 | 0 | $0 | 0 | $0 | 17 | $12,750 | 36 | $27,000 | 100 | $75,000 |
| *Place LWD with anchors* | EA | $1,250 | 58.5 | $73,125 | 75 | $93,875 | 75 | $93,875 | 17 | $21,250 | 36 | $45,000 | 100 | $125,000 |
| *Excavate levee notch* | CY | $20 | 0 | $0 | 0 | $0 | 0 | $0 | 244 | $4,889 | 1687 | $33,733 | 3740 | $74,800 |
| *Remove existing tide gate* | EA | $5,000 | 1 | $5,000 | 1 | $5,000 | 1 | $5,000 | 1 | $5,000 | 1 | $5,000 | 1 | $5,000 |
| *Install SRT/SRF (~6' diameter)* | EA | $100,000 | 2 | $200,000 | 2 | $200,000 | 2 | $200,000 | 3 | $300,000 | 3 | $300,000 | 3 | $300,000 |
| *Plant riparian vegetation* | AC | $10,000 | 21.5 | $214,600 | 95.62 | $956,200 | 398.64 | $3,986,400 | 13.1 | $131,000 | 9.99 | $99,900 | 42.74 | $427,400 |
| *Plant wetland vegetation* | AC | $10,000 | 0.0 | $0 | 16.5 | $164,600 | 16.5 | $164,600 | 0.0 | $0 | 0.0 | $0 | 0.0 | $0 |
| *Plant forested tidal vegetation* | AC | $10,000 | 0.0 | $0 | 0.0 | $0 | 0.0 | $0 | 0.0 | $0 | 28.1 | $280,900 | 303.8 | $3,037,900 |
| *Place livestock fence* | LF | $8 | 5850 | $43,875 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 |
| *Replace culverts (medium ~6' diameter)* | EA | $150,000 | 20 | $3,000,000 | 20 | $3,000,000 | 20 | $3,000,000 | 1 | $150,000 | 2 | $300,000 | 4 | $600,000 |
| *Replace culverts (large)* | EA | $500,000 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 |
| *Construct new levee* | CY | $20 | 0 | $0 | 0 | $0 | 37733 | $754,667 | 0 | $0 | 35200 | $704,000 | 68600 | $1,372,000 |
| *Remove existing roadway* | LF | $100 | 0 | $0 | 0 | $0 | 10860 | $1,086,000 | 0 | $0 | 0 | $0 | 0 | $0 |
| *Construct new roadway* | LF | $250 | 0 | $0 | 0 | $0 | 10860 | $2,715,000 | 0 | $0 | 0 | $0 | 0 | $0 |
| **Construction Subtotal** | **LS** | | | **$3,803,213** | | **$5,144,019** | | **$13,314,143** | | **$674,723** | | **$1,915,082** | | **$6,783,480** |
| Contingency | LS | 30% | | $1,140,964 | $0 | $1,543,206 | $0 | $3,994,243 | $0 | $202,417 | $0 | $574,524 | $0 | $2,035,044 |
| **Total Construction Cost** | **LS** | | | **$4,944,177** | | **$6,687,225** | | **$17,308,386** | | **$877,140** | | **$2,489,606** | | **$8,818,524** |
| Engineering Design and Specifications | LS | 10% | | $494,418 | | $668,722 | | $1,730,839 | | $87,714 | | $248,961 | | $881,852 |
| Construction Inspection and Administration | LS | 12% | | $593,301 | 12% | $802,467 | 12% | $2,077,006 | 12% | $105,257 | 12% | $298,753 | 12% | $1,058,223 |
| Estimated Real Estate | LS | | 1 | $6,408,500 | 1 | $17,546,800 | 1 | $35,365,800 | 1 | $579,500 | 1 | $2,006,300 | 1 | $5,761,000 |
| **Total First Costs** | **LS** | | | **$12,440,396** | | **$25,705,214** | | **$56,482,031** | | **$1,649,611** | | **$5,043,619** | | **$16,519,599** |
| Planting replacement (1-time cost during establishment) | AC | $5,000 | 21.5 | $107,300 | 112.1 | $560,400 | 415.1 | $2,075,500 | 13.1 | $65,500 | 38.1 | $190,400 | 346.5 | $1,732,650 |
| Exotic Species Control (establishment period) | AC/YR | $1,000 | 21.5 | $21,460 | 95.6 | $95,620 | 398.6 | $398,640 | 13.1 | $13,100 | 10.0 | $9,990 | 42.7 | $42,740 |
| Fence Repair (annual for project life) | LF | $8 | 117 | $878 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 |
| Inspection and flood damage (annual - LWD) | LS | 1% | 1 | $731 | 1 | $939 | 1 | $939 | 1 | $340 | 1 | $720 | 1 | $2,000 |
| Total O&M Costs (over project life) | LS | | | $295,038 | | $1,085,438 | | $4,115,638 | | $148,000 | | $276,350 | | $2,046,350 |
| Average Annual O&M Costs (over project life) | LS/YR | | | $5,901 | | $21,709 | | $82,313 | | $2,960 | | $5,527 | | $40,927 |
| **Total Present Value of O&M Costs** | **LS** | | | | | | | | | | | | | |

| | | | Carpenter Minimum | | Carpenter Moderate | | Carpenter Maximum | | Deepwater Minimum | | Deepwater Moderate | | Deepwater Maximum | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Evaluation Areas and Restoration Components** | **unit** | **unit cost** | **qt.** | **cost** | **qt.** | **cost** | **qt.** | **cost** | **qt.** | **cost** | **qt.** | **cost** | **qt.** | **cost** |
| *Mobilization/Demobilization* | LS | 4% | 1 | $106,750 | 1 | $386,786 | 1 | $580,283 | 1 | $24,440 | 1 | $43,115 | 1 | $73,612 |
| *Erosion control & SMWP (exc. silt fence)* | LS | 1% | 1 | $26,687 | 1 | $96,696 | 1 | $145,071 | 1 | $6,110 | 1 | $10,779 | 1 | $18,403 |
| *Place silt fence* | LF | $5 | 14925 | $74,625 | 15425 | $77,125 | 15925 | $79,625 | 22072.5 | $110,363 | 22822.5 | $114,113 | 27722.5 | $138,613 |
| *Remove non-native plants* | AC | $5,800 | 5.8 | $33,721 | 42.5 | $246,291 | 75.7 | $438,869 | 0.0 | $0 | 2.7 | $15,909 | 9.7 | $56,405 |
| *Excavate new channel* | CY | $20 | 0 | $0 | 17361 | $347,222 | 18750 | $375,000 | 0 | $0 | 0 | $0 | 2667 | $53,333 |
| *Place LWD* | EA | $750 | 0 | $0 | 0 | $0 | 0 | $0 | 221 | $165,750 | 228 | $171,000 | 227 | $170,250 |
| *Place LWD with anchors* | EA | $1,250 | 149 | $186,563 | 154 | $192,813 | 159 | $199,063 | 220 | $275,000 | 228 | $285,000 | 227 | $283,750 |
| *Excavate levee notch* | CY | $20 | 0 | $0 | 0 | $0 | 0 | $0 | 1467 | $29,333 | 2933 | $58,667 | 3422 | $68,444 |
| *Remove existing tide gate* | EA | $5,000 | 1 | $5,000 | 1 | $5,000 | 1 | $5,000 | 0 | $0 | 1 | $5,000 | 1 | $5,000 |
| *Install SRT/SRF (~6' diameter)* | EA | $100,000 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 1 | $100,000 | 0 | $0 |
| *Plant riparian vegetation* | AC | $10,000 | 58.14 | $581,400 | 424.64 | $4,246,400 | 756.67 | $7,566,700 | 0 | $0 | 27.43 | $274,300 | 97.25 | $972,500 |
| *Plant wetland vegetation* | AC | $10,000 | 15.4 | $154,000 | 65.4 | $654,000 | 163.4 | $1,634,400 | 0.0 | $0 | 0.0 | $0 | 0.0 | $0 |
| *Plant forested tidal vegetation* | AC | $10,000 | 0.0 | $0 | 0.0 | $0 | 0.0 | $0 | 0.0 | $0 | 0.0 | $0 | 0.0 | $0 |
| *Place livestock fence* | LF | $8 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 |
| *Replace culverts (medium ~6' diameter)* | EA | $150,000 | 10 | $1,500,000 | 15 | $2,250,000 | 15 | $2,250,000 | 0 | $0 | 0 | $0 | 0 | $0 |
| *Replace culverts (large)* | EA | $500,000 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 |
| *Construct new levee* | CY | $20 | 0 | $0 | 58365 | $1,167,307 | 61653 | $1,233,067 | 0 | $0 | 0 | $0 | 0 | $0 |
| *Remove existing roadway* | LF | $100 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 |
| *Construct new roadway* | LF | $250 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 |
| Construction Subtotal | LS | | | $2,668,746 | | $9,669,640 | | $14,507,077 | | $610,996 | | $1,077,883 | | $1,840,311 |
| Contingency | LS | 30% | $0 | $800,624 | $0 | $2,900,892 | $0 | $4,352,123 | $0 | $183,299 | $0 | $323,365 | $0 | $552,093 |
| **Total Construction Cost** | **LS** | | | **$3,469,370** | | **$12,570,531** | | **$18,859,200** | | **$794,294** | | **$1,401,248** | | **$2,392,404** |
| Engineering Design and Specifications | LS | 10% | | $346,937 | | $1,257,053 | | $1,885,920 | | $79,429 | | $140,125 | | $239,240 |
| Construction Inspection and Administration | LS | 12% | 12% | $416,324 | 12% | $1,508,464 | 12% | $2,263,104 | 12% | $95,315 | 12% | $168,150 | 12% | $287,088 |
| Estimated Real Estate | LS | | 1 | $7,204,900 | 1 | $10,458,400 | 1 | $11,651,000 | 1 | $121,100 | 1 | $266,084 | 1 | $339,668 |
| **Total First Costs** | **LS** | | | **$11,437,531** | | **$25,794,448** | | **$34,659,223** | | **$1,090,139** | | **$1,975,606** | | **$3,258,401** |
| Planting replacement (1-time cost during establishment) | AC | $5,000 | 73.5 | $367,700 | 490.0 | $2,450,200 | 920.1 | $4,600,550 | 0.0 | $0 | 27.4 | $137,150 | 97.3 | $486,250 |
| Exotic Species Control (establishment period) | AC/YR | $1,000 | 58.1 | $58,140 | 424.6 | $424,640 | 756.7 | $756,670 | 0.0 | $0 | 27.4 | $27,430 | 97.3 | $97,250 |
| Fence Repair (annual for project life) | LF | $8 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 |
| Inspection and flood damage (annual - LWD) | LS | 1% | 1 | $1,866 | 1 | $1,928 | 1 | $1,991 | 1 | $4,408 | 1 | $4,560 | 1 | $4,540 |
| Total O&M Costs (over project life) | LS | | | $751,681 | | $4,669,806 | | $8,483,431 | | $220,375 | | $502,300 | | $1,199,500 |
| Average Annual O&M Costs (over project life) | LS/YR | | | $15,034 | | $93,396 | | $169,669 | | $4,408 | | $10,046 | | $23,990 |
| **Total Present Value of O&M Costs** | **LS** | | | | | | | | | | | | | |

| | | | **Dry Minimum** | | **Dry Moderate** | | **Dry Maximum** | | **Edison Minimum** | | **Edison Moderate** | | **Edison Maximum** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Evaluation Areas and Restoration Components** | **unit** | **unit cost** | **qt** | **cost** | **qt** | **cost** | **qt** | **cost** | **qt** | **cost** | **qt** | **cost** | **qt** | **cost** |
| *Mobilization/Demobilization* | LS | 4% | 1 | $22,718 | 1 | $168,366 | 1 | $655,032 | 1 | $15,659 | 1 | $49,269 | 1 | $58,597 |
| *Erosion control & SMWP (exc. silt fence)* | LS | 1% | 1 | $5,679 | 1 | $42,092 | 1 | $163,758 | 1 | $3,915 | 1 | $12,317 | 1 | $14,649 |
| *Place silt fence* | LF | $5 | 3800 | $19,000 | 13650 | $68,250 | 13650 | $68,250 | 3137 | $15,685 | 5887 | $29,435 | 5887 | $29,435 |
| *Remove non-native plants* | AC | $5,800 | 1.3 | $7,650 | 3.1 | $18,229 | 14.3 | $83,062 | 1.3 | $7,273 | 2.5 | $14,239 | 3.3 | $19,250 |
| *Excavate new channel* | CY | $20 | 0 | $0 | 1000 | $20,000 | 1000 | $20,000 | 0 | $0 | 0 | $0 | 0 | $0 |
| *Place LWD* | EA | $750 | 38 | $28,500 | 137 | $102,750 | 137 | $102,750 | 32 | $24,000 | 59 | $44,250 | 59 | $44,250 |
| *Place LWD with anchors* | EA | $1,250 | 38 | $47,500 | 136 | $170,000 | 136 | $170,000 | 31 | $38,750 | 59 | $73,750 | 59 | $73,750 |
| *Excavate levee notch* | CY | $20 | 0 | $0 | 2200 | $44,000 | 2909 | $58,178 | 0 | $0 | 978 | $19,556 | 1467 | $29,333 |
| *Remove existing tide gate* | EA | $5,000 | 1 | $5,000 | 1 | $5,000 | 1 | $5,000 | 0 | $0 | 0 | $0 | 0 | $0 |
| *Install SRT/SRF (~6' diameter)* | EA | $100,000 | 3 | $300,000 | 3 | $300,000 | 3 | $300,000 | 0 | $0 | 0 | $0 | 0 | $0 |
| *Plant riparian vegetation* | AC | $10,000 | 13.19 | $131,900 | 31.43 | $314,300 | 143.21 | $1,432,100 | 12.54 | $125,400 | 24.55 | $245,500 | 33.19 | $331,900 |
| *Plant wetland vegetation* | AC | $10,000 | 0.0 | $0 | 0.0 | $0 | 0.0 | $0 | 0.0 | $0 | 3.1 | $31,400 | 7.7 | $77,100 |
| *Plant forested tidal vegetation* | AC | $10,000 | 0.0 | $0 | 71.1 | $710,700 | 994.9 | $9,949,000 | 0.0 | $0 | 0.0 | $0 | 0.0 | $0 |
| *Place livestock fence* | LF | $8 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 |
| *Replace culverts (medium ~6' diameter)* | EA | $150,000 | 0 | $0 | 9 | $1,350,000 | 9 | $1,350,000 | 0 | $0 | 4 | $600,000 | 4 | $600,000 |
| *Replace culverts (large)* | EA | $500,000 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 |
| *Construct new levee* | CY | $20 | 0 | $0 | 44773 | $895,467 | 100933 | $2,018,667 | 8040 | $160,800 | 5600 | $112,000 | 9333 | $186,667 |
| *Remove existing roadway* | LF | $100 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 |
| *Construct new roadway* | LF | $250 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 |
| Construction Subtotal | LS | | | $567,948 | | $4,209,154 | | $16,375,796 | | $391,482 | | $1,231,715 | | $1,464,932 |
| Contingency | LS | 30% | $0 | $170,384 | $0 | $1,262,746 | $0 | $4,912,739 | $0 | $117,445 | $0 | $369,515 | $0 | $439,480 |
| **Total Construction Cost** | **LS** | | | **$738,332** | | **$5,471,900** | | **$21,288,535** | | **$508,927** | | **$1,601,230** | | **$1,904,411** |
| Engineering Design and Specifications | LS | 10% | | $73,833 | | $547,190 | | $2,128,853 | | $50,893 | | $160,123 | | $190,441 |
| Construction Inspection and Administration | LS | 12% | 12% | $88,600 | 12% | $656,628 | 12% | $2,554,624 | 12% | $61,071 | 12% | $192,148 | 12% | $228,529 |
| Estimated Real Estate | LS | | 1 | $1,233,100 | 1 | $9,824,700 | 1 | $18,652,500 | 1 | $3,522,300 | 1 | $3,522,300 | 1 | $8,327,900 |
| **Total First Costs** | **LS** | | | **$2,133,865** | | **$16,500,418** | | **$44,624,513** | | **$4,143,191** | | **$5,475,801** | | **$10,651,282** |
| Planting replacement (1-time cost during establishment) | AC | $5,000 | 13.2 | $65,950 | 102.5 | $512,500 | 1138.1 | $5,690,550 | 12.5 | $62,700 | 27.7 | $138,450 | 40.9 | $204,500 |
| Exotic Species Control (establishment period) | AC/YR | $1,000 | 13.2 | $13,190 | 31.4 | $31,430 | 143.2 | $143,210 | 12.5 | $12,540 | 24.6 | $24,550 | 33.2 | $33,190 |
| Fence Repair (annual for project life) | LF | $8 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 |
| Inspection and flood damage (annual - LWD) | LS | 1% | 1 | $760 | 1 | $2,728 | 1 | $2,728 | 1 | $628 | 1 | $1,180 | 1 | $1,180 |
| Total O&M Costs (over project life) | LS | | | $169,900 | | $806,025 | | $6,542,975 | | $156,775 | | $320,200 | | $429,450 |
| Average Annual O&M Costs (over project life) | LS/YR | | | $3,398 | | $16,121 | | $130,860 | | $3,136 | | $6,404 | | $8,589 |
| **Total Present Value of O&M Costs** | **LS** | | | | | | | | | | | | | |

| | | | Gages Minimum | | Gages Moderate | | Gages Maximum | | Hall Minimum | | Hall Moderate | | Hall Maximum | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Evaluation Areas and Restoration Components** | **unit** | **unit cost** | **qt** | **cost** | **qt** | **cost** | **qt** | **cost** | **qt** | **cost** | **qt** | **cost** | **qt** | **cost** |
| *Mobilization/Demobilization* | LS | 4% | 1 | $104,121 | 1 | $177,957 | 1 | $335,768 | 1 | $34,953 | 1 | $39,576 | 1 | $49,577 |
| *Erosion control & SMWP (exc. silt fence)* | LS | 1% | 1 | $26,030 | 1 | $44,489 | 1 | $83,942 | 1 | $8,738 | 1 | $9,894 | 1 | $12,394 |
| *Place silt fence* | LF | $5 | 4625 | $23,125 | 7775 | $38,875 | 19500 | $97,500 | 2895 | $14,475 | 2895 | $14,475 | 2895 | $14,475 |
| *Remove non-native plants* | AC | $5,800 | 2.5 | $14,396 | 10.6 | $61,602 | 29.1 | $168,600 | 0.3 | $1,804 | 0.4 | $2,604 | 0.6 | $3,202 |
| *Excavate new channel* | CY | $20 | 0 | $0 | 11500 | $230,000 | 6500 | $130,000 | 0 | $0 | 400 | $8,000 | 4833 | $96,667 |
| *Place LWD* | EA | $750 | 0 | $0 | 0 | $0 | 0 | $0 | 29 | $21,750 | 29 | $21,750 | 29 | $21,750 |
| *Place LWD with anchors* | EA | $1,250 | 93 | $116,250 | 156 | $195,000 | 390 | $487,500 | 29 | $36,250 | 29 | $36,250 | 29 | $36,250 |
| *Excavate levee notch* | CY | $20 | 0 | $0 | 0 | $0 | 0 | $0 | 1564 | $31,289 | 2298 | $45,956 | 2542 | $50,844 |
| *Remove existing tide gate* | EA | $5,000 | 1 | $5,000 | 1 | $5,000 | 1 | $5,000 | 1 | $5,000 | 1 | $5,000 | 1 | $5,000 |
| *Install SRT/SRF (~6' diameter)* | EA | $100,000 | 0 | $0 | 2 | $200,000 | 2 | $200,000 | 3 | $300,000 | 3 | $300,000 | 3 | $300,000 |
| *Plant riparian vegetation* | AC | $10,000 | 24.82 | $248,200 | 106.2 | $1,062,100 | 290.69 | $2,906,900 | 3.11 | $31,100 | 4.49 | $44,900 | 5.52 | $55,200 |
| *Plant wetland vegetation* | AC | $10,000 | 11.6 | $115,900 | 18.4 | $183,900 | 22.9 | $229,000 | 0.0 | $0 | 0.0 | $0 | 0.0 | $0 |
| *Plant forested tidal vegetation* | AC | $10,000 | 0.0 | $0 | 0.0 | $0 | 0.0 | $0 | 15.1 | $151,000 | 15.1 | $151,000 | 29.9 | $299,000 |
| *Place livestock fence* | LF | $8 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 |
| *Replace culverts (medium ~6' diameter)* | EA | $150,000 | 13 | $1,950,000 | 15 | $2,250,000 | 25 | $3,750,000 | 1 | $150,000 | 1 | $150,000 | 1 | $150,000 |
| *Replace culverts (large)* | EA | $500,000 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 |
| *Construct new levee* | CY | $20 | 0 | $0 | 0 | $0 | 0 | $0 | 4373 | $87,467 | 8000 | $160,000 | 7253 | $145,067 |
| *Remove existing roadway* | LF | $100 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 |
| *Construct new roadway* | LF | $250 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 |
| Construction Subtotal | LS | | | $2,603,022 | | $4,448,923 | | $8,394,211 | | $873,826 | | $989,405 | | $1,239,426 |
| Contingency | LS | 30% | $0 | $780,907 | $0 | $1,334,677 | $0 | $2,518,263 | $0 | $262,148 | $0 | $296,822 | $0 | $371,828 |
| **Total Construction Cost** | **LS** | | | **$3,383,928** | | **$5,783,600** | | **$10,912,474** | | **$1,135,973** | | **$1,286,227** | | **$1,611,253** |
| Engineering Design and Specifications | LS | 10% | | $338,393 | | $578,360 | | $1,091,247 | | $113,597 | | $128,623 | | $161,125 |
| Construction Inspection and Administration | LS | 12% | 12% | $406,071 | 12% | $694,032 | 12% | $1,309,497 | 12% | $136,317 | 12% | $154,347 | 12% | $193,350 |
| Estimated Real Estate | LS | | 1 | $3,888,300 | 1 | $8,634,100 | 1 | $41,906,700 | 1 | $1,712,700 | 1 | $2,248,600 | 1 | $2,971,000 |
| **Total First Costs** | **LS** | | | **$8,016,692** | | **$15,690,092** | | **$55,219,918** | | **$3,098,587** | | **$3,817,796** | | **$4,936,729** |
| Planting replacement (1-time cost during establishment) | AC | $5,000 | 36.4 | $182,050 | 124.6 | $623,000 | 313.6 | $1,567,950 | 18.2 | $91,050 | 19.6 | $97,950 | 35.4 | $177,100 |
| Exotic Species Control (establishment period) | AC/YR | $1,000 | 24.8 | $24,820 | 106.2 | $106,210 | 290.7 | $290,690 | 3.1 | $3,110 | 4.5 | $4,490 | 5.5 | $5,520 |
| Fence Repair (annual for project life) | LF | $8 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 |
| Inspection and flood damage (annual - LWD) | LS | 1% | 1 | $1,163 | 1 | $1,950 | 1 | $4,875 | 1 | $580 | 1 | $580 | 1 | $580 |
| Total O&M Costs (over project life) | LS | | | $364,275 | | $1,251,550 | | $3,265,150 | | $135,600 | | $149,400 | | $233,700 |
| Average Annual O&M Costs (over project life) | LS/YR | | | $7,286 | | $25,031 | | $65,303 | | $2,712 | | $2,988 | | $4,674 |
| **Total Present Value of O&M Costs** | **LS** | | | | | | | | | | | | | |

| | | | **Indian Minimum** | | **Indian Moderate** | | **Indian Maximum** | | **Joe Leary Minimum** | | **Joe Leary Moderate** | | **Joe Leary Maximum** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Evaluation Areas and Restoration Components** | **unit** | **unit cost** | **qt** | **cost** | **qt** | **cost** | **qt** | **cost** | **qt** | **cost** | **qt** | **cost** | **qt** | **cost** |
| *Mobilization/Demobilization* | LS | 4% | 1 | $42,282 | 1 | $74,000 | 1 | $99,232 | 1 | $20,261 | 1 | $28,703 | 1 | $91,483 |
| *Erosion control & SMWP (exc. silt fence)* | LS | 1% | 1 | $10,570 | 1 | $18,500 | 1 | $24,808 | 1 | $5,065 | 1 | $7,176 | 1 | $22,871 |
| *Place silt fence* | LF | $5 | 8150 | $40,750 | 8150 | $40,750 | 11275 | $56,375 | 1450 | $7,250 | 3175 | $15,875 | 6450 | $32,250 |
| *Remove non-native plants* | AC | $5,800 | 3.7 | $21,692 | 2.8 | $16,385 | 2.5 | $14,541 | 0.5 | $2,935 | 1.8 | $10,341 | 8.8 | $50,953 |
| *Excavate new channel* | CY | $20 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 963 | $19,267 |
| *Place LWD* | EA | $750 | 82 | $61,500 | 82 | $61,500 | 113 | $84,750 | 15 | $11,250 | 32 | $24,000 | 65 | $48,750 |
| *Place LWD with anchors* | EA | $1,250 | 81 | $101,250 | 81 | $101,250 | 113 | $141,250 | 14 | $17,500 | 32 | $40,000 | 64 | $80,000 |
| *Excavate levee notch* | CY | $20 | 0 | $0 | 978 | $19,556 | 2933 | $58,667 | 0 | $0 | 489 | $9,778 | 1467 | $29,333 |
| *Remove existing tide gate* | EA | $5,000 | 1 | $5,000 | 1 | $5,000 | 1 | $5,000 | 1 | $5,000 | 1 | $5,000 | 1 | $5,000 |
| *Install SRT/SRF (~6' diameter)* | EA | $100,000 | 4 | $400,000 | 4 | $400,000 | 3 | $300,000 | 2 | $200,000 | 2 | $200,000 | 2 | $200,000 |
| *Plant riparian vegetation* | AC | $10,000 | 37.4 | $374,000 | 28.25 | $282,500 | 25.07 | $250,700 | 5.06 | $50,600 | 17.83 | $178,300 | 87.85 | $878,500 |
| *Plant wetland vegetation* | AC | $10,000 | 0.0 | $0 | 0.0 | $0 | 0.0 | $0 | 0.0 | $0 | 0.0 | $0 | 0.0 | $0 |
| *Plant forested tidal vegetation* | AC | $10,000 | 0.0 | $0 | 27.3 | $272,700 | 107.2 | $1,071,600 | 0.0 | $0 | 0.0 | $0 | 0.0 | $0 |
| *Place livestock fence* | LF | $8 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 |
| *Replace culverts (medium ~6' diameter)* | EA | $150,000 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 3 | $450,000 |
| *Replace culverts (large)* | EA | $500,000 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 |
| *Construct new levee* | CY | $20 | 0 | $0 | 27893 | $557,867 | 18693 | $373,867 | 9333 | $186,667 | 9920 | $198,400 | 18933 | $378,667 |
| *Remove existing roadway* | LF | $100 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 |
| *Construct new roadway* | LF | $250 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 |
| Construction Subtotal | LS | | | $1,057,044 | | $1,850,008 | | $2,480,788 | | $506,528 | | $717,573 | | $2,287,073 |
| Contingency | LS | 30% | $0 | $317,113 | $0 | $555,002 | $0 | $744,237 | $0 | $151,958 | $0 | $215,272 | $0 | $686,122 |
| **Total Construction Cost** | **LS** | | | **$1,374,157** | | **$2,405,010** | | **$3,225,025** | | **$658,486** | | **$932,845** | | **$2,973,195** |
| Engineering Design and Specifications | LS | 10% | | $137,416 | | $240,501 | | $322,502 | | $65,849 | | $93,284 | | $297,320 |
| Construction Inspection and Administration | LS | 12% | 12% | $164,899 | 12% | $288,601 | 12% | $387,003 | 12% | $79,018 | 12% | $111,941 | 12% | $356,783 |
| Estimated Real Estate | LS | | 1 | $2,811,200 | 1 | $2,811,200 | 1 | $8,181,500 | 1 | $672,600 | 1 | $2,874,600 | 1 | $3,174,800 |
| **Total First Costs** | **LS** | | | **$4,487,672** | | **$5,745,312** | | **$12,116,030** | | **$1,475,953** | | **$4,012,670** | | **$6,802,098** |
| Planting replacement (1-time cost during establishment) | AC | $5,000 | 37.4 | $187,000 | 55.5 | $277,600 | 132.2 | $661,150 | 5.1 | $25,300 | 17.8 | $89,150 | 87.9 | $439,250 |
| Exotic Species Control (establishment period) | AC/YR | $1,000 | 37.4 | $37,400 | 28.3 | $28,250 | 25.1 | $25,070 | 5.1 | $5,060 | 17.8 | $17,830 | 87.9 | $87,850 |
| Fence Repair (annual for project life) | LF | $8 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 |
| Inspection and flood damage (annual - LWD) | LS | 1% | 1 | $1,628 | 1 | $1,628 | 1 | $2,260 | 1 | $288 | 1 | $640 | 1 | $1,288 |
| Total O&M Costs (over project life) | LS | | | $455,375 | | $500,225 | | $899,500 | | $64,975 | | $210,300 | | $942,875 |
| Average Annual O&M Costs (over project life) | LS/YR | | | $9,108 | | $10,005 | | $17,990 | | $1,300 | | $4,206 | | $18,858 |
| **Total Present Value of O&M Costs** | **LS** | | | | | | | | | | | | | |

| | | | No Name Minimum | | No Name Moderate | | No Name Maximum | | Sullivan Minimum | | Sullivan Moderate | | Sullivan Maximum | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Evaluation Areas and Restoration Components** | **unit** | **unit cost** | **qt** | **cost** | **qt** | **cost** | **qt** | **cost** | **qt** | **cost** | **qt** | **cost** | **qt** | **cost** |
| *Mobilization/Demobilization* | LS | 4% | 1 | $9,396 | 1 | $45,617 | 1 | $77,474 | 1 | $37,153 | 1 | $49,464 | 1 | $65,161 |
| *Erosion control & SMWP (exc. silt fence)* | LS | 1% | 1 | $2,349 | 1 | $11,404 | 1 | $19,368 | 1 | $9,288 | 1 | $12,366 | 1 | $16,290 |
| *Place silt fence* | LF | $5 | 550 | $2,750 | 3050 | $15,250 | 3050 | $15,250 | 6960 | $34,800 | 6960 | $34,800 | 6960 | $34,800 |
| *Remove non-native plants* | AC | $5,800 | 0.2 | $1,264 | 1.2 | $6,711 | 1.5 | $8,903 | 3.8 | $22,139 | 3.9 | $22,817 | 4.2 | $24,163 |
| *Excavate new channel* | CY | $20 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 |
| *Place LWD* | EA | $750 | 6 | $4,500 | 31 | $23,250 | 6 | $4,500 | 70 | $52,500 | 70 | $52,500 | 70 | $52,500 |
| *Place LWD with anchors* | EA | $1,250 | 5 | $6,250 | 30 | $37,500 | 5 | $6,250 | 69 | $86,250 | 69 | $86,250 | 69 | $86,250 |
| *Excavate levee notch* | CY | $20 | 0 | $0 | 733 | $14,667 | 2933 | $58,667 | 0 | $0 | 1467 | $29,333 | 2933 | $58,667 |
| *Remove existing tide gate* | EA | $5,000 | 1 | $5,000 | 1 | $5,000 | 1 | $5,000 | 1 | $5,000 | 1 | $5,000 | 1 | $5,000 |
| *Install SRT/SRF (~6' diameter)* | EA | $100,000 | 1 | $100,000 | 1 | $100,000 | 1 | $100,000 | 3 | $300,000 | 3 | $300,000 | 3 | $300,000 |
| *Plant riparian vegetation* | AC | $10,000 | 2.18 | $21,800 | 11.57 | $115,700 | 15.35 | $153,500 | 38.17 | $381,700 | 39.34 | $393,400 | 41.66 | $416,600 |
| *Plant wetland vegetation* | AC | $10,000 | 0.0 | $0 | 0.0 | $0 | 0.0 | $0 | 0.0 | $0 | 0.0 | $0 | 0.0 | $0 |
| *Plant forested tidal vegetation* | AC | $10,000 | 0.0 | $0 | 0.0 | $0 | 105.1 | $1,050,600 | 0.0 | $0 | 0.0 | $0 | 0.0 | $0 |
| *Place livestock fence* | LF | $8 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 |
| *Replace culverts (medium ~6' diameter)* | EA | $150,000 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 |
| *Replace culverts (large)* | EA | $500,000 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 |
| *Construct new levee* | CY | $20 | 4080 | $81,600 | 38267 | $765,333 | 21867 | $437,333 | 0 | $0 | 12533 | $250,667 | 28480 | $569,600 |
| *Remove existing roadway* | LF | $100 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 |
| *Construct new roadway* | LF | $250 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 |
| Construction Subtotal | LS | | | $234,910 | | $1,140,432 | | $1,936,845 | | $928,830 | | $1,236,597 | | $1,629,031 |
| Contingency | LS | 30% | $0 | $70,473 | $0 | $342,130 | $0 | $581,054 | $0 | $278,649 | $0 | $370,979 | $0 | $488,709 |
| **Total Construction Cost** | **LS** | | | **$305,383** | | **$1,482,562** | | **$2,517,899** | | **$1,207,479** | | **$1,607,576** | | **$2,117,740** |
| Engineering Design and Specifications | LS | 10% | | $30,538 | | $148,256 | | $251,790 | | $120,748 | | $160,758 | | $211,774 |
| Construction Inspection and Administration | LS | 12% | 12% | $36,646 | 12% | $177,907 | 12% | $302,148 | 12% | $144,897 | 12% | $192,909 | 12% | $254,129 |
| Estimated Real Estate | LS | | 1 | $365,400 | 1 | $603,000 | 1 | $1,049,700 | 1 | $4,481,700 | 1 | $4,332,100 | 1 | $5,664,600 |
| **Total First Costs** | **LS** | | | **$737,967** | | **$2,411,725** | | **$4,121,537** | | **$5,954,825** | | **$6,293,343** | | **$8,248,243** |
| Planting replacement (1-time cost during establishment) | AC | $5,000 | 2.2 | $10,900 | 11.6 | $57,850 | 120.4 | $602,050 | 38.2 | $190,850 | 39.3 | $196,700 | 41.7 | $208,300 |
| Exotic Species Control (establishment period) | AC/YR | $1,000 | 2.2 | $2,180 | 11.6 | $11,570 | 15.4 | $15,350 | 38.2 | $38,170 | 39.3 | $39,340 | 41.7 | $41,660 |
| Fence Repair (annual for project life) | LF | $8 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 |
| Inspection and flood damage (annual - LWD) | LS | 1% | 1 | $108 | 1 | $608 | 1 | $108 | 1 | $1,388 | 1 | $1,388 | 1 | $1,388 |
| Total O&M Costs (over project life) | LS | | | $27,175 | | $146,075 | | $684,175 | | $451,075 | | $462,775 | | $485,975 |
| Average Annual O&M Costs (over project life) | LS/YR | | | $544 | | $2,922 | | $13,684 | | $9,022 | | $9,256 | | $9,720 |
| **Total Present Value of O&M Costs** | **LS** | | | | | | | | | | | | | |

| | | | **Telegraph Minimum** | | **Telegraph Moderate** | | **Telegraph Maximum** | |
|---|---|---|---|---|---|---|---|---|
| **Evaluation Areas and Restoration Components** | **unit** | **unit cost** | **qt** | **cost** | **qt** | **cost** | **qt** | **cost** |
| *Mobilization/Demobilization* | LS | 4% | 1 | $17,229 | 1 | $35,739 | 1 | $61,832 |
| *Erosion control & SMWP (exc. silt fence)* | LS | 1% | 1 | $4,307 | 1 | $8,935 | 1 | $15,458 |
| *Place silt fence* | LF | $5 | 2825 | $14,125 | 2825 | $14,125 | 11112.5 | $55,563 |
| *Remove non-native plants* | AC | $5,800 | 1.3 | $7,308 | 1.3 | $7,726 | 1.8 | $10,510 |
| *Excavate new channel* | CY | $20 | 0 | $0 | 0 | $0 | 11458 | $229,167 |
| *Place LWD* | EA | $750 | 29 | $21,750 | 29 | $21,750 | 111 | $83,250 |
| *Place LWD with anchors* | EA | $1,250 | 28 | $35,000 | 28 | $35,000 | 111 | $138,750 |
| *Excavate levee notch* | CY | $20 | 0 | $0 | 1467 | $29,333 | 2933 | $58,667 |
| *Remove existing tide gate* | EA | $5,000 | 1 | $5,000 | 1 | $5,000 | 1 | $5,000 |
| *Install SRT/SRF (~6' diameter)* | EA | $100,000 | 2 | $200,000 | 2 | $200,000 | 0 | $0 |
| *Plant riparian vegetation* | AC | $10,000 | 12.6 | $126,000 | 13.32 | $133,200 | 18.12 | $181,200 |
| *Plant wetland vegetation* | AC | $10,000 | 0.0 | $0 | 0.0 | $0 | 0.0 | $0 |
| *Plant forested tidal vegetation* | AC | $10,000 | 0.0 | $0 | 0.0 | $0 | 0.0 | $0 |
| *Place livestock fence* | LF | $8 | 0 | $0 | 0 | $0 | 0 | $0 |
| *Replace culverts (medium ~6' diameter)* | EA | $150,000 | 0 | $0 | 0 | $0 | 0 | $0 |
| *Replace culverts (large)* | EA | $500,000 | 0 | $0 | 0 | $0 | 1 | $500,000 |
| *Construct new levee* | CY | $20 | 0 | $0 | 20133 | $402,667 | 10320 | $206,400 |
| *Remove existing roadway* | LF | $100 | 0 | $0 | 0 | $0 | 0 | $0 |
| *Construct new roadway* | LF | $250 | 0 | $0 | 0 | $0 | 0 | $0 |
| Construction Subtotal | LS | | | $430,719 | | $893,474 | | $1,545,795 |
| Contingency | LS | 30% | $0 | $129,216 | $0 | $268,042 | $0 | $463,739 |
| **Total Construction Cost** | **LS** | | | **$559,935** | | **$1,161,517** | | **$2,009,534** |
| Engineering Design and Specifications | LS | 10% | | $55,993 | | $116,152 | | $200,953 |
| Construction Inspection and Administration | LS | 12% | 12% | $67,192 | 12% | $139,382 | 12% | $241,144 |
| Estimated Real Estate | LS | | 1 | $715,900 | 1 | $748,900 | 1 | $880,700 |
| **Total First Costs** | **LS** | | | **$1,399,020** | | **$2,165,950** | | **$3,332,331** |
| Planting replacement (1-time cost during establishment) | AC | $5,000 | 12.6 | $63,000 | 13.3 | $66,600 | 18.1 | $90,600 |
| Exotic Species Control (establishment period) | AC/YR | $1,000 | 12.6 | $12,600 | 13.3 | $13,320 | 18.1 | $18,120 |
| Fence Repair (annual for project life) | LF | $8 | 0 | $0 | 0 | $0 | 0 | $0 |
| Inspection and flood damage (annual - LWD) | LS | 1% | 1 | $568 | 1 | $568 | 1 | $2,220 |
| Total O&M Costs (over project life) | LS | | | $154,375 | | $161,575 | | $292,200 |
| Average Annual O&M Costs (over project life) | LS/YR | | | $3,088 | | $3,232 | | $5,844 |
| **Total Present Value of O&M Costs** | **LS** | | | | | | | |

# APPENDIX C

## COST EFFECTIVENESS AND INCREMENTAL COST ANALYSES

## SKAGIT RIVER FLOOD DAMAGE REDUCTION AND ECOSYSTEM RESTORATION STUDY

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# APPENDIX C

# COST EFFECTIVENESS AND INCREMENTAL COST ANALYSES

## Cost and Output of Alternatives

Table C-1 displays cost and output estimates for each of three scaled alternatives at each of thirteen evaluation areas. Each alternative includes an Identifier (ID) Code that was used to track the alternative in the IWR-PLAN cost effectiveness and incremental cost analysis software program produced by the Corps of Engineers.

The purpose of the analyses is to compare habitat benefits with costs and to screen out projects with relatively low habitat benefit for high costs.

The development of the habitat units (output estimates) is described in the environmental sections of this report.

The cost estimate for each alternative is provided in Appendix C. The cost estimates used in these analyses are life cycle cost estimates that include the present value of all preconstruction engineering and design, real estate acquisition, construction, operation, and maintenance costs

**Table C-1: Skagit River Restoration Analysis**
**All Alternatives with Cost and Output Estimates**

| ID Code | Evaluation Area | Alternatives | HU | Cost |
|---|---|---|---|---|
| A 1 | Britt | Minimum | 15.0 | -$12,528,740 |
| A 2 | Britt | Moderate | 79.0 | -$26,030,250 |
| A 3 | Britt | Maximum | 349.3 | -$57,714,460 |
| B 1 | Browns | Minimum | 16.8 | -$1,693,930 |
| B 2 | Browns | Moderate | 171.5 | -$5,126,370 |
| B 3 | Browns | Maximum | 970.0 | -$17,132,380 |
| C 1 | Carpenter | Minimum | 28.3 | -$11,662,620 |
| C 2 | Carpenter | Moderate | 316.6 | -$27,192,820 |
| C 3 | Carpenter | Maximum | 609.8 | -$37,199,590 |
| D 1 | Deepwater | Minimum | 467.6 | -$1,156,130 |
| D 2 | Deepwater | Moderate | 1,088.6 | -$2,126,020 |
| D 3 | Deepwater | Maximum | 1,582.2 | -$3,617,590 |
| E 1 | Dry | Minimum | 8.2 | -$2,184,740 |
| E 2 | Dry | Moderate | 1,619.7 | -$16,741,780 |
| E 3 | Dry | Maximum | 3,143.3 | -$46,583,810 |
| F 1 | Edison | Minimum | 10.4 | -$4,190,140 |
| F 2 | Edison | Moderate | 39.4 | -$5,571,680 |
| F 3 | Edison | Maximum | 154.5 | -$10,779,880 |
| G 1 | Gages | Minimum | 7.6 | -$8,125,770 |
| G 2 | Gages | Moderate | 96.9 | -$16,064,870 |
| G 3 | Gages | Maximum | 256.8 | -$56,197,670 |
| H 1 | Hall | Minimum | 20.4 | -$3,139,190 |
| H 2 | Hall | Moderate | 86.1 | -$3,862,530 |
| H 3 | Hall | Maximum | 242.7 | -$5,006,710 |
| I 1 | Indian | Minimum | 29.9 | -$4,624,030 |
| I 2 | Indian | Moderate | 164.0 | -$5,895,100 |
| I 3 | Indian | Maximum | 962.6 | -$12,385,390 |
| J 1 | Joe Leary | Minimum | 25.2 | -$1,495,410 |
| J 2 | Joe Leary | Moderate | 68.4 | -$4,075,640 |
| J 3 | Joe Leary | Maximum | 229.8 | -$7,084,440 |
| K 1 | No Name | Minimum | 4.6 | -$746,100 |
| K 2 | No Name | Moderate | 66.4 | -$2,455,470 |
| K 3 | No Name | Maximum | 406.2 | -$4,326,410 |
| L 1 | Sullivan | Minimum | 58.7 | -$6,089,900 |
| L 2 | Sullivan | Moderate | 122.9 | -$6,431,920 |
| L 3 | Sullivan | Maximum | 802.7 | -$8,393,770 |
| M 1 | Telegraph | Minimum | 11.0 | -$1,445,250 |
| M 2 | Telegraph | Moderate | 103.4 | -$2,214,330 |
| M 3 | Telegraph | Maximum | 860.0 | -$3,419,830 |

## Alternatives Sorted by Increasing Output

Table C-2 presents the alternatives with their cost and output estimates sorted by increasing output. The result is the full array of alternatives under consideration ordered form the smallest habitat unit production to the most extensive habitat unit production.

**Table C-2: Skagit River Restoration Analysis**
**All Alternatives Sorted by Increasing Output**

| ID Code | | Evaluation Area | Alternatives | HU | Cost |
|---|---|---|---|---|---|
| K | 1 | No Name | Minimum | 4.6 | -$746,100 |
| G | 1 | Gages | Minimum | 7.6 | -$8,125,770 |
| E | 1 | Dry | Minimum | 8.2 | -$2,184,740 |
| F | 1 | Edison | Minimum | 10.4 | -$4,190,140 |
| M | 1 | Telegraph | Minimum | 11.0 | -$1,445,250 |
| A | 1 | Britt | Minimum | 15.0 | -$12,528,740 |
| B | 1 | Browns | Minimum | 16.8 | -$1,693,930 |
| H | 1 | Hall | Minimum | 20.4 | -$3,139,190 |
| J | 1 | Joe Leary | Minimum | 25.2 | -$1,495,410 |
| C | 1 | Carpenter | Minimum | 28.3 | -$11,662,620 |
| I | 1 | Indian | Minimum | 29.9 | -$4,624,030 |
| F | 2 | Edison | Moderate | 39.4 | -$5,571,680 |
| L | 1 | Sullivan | Minimum | 58.7 | -$6,089,900 |
| K | 2 | No Name | Moderate | 66.4 | -$2,455,470 |
| J | 2 | Joe Leary | Moderate | 68.4 | -$4,075,640 |
| A | 2 | Britt | Moderate | 79.0 | -$26,030,250 |
| H | 2 | Hall | Moderate | 86.1 | -$3,862,530 |
| G | 2 | Gages | Moderate | 96.9 | -$16,064,870 |
| M | 2 | Telegraph | Moderate | 103.4 | -$2,214,330 |
| L | 2 | Sullivan | Moderate | 122.9 | -$6,431,920 |
| F | 3 | Edison | Maximum | 154.5 | -$10,779,880 |
| I | 2 | Indian | Moderate | 164.0 | -$5,895,100 |
| B | 2 | Browns | Moderate | 171.5 | -$5,126,370 |
| J | 3 | Joe Leary | Maximum | 229.8 | -$7,084,440 |
| H | 3 | Hall | Maximum | 242.7 | -$5,006,710 |
| G | 3 | Gages | Maximum | 256.8 | -$56,197,670 |
| C | 2 | Carpenter | Moderate | 316.6 | -$27,192,820 |
| A | 3 | Britt | Maximum | 349.3 | -$57,714,460 |
| K | 3 | No Name | Maximum | 406.2 | -$4,326,410 |
| D | 1 | Deepwater | Minimum | 467.6 | -$1,156,130 |
| C | 3 | Carpenter | Maximum | 609.8 | -$37,199,590 |
| L | 3 | Sullivan | Maximum | 802.7 | -$8,393,770 |
| M | 3 | Telegraph | Maximum | 860.0 | -$3,419,830 |
| I | 3 | Indian | Maximum | 962.6 | -$12,385,390 |
| B | 3 | Browns | Maximum | 970.0 | -$17,132,380 |
| D | 2 | Deepwater | Moderate | 1,088.6 | -$2,126,020 |
| D | 3 | Deepwater | Maximum | 1,582.2 | -$3,617,590 |
| E | 2 | Dry | Moderate | 1,619.7 | -$16,741,780 |
| E | 3 | Dry | Maximum | 3,143.3 | -$46,583,810 |

## Alternatives Sorted by Increasing Cost

Table C-3 presents the alternatives with their cost and output estimates sorted by increasing cost. The result is the full array of alternatives under consideration ordered from the least expensive to the most expensive.

**Table C-3: Skagit River Restoration Analysis**
**All Alternatives Sorted by Increasing Cost**

| ID Code | | Evaluation Area | Alternatives | HU | Cost |
|---|---|---|---|---|---|
| K | 1 | No Name | Minimum | 4.6 | -$746,100 |
| D | 1 | Deepwater | Minimum | 467.6 | -$1,156,130 |
| M | 1 | Telegraph | Minimum | 11.0 | -$1,445,250 |
| J | 1 | Joe Leary | Minimum | 25.2 | -$1,495,410 |
| B | 1 | Browns | Minimum | 16.8 | -$1,693,930 |
| D | 2 | Deepwater | Moderate | 1,088.6 | -$2,126,020 |
| E | 1 | Dry | Minimum | 8.2 | -$2,184,740 |
| M | 2 | Telegraph | Moderate | 103.4 | -$2,214,330 |
| K | 2 | No Name | Moderate | 66.4 | -$2,455,470 |
| H | 1 | Hall | Minimum | 20.4 | -$3,139,190 |
| M | 3 | Telegraph | Maximum | 860.0 | -$3,419,830 |
| D | 3 | Deepwater | Maximum | 1,582.2 | -$3,617,590 |
| H | 2 | Hall | Moderate | 86.1 | -$3,862,530 |
| J | 2 | Joe Leary | Moderate | 68.4 | -$4,075,640 |
| F | 1 | Edison | Minimum | 10.4 | -$4,190,140 |
| K | 3 | No Name | Maximum | 406.2 | -$4,326,410 |
| I | 1 | Indian | Minimum | 29.9 | -$4,624,030 |
| H | 3 | Hall | Maximum | 242.7 | -$5,006,710 |
| B | 2 | Browns | Moderate | 171.5 | -$5,126,370 |
| F | 2 | Edison | Moderate | 39.4 | -$5,571,680 |
| I | 2 | Indian | Moderate | 164.0 | -$5,895,100 |
| L | 1 | Sullivan | Minimum | 58.7 | -$6,089,900 |
| L | 2 | Sullivan | Moderate | 122.9 | -$6,431,920 |
| J | 3 | Joe Leary | Maximum | 229.8 | -$7,084,440 |
| G | 1 | Gages | Minimum | 7.6 | -$8,125,770 |
| L | 3 | Sullivan | Maximum | 802.7 | -$8,393,770 |
| F | 3 | Edison | Maximum | 154.5 | -$10,779,880 |
| C | 1 | Carpenter | Minimum | 28.3 | -$11,662,620 |
| I | 3 | Indian | Maximum | 962.6 | -$12,385,390 |
| A | 1 | Britt | Minimum | 15.0 | -$12,528,740 |
| G | 2 | Gages | Moderate | 96.9 | -$16,064,870 |
| E | 2 | Dry | Moderate | 1,619.7 | -$16,741,780 |
| B | 3 | Browns | Maximum | 970.0 | -$17,132,380 |
| A | 2 | Britt | Moderate | 79.0 | -$26,030,250 |
| C | 2 | Carpenter | Moderate | 316.6 | -$27,192,820 |
| C | 3 | Carpenter | Maximum | 609.8 | -$37,199,590 |
| E | 3 | Dry | Maximum | 3,143.3 | -$46,583,810 |
| G | 3 | Gages | Maximum | 256.8 | -$56,197,670 |
| A | 3 | Britt | Maximum | 349.3 | -$57,714,460 |

## Analysis of Average Costs at Individual Evaluation Areas

Table C-4 presents the three alternative scaled projects at each evaluation area with average cost calculated. For each site, the alternatives are sorted by increasing average cost.

This data is useful to rank the efficiency of habitat unit production at each individual site. The alternative with the lowest average cost is the most efficient alternative under consideration at that site.

**Table C-4: Skagit River Restoration Analysis**
**Most Efficient Alternatives at Each Evaluation Area**

| ID Code | | Evaluation Area | Alternatives | HU | Cost | Avg. Cost |
|---|---|---|---|---|---|---|
| A | 3 | Britt | Maximum | 349.3 | -$57,714,460 | -$165,230 |
| A | 2 | Britt | Moderate | 79.0 | -$26,030,250 | -$329,620 |
| A | 1 | Britt | Minimum | 15.0 | -$12,528,740 | -$835,250 |
| B | 3 | Browns | Maximum | 970.0 | -$17,132,380 | -$17,660 |
| B | 2 | Browns | Moderate | 171.5 | -$5,126,370 | -$29,900 |
| B | 1 | Browns | Minimum | 16.8 | -$1,693,930 | -$100,950 |
| C | 3 | Carpenter | Maximum | 609.8 | -$37,199,590 | -$61,000 |
| C | 2 | Carpenter | Moderate | 316.6 | -$27,192,820 | -$85,890 |
| C | 1 | Carpenter | Minimum | 28.3 | -$11,662,620 | -$412,400 |
| D | 1 | Deepwater | Minimum | 467.6 | -$1,156,130 | -$2,470 |
| D | 2 | Deepwater | Moderate | 1,088.6 | -$2,126,020 | -$3,420 |
| D | 3 | Deepwater | Maximum | 1,582.2 | -$3,617,590 | -$7,330 |
| E | 2 | Dry | Moderate | 1,619.7 | -$16,741,780 | -$10,390 |
| E | 3 | Dry | Maximum | 3,143.3 | -$46,583,810 | -$30,580 |
| E | 1 | Dry | Minimum | 8.2 | -$2,184,740 | -$268,070 |
| F | 3 | Edison | Maximum | 154.5 | -$10,779,880 | -$93,630 |
| F | 2 | Edison | Moderate | 39.4 | -$5,571,680 | -$192,190 |
| F | 1 | Edison | Minimum | 10.4 | -$4,190,140 | -$404,060 |
| G | 2 | Gages | Moderate | 96.9 | -$16,064,870 | -$179,960 |
| G | 3 | Gages | Maximum | 256.8 | -$56,197,670 | -$351,570 |
| G | 1 | Gages | Minimum | 7.6 | -$8,125,770 | -$1,064,980 |
| H | 3 | Hall | Maximum | 242.7 | -$5,006,710 | -$31,970 |
| H | 2 | Hall | Moderate | 86.1 | -$3,862,530 | -$58,770 |
| H | 1 | Hall | Minimum | 20.4 | -$3,139,190 | -$153,880 |
| I | 3 | Indian | Maximum | 962.6 | -$12,385,390 | -$15,510 |
| I | 2 | Indian | Moderate | 164.0 | -$5,895,100 | -$43,950 |
| I | 1 | Indian | Minimum | 29.9 | -$4,624,030 | -$154,650 |
| J | 3 | Joe Leary | Maximum | 229.8 | -$7,084,440 | -$43,900 |
| J | 2 | Joe Leary | Minimum | 68.4 | -$1,495,410 | -$59,250 |
| J | 1 | Joe Leary | Moderate | 25.2 | -$4,075,640 | -$94,410 |
| K | 3 | No Name | Maximum | 406.2 | -$4,326,410 | -$12,730 |
| K | 2 | No Name | Moderate | 66.4 | -$2,455,470 | -$39,690 |
| K | 1 | No Name | Minimum | 4.6 | -$746,100 | -$163,260 |
| L | 3 | Sullivan | Maximum | 802.7 | -$8,393,770 | -$12,350 |
| L | 2 | Sullivan | Moderate | 122.9 | -$6,431,920 | -$100,120 |
| L | 1 | Sullivan | Minimum | 58.7 | -$6,089,900 | -$103,800 |
| M | 3 | Telegraph | Maximum | 860.0 | -$3,419,830 | -$4,520 |
| M | 2 | Telegraph | Moderate | 103.4 | -$2,214,330 | -$23,960 |
| M | 1 | Telegraph | Minimum | 11.0 | -$1,445,250 | -$131,510 |

## Analysis of Average Costs Across All Evaluation Areas

Table C-5 presents all alternative scaled projects at all evaluation areas sorted by increasing average cost.

This data is useful in comparisons of the production efficiency of one alternative to that of another.

The analysis shows that of all alternatives under consideration, Alternative D1 (the moderate-scaled plan at Deepwater) is the most efficient alternative available. That is, it produces habitat units at the lowest cost per unit.

**Table C-5: Skagit River Restoration Analysis**
**All Alternatives Ranked by Average Cost**

| ID Code | | Evaluation Area | Alternatives | HU | Cost | Avg. Cost |
|---|---|---|---|---|---|---|
| D | 2 | Deepwater | Moderate | 1,088.6 | -$2,126,020 | -$4,420 |
| D | 3 | Deepwater | Maximum | 1,582.2 | -$3,617,590 | -$4,760 |
| D | 1 | Deepwater | Minimum | 467.6 | -$1,156,130 | -$4,940 |
| M | 3 | Telegraph | Maximum | 860.0 | -$3,419,830 | -$6,450 |
| E | 2 | Dry | Moderate | 1,619.7 | -$16,741,780 | -$12,810 |
| L | 3 | Sullivan | Maximum | 802.7 | -$8,393,770 | -$12,930 |
| K | 3 | No Name | Maximum | 406.2 | -$4,326,410 | -$13,120 |
| I | 3 | Indian | Maximum | 962.6 | -$12,385,390 | -$15,340 |
| E | 3 | Dry | Maximum | 3,143.3 | -$46,583,810 | -$17,290 |
| B | 3 | Browns | Maximum | 970.0 | -$17,132,380 | -$20,130 |
| H | 3 | Hall | Maximum | 242.7 | -$5,006,710 | -$23,100 |
| M | 2 | Telegraph | Moderate | 103.4 | -$2,214,330 | -$23,890 |
| B | 2 | Browns | Moderate | 171.5 | -$5,126,370 | -$32,370 |
| J | 3 | Joe Leary | Maximum | 229.8 | -$7,084,440 | -$33,300 |
| I | 2 | Indian | Moderate | 164.0 | -$5,895,100 | -$38,410 |
| K | 2 | No Name | Moderate | 66.4 | -$2,455,470 | -$39,430 |
| H | 2 | Hall | Moderate | 86.1 | -$3,862,530 | -$47,320 |
| L | 2 | Sullivan | Moderate | 122.9 | -$6,431,920 | -$54,800 |
| J | 1 | Joe Leary | Minimum | 25.2 | -$1,495,410 | -$61,720 |
| J | 2 | Joe Leary | Moderate | 68.4 | -$4,075,640 | -$62,050 |
| C | 3 | Carpenter | Maximum | 609.8 | -$37,199,590 | -$63,470 |
| F | 3 | Edison | Maximum | 154.5 | -$10,779,880 | -$72,240 |
| C | 2 | Carpenter | Moderate | 316.6 | -$27,192,820 | -$88,360 |
| B | 1 | Browns | Minimum | 16.8 | -$1,693,930 | -$103,420 |
| L | 1 | Sullivan | Minimum | 58.7 | -$6,089,900 | -$106,270 |
| M | 1 | Telegraph | Minimum | 11.0 | -$1,445,250 | -$133,980 |
| F | 2 | Edison | Moderate | 39.4 | -$5,571,680 | -$143,880 |
| H | 1 | Hall | Minimum | 20.4 | -$3,139,190 | -$156,350 |
| I | 1 | Indian | Minimum | 29.9 | -$4,624,030 | -$157,120 |
| K | 1 | No Name | Minimum | 4.6 | -$746,100 | -$165,730 |
| A | 3 | Britt | Maximum | 349.3 | -$57,714,460 | -$167,700 |
| G | 2 | Gages | Moderate | 96.9 | -$16,064,870 | -$168,260 |
| G | 3 | Gages | Maximum | 256.8 | -$56,197,670 | -$221,350 |
| E | 1 | Dry | Minimum | 8.2 | -$2,184,740 | -$270,540 |
| A | 2 | Britt | Moderate | 79.0 | -$26,030,250 | -$332,090 |
| F | 1 | Edison | Minimum | 10.4 | -$4,190,140 | -$406,530 |
| C | 1 | Carpenter | Minimum | 28.3 | -$11,662,620 | -$414,870 |
| A | 1 | Britt | Minimum | 15.0 | -$12,528,740 | -$837,720 |
| G | 1 | Gages | Minimum | 7.6 | -$8,125,770 | -$1,067,450 |

## Cost Effectiveness Analysis of Combinations of Alternatives

To conduct a cost effectiveness analysis for the project, the software program IWR-PLAN was utilized to develop all possible combinations of all alternatives at all evaluation areas.

Of this set of all possible combinations, cost effectiveness analysis deleted from further consideration those plans where:

1) the same output can be produced by another plan at lesser cost
2) greater output can be produced by another plan at lesser or equal cost

Cost effective combinations that are not screened out by these criteria are called "cost effective" combinations. Table C-6 presents the set of cost effective combinations of alternatives or "plans". The plans are sorted by increasing output. The analysis identified 155 cost effective combinations.

The plan identifier code in column 1 of Table C-6 indicates which scale at which evaluation areas are included in that plan. A code ending in "0" indicates no feature is included in that plan for that evaluation area. The remaining codes correspond to the ID codes presented in Table C-1 and other tables in this Appendix.

Figure C-1 follows the table and plots the total cost vs. output produced for the plans in Table C-6.

**Table C-6: Skagit River Restoration Analysis Cost Effective Combinations of Alternatives**

| Plan | Cost | Output |
|---|---|---|
| A0B0C0D0E0F0G0H0I0J0K0L0M0 | $0 | - |
| A0B0C0D0E0F0G0H0I0J0K1L0M0 | $746,100 | 4.6 |
| A0B0C0D1E0F0G0H0I0J0K0L0M0 | $1,156,130 | 467.6 |
| A0B0C0D1E0F0G0H0I0J0K1L0M0 | $1,902,230 | 472.2 |
| A0B0C0D2E0F0G0H0I0J0K0L0M0 | $2,126,020 | 1,088.6 |
| A0B0C0D2E0F0G0H0I0J0K0L0M1 | $3,571,270 | 1,099.6 |
| A0B0C0D2E0F0G0H0I0J0K0L0M3 | $5,545,850 | 1,948.6 |
| A0B0C0D2E0F0G0H0I0J0K1L0M0 | $2,872,120 | 1,093.2 |
| A0B0C0D2E0F0G0H0I0J0K1L0M3 | $6,291,950 | 1,953.2 |
| A0B0C0D3E0F0G0H0I0J0K0L0M0 | $3,617,590 | 1,582.2 |
| A0B0C0D3E0F0G0H0I0J0K0L0M1 | $5,062,840 | 1,593.2 |
| A0B0C0D3E0F0G0H0I0J0K0L0M3 | $7,037,420 | 2,442.2 |
| A0B0C0D3E0F0G0H0I0J0K0L3M3 | $15,431,190 | 3,244.9 |
| A0B0C0D3E0F0G0H0I0J0K1L0M0 | $4,363,690 | 1,586.8 |
| A0B0C0D3E0F0G0H0I0J0K1L0M3 | $7,783,520 | 2,446.8 |
| A0B0C0D3E0F0G0H0I0J0K1L3M3 | $16,177,290 | 3,249.5 |
| A0B0C0D3E0F0G0H0I0J0K2L0M3 | $9,492,890 | 2,508.6 |
| A0B0C0D3E0F0G0H0I0J0K2L3M3 | $17,886,660 | 3,311.3 |
| A0B0C0D3E0F0G0H0I0J0K3L0M3 | $11,363,830 | 2,848.4 |
| A0B0C0D3E0F0G0H0I0J0K3L3M3 | $19,757,600 | 3,651.1 |
| A0B0C0D3E0F0G0H0I0J1K0L0M0 | $5,113,000 | 1,607.4 |
| A0B0C0D3E0F0G0H0I0J1K0L0M3 | $8,532,830 | 2,467.4 |
| A0B0C0D3E0F0G0H0I0J1K0L3M3 | $16,926,600 | 3,270.1 |
| A0B0C0D3E0F0G0H0I0J1K1L0M3 | $9,278,930 | 2,472.0 |
| A0B0C0D3E0F0G0H0I0J1K1L3M3 | $17,672,700 | 3,274.7 |
| A0B0C0D3E0F0G0H0I0J1K2L0M3 | $10,988,300 | 2,533.8 |
| A0B0C0D3E0F0G0H0I0J1K2L3M3 | $19,382,070 | 3,336.5 |
| A0B0C0D3E0F0G0H0I0J1K3L0M3 | $12,859,240 | 2,873.6 |
| A0B0C0D3E0F0G0H0I0J1K3L3M3 | $21,253,010 | 3,676.3 |
| A0B0C0D3E0F0G0H0I3J0K0L0M3 | $19,422,810 | 3,404.8 |
| A0B0C0D3E0F0G0H0I3J0K0L3M3 | $27,816,580 | 4,207.5 |
| A0B0C0D3E0F0G0H0I3J0K3L0M3 | $23,749,220 | 3,811.0 |
| A0B0C0D3E0F0G0H0I3J0K3L3M3 | $32,142,990 | 4,613.7 |
| A0B0C0D3E0F0G0H2I0J0K0L0M3 | $10,899,950 | 2,528.3 |
| A0B0C0D3E0F0G0H2I0J0K0L3M3 | $19,293,720 | 3,331.0 |
| A0B0C0D3E0F0G0H2I0J0K3L0M3 | $15,226,360 | 2,934.5 |
| A0B0C0D3E0F0G0H2I0J0K3L3M3 | $23,620,130 | 3,737.2 |
| A0B0C0D3E2F0G0H0I0J0K0L0M3 | $23,779,200 | 4,061.9 |
| A0B0C0D3E2F0G0H0I0J0K0L3M3 | $32,172,970 | 4,864.6 |
| A0B0C0D3E2F0G0H0I0J0K1L0M3 | $24,525,300 | 4,066.5 |
| A0B0C0D3E2F0G0H0I0J0K1L3M3 | $32,919,070 | 4,869.2 |
| A0B0C0D3E2F0G0H0I0J0K2L0M3 | $26,234,670 | 4,128.3 |

| Table C-6: Skagit River Restoration Analysis Cost Effective Combinations of Alternatives | | |
|---|---|---|
| Plan | Cost | Output |
| A0B0C0D3E2F0G0H0I0J0K2L3M3 | $34,628,440 | 4,931.0 |
| A0B0C0D3E2F0G0H0I0J0K3L0M3 | $28,105,610 | 4,468.1 |
| A0B0C0D3E2F0G0H0I0J0K3L3M3 | $36,499,380 | 5,270.8 |
| A0B0C0D3E2F0G0H0I0J1K0L0M3 | $25,274,610 | 4,087.1 |
| A0B0C0D3E2F0G0H0I0J1K0L3M3 | $33,668,380 | 4,889.8 |
| A0B0C0D3E2F0G0H0I0J1K1L0M3 | $26,020,710 | 4,091.7 |
| A0B0C0D3E2F0G0H0I0J1K1L3M3 | $34,414,480 | 4,894.4 |
| A0B0C0D3E2F0G0H0I0J1K2L0M3 | $27,730,080 | 4,153.5 |
| A0B0C0D3E2F0G0H0I0J1K2L3M3 | $36,123,850 | 4,956.2 |
| A0B0C0D3E2F0G0H0I0J1K3L0M3 | $29,601,020 | 4,493.3 |
| A0B0C0D3E2F0G0H0I0J1K3L3M3 | $37,994,790 | 5,296.0 |
| A0B0C0D3E2F0G0H0I3J0K0L0M3 | $36,164,590 | 5,024.5 |
| A0B0C0D3E2F0G0H0I3J0K0L3M3 | $44,558,360 | 5,827.2 |
| A0B0C0D3E2F0G0H0I3J0K1L3M3 | $45,304,460 | 5,831.8 |
| A0B0C0D3E2F0G0H0I3J0K2L3M3 | $47,013,830 | 5,893.6 |
| A0B0C0D3E2F0G0H0I3J0K3L0M3 | $40,491,000 | 5,430.7 |
| A0B0C0D3E2F0G0H0I3J0K3L3M3 | $48,884,770 | 6,233.4 |
| A0B0C0D3E2F0G0H0I3J1K0L3M3 | $46,053,770 | 5,852.4 |
| A0B0C0D3E2F0G0H0I3J1K1L3M3 | $46,799,870 | 5,857.0 |
| A0B0C0D3E2F0G0H0I3J1K2L3M3 | $48,509,240 | 5,918.8 |
| A0B0C0D3E2F0G0H0I3J1K3L3M3 | $50,380,180 | 6,258.6 |
| A0B0C0D3E2F0G0H2I0J0K0L0M3 | $27,641,730 | 4,148.0 |
| A0B0C0D3E2F0G0H2I0J0K0L3M3 | $36,035,500 | 4,950.7 |
| A0B0C0D3E2F0G0H2I0J0K3L0M3 | $31,968,140 | 4,554.2 |
| A0B0C0D3E2F0G0H2I0J0K3L3M3 | $40,361,910 | 5,356.9 |
| A0B0C0D3E2F0G0H2I3J0K0L3M3 | $48,420,890 | 5,913.3 |
| A0B0C0D3E2F0G0H2I3J0K3L3M3 | $52,747,300 | 6,319.5 |
| A0B0C0D3E2F0G0H3I0J0K3L3M3 | $41,506,090 | 5,513.5 |
| A0B0C0D3E2F0G0H3I0J1K3L3M3 | $43,001,500 | 5,538.7 |
| A0B0C0D3E2F0G0H3I3J0K3L3M3 | $53,891,480 | 6,476.1 |
| A0B0C0D3E2F0G0H3I3J1K3L3M3 | $55,386,890 | 6,501.3 |
| A0B0C0D3E2F0G0H3I3J2K3L3M3 | $57,967,120 | 6,544.5 |
| A0B0C0D3E2F0G0H3I3J3K3L3M3 | $60,975,920 | 6,705.9 |
| A0B0C0D3E3F0G0H0I3J0K3L3M3 | $78,726,800 | 7,757.0 |
| A0B0C0D3E3F0G0H0I3J1K3L3M3 | $80,222,210 | 7,782.2 |
| A0B0C0D3E3F0G0H2I3J0K3L3M3 | $82,589,330 | 7,843.1 |
| A0B0C0D3E3F0G0H3I3J0K3L3M3 | $83,733,510 | 7,999.7 |
| A0B0C0D3E3F0G0H3I3J1K3L3M3 | $85,228,920 | 8,024.9 |
| A0B0C0D3E3F0G0H3I3J2K3L3M3 | $87,809,150 | 8,068.1 |
| A0B0C0D3E3F0G0H3I3J3K3L3M3 | $90,817,950 | 8,229.5 |
| A0B1C0D3E0F0G0H0I0J1K3L0M3 | $14,553,170 | 2,890.4 |
| A0B1C0D3E0F0G0H0I0J1K3L3M3 | $22,946,940 | 3,693.1 |
| A0B1C0D3E2F0G0H0I0J1K3L0M3 | $31,294,950 | 4,510.1 |
| A0B1C0D3E2F0G0H0I0J1K3L3M3 | $39,688,720 | 5,312.8 |
| A0B1C0D3E2F0G0H0I3J1K3L3M3 | $52,074,110 | 6,275.4 |
| A0B1C0D3E2F0G0H3I3J1K3L3M3 | $57,080,820 | 6,518.1 |
| A0B1C0D3E3F0G0H0I3J1K3L3M3 | $81,916,140 | 7,799.0 |
| A0B1C0D3E3F0G0H3I3J1K3L3M3 | $86,922,850 | 8,041.7 |
| A0B2C0D3E2F0G0H3I3J0K3L3M3 | $59,017,850 | 6,647.6 |
| A0B2C0D3E2F0G0H3I3J1K3L3M3 | $60,513,260 | 6,672.8 |
| A0B2C0D3E3F0G0H3I3J0K3L3M3 | $88,859,880 | 8,171.2 |
| A0B2C0D3E3F0G0H3I3J1K3L3M3 | $90,355,290 | 8,196.4 |
| A0B3C0D3E2F0G0H0I3J0K0L3M3 | $61,690,740 | 6,797.2 |
| A0B3C0D3E2F0G0H0I3J0K1L3M3 | $62,436,840 | 6,801.8 |
| A0B3C0D3E2F0G0H0I3J0K2L3M3 | $64,146,210 | 6,863.6 |
| A0B3C0D3E2F0G0H0I3J0K3L3M3 | $66,017,150 | 7,203.4 |
| A0B3C0D3E2F0G0H0I3J1K0L3M3 | $63,186,150 | 6,822.4 |
| A0B3C0D3E2F0G0H0I3J1K1L3M3 | $63,932,250 | 6,827.0 |
| A0B3C0D3E2F0G0H0I3J1K2L3M3 | $65,641,620 | 6,888.8 |
| A0B3C0D3E2F0G0H0I3J1K3L3M3 | $67,512,560 | 7,228.6 |
| A0B3C0D3E2F0G0H2I3J0K0L3M3 | $65,553,270 | 6,883.3 |
| A0B3C0D3E2F0G0H2I3J0K3L3M3 | $69,879,680 | 7,289.5 |
| A0B3C0D3E2F0G0H2I3J3K3L3M3 | $76,964,120 | 7,519.3 |
| A0B3C0D3E2F0G0H3I3J0K3L3M3 | $71,023,860 | 7,446.1 |
| A0B3C0D3E2F0G0H3I3J1K3L3M3 | $72,519,270 | 7,471.3 |
| A0B3C0D3E2F0G0H3I3J2K3L3M3 | $75,099,500 | 7,514.5 |
| A0B3C0D3E2F0G0H3I3J3K3L3M3 | $78,108,300 | 7,675.9 |
| A0B3C0D3E3F0G0H0I3J0K0L3M3 | $91,532,770 | 8,320.8 |
| A0B3C0D3E3F0G0H0I3J0K1L3M3 | $92,278,870 | 8,325.4 |
| A0B3C0D3E3F0G0H0I3J0K2L3M3 | $93,988,240 | 8,387.2 |
| A0B3C0D3E3F0G0H0I3J0K3L3M3 | $95,859,180 | 8,727.0 |
| A0B3C0D3E3F0G0H0I3J1K0L3M3 | $93,028,180 | 8,346.0 |
| A0B3C0D3E3F0G0H0I3J1K1L3M3 | $93,774,280 | 8,350.6 |
| A0B3C0D3E3F0G0H0I3J1K2L3M3 | $95,483,650 | 8,412.4 |
| A0B3C0D3E3F0G0H0I3J1K3L3M3 | $97,354,590 | 8,752.2 |
| A0B3C0D3E3F0G0H2I3J0K0L3M3 | $95,395,300 | 8,406.9 |
| A0B3C0D3E3F0G0H2I3J0K3L3M3 | $99,721,710 | 8,813.1 |
| A0B3C0D3E3F0G0H2I3J3K3L3M3 | $106,806,150 | 9,042.9 |
| A0B3C0D3E3F0G0H3I3J0K3L3M3 | $100,865,890 | 8,969.7 |
| A0B3C0D3E3F0G0H3I3J1K3L3M3 | $102,361,300 | 8,994.9 |
| A0B3C0D3E3F0G0H3I3J2K3L3M3 | $104,941,530 | 9,038.1 |
| A0B3C0D3E3F0G0H3I3J3K3L3M3 | $107,950,330 | 9,199.5 |
| A0B3C0D3E3F1G0H3I3J3K3L3M3 | $112,140,470 | 9,209.9 |
| A0B3C0D3E3F2G0H3I3J3K3L3M3 | $113,522,010 | 9,238.9 |
| A0B3C0D3E3F3G0H3I3J3K3L3M3 | $118,730,210 | 9,354.0 |
| A0B3C0D3E3F3G1H3I3J3K3L3M3 | $126,855,980 | 9,361.6 |

| Table C-6: Skagit River Restoration Analysis Cost Effective Combinations of Alternatives | | |
|---|---|---|
| **Plan** | **Cost** | **Output** |
| A0B3C0D3E3F3G2H3I3J3K3L3M3 | $134,795,080 | 9,450.9 |
| A0B3C1D3E3F3G0H3I3J3K3L3M3 | $130,392,830 | 9,382.3 |
| A0B3C2D3E3F0G0H3I3J3K3L3M3 | $135,143,150 | 9,516.1 |
| A0B3C3D3E3F0G0H2I3J3K3L3M3 | $144,005,740 | 9,652.7 |
| A0B3C3D3E3F0G0H3I3J0K3L3M3 | $138,065,480 | 9,579.5 |
| A0B3C3D3E3F0G0H3I3J1K3L3M3 | $139,560,890 | 9,604.7 |
| A0B3C3D3E3F0G0H3I3J2K3L3M3 | $142,141,120 | 9,647.9 |
| A0B3C3D3E3F0G0H3I3J3K3L3M3 | $145,149,920 | 9,809.3 |
| A0B3C3D3E3F1G0H3I3J3K3L3M3 | $149,340,060 | 9,819.7 |
| A0B3C3D3E3F2G0H3I3J3K3L3M3 | $150,721,600 | 9,848.7 |
| A0B3C3D3E3F3G0H3I3J3K3L3M3 | $155,929,800 | 9,963.8 |
| A0B3C3D3E3F3G1H3I3J3K3L3M3 | $164,055,570 | 9,971.4 |
| A0B3C3D3E3F3G2H3I3J3K3L3M3 | $171,994,670 | 10,060.7 |
| A0B3C3D3E3F3G3H3I3J3K3L3M3 | $212,127,470 | 10,220.6 |
| A1B3C3D3E3F3G0H3I3J3K3L3M3 | $168,458,540 | 9,978.8 |
| A1B3C3D3E3F3G2H3I3J3K3L3M3 | $184,523,410 | 10,075.7 |
| A2B3C3D3E3F3G2H3I3J3K3L3M3 | $198,024,920 | 10,139.7 |
| A3B3C3D3E3F0G0H3I3J3K3L3M3 | $202,864,380 | 10,158.6 |
| A3B3C3D3E3F0G3H3I3J3K3L3M3 | $259,062,050 | 10,415.4 |
| A3B3C3D3E3F1G0H3I3J3K3L3M3 | $207,054,520 | 10,169.0 |
| A3B3C3D3E3F1G3H3I3J3K3L3M3 | $263,252,190 | 10,425.8 |
| A3B3C3D3E3F2G0H3I3J3K3L3M3 | $208,436,060 | 10,198.0 |
| A3B3C3D3E3F2G3H3I3J3K3L3M3 | $264,633,730 | 10,454.8 |
| A3B3C3D3E3F3G0H3I3J3K3L3M3 | $213,644,260 | 10,313.1 |
| A3B3C3D3E3F3G1H3I3J3K3L3M3 | $221,770,030 | 10,320.7 |
| A3B3C3D3E3F3G2H3I3J3K3L3M3 | $229,709,130 | 10,410.0 |
| A3B3C3D3E3F3G3H3I3J3K3L3M3 | $269,841,930 | 10,569.9 |

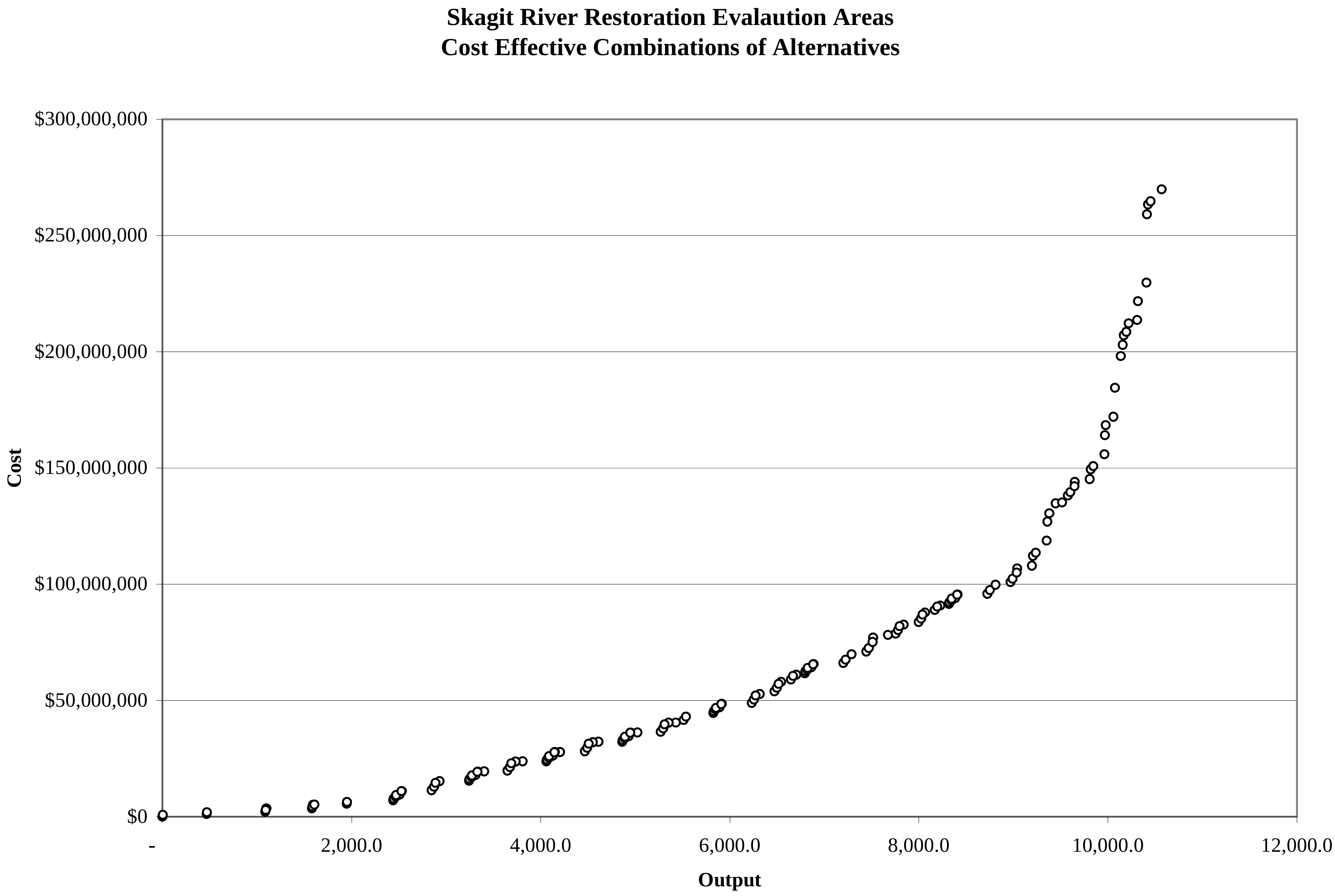
Skagit River Restoration Evalaution Areas
Cost Effective Combinations of Alternatives
$300,000,000
$250,000,000
$200,000,000
$150,000,000
$100,000,000
$50,000,000
$0
Cost
-
2,000.0
4,000.0
6,000.0
8,000.0
10,000.0
12,000.0
Output

Figure C-1

## Incremental Cost Analysis of Combinations of Alternatives

An incremental cost analysis was performed on the cost effective plans identified in Table C-6. This analysis was to identify the array of plans that comprise the most efficient production schedule for producing habitat units.

This analysis first identifies the "best-buy" or plan that produces the greatest increase in output for the least increase in cost (that is, it has the lowest incremental cost per habitat unit produced). Is this case that is Plan 1, which includes Alternative D2.

The analysis then identifies the "next–best-buy", which corresponds to the next most efficient plan (the plan with the next lowest incremental cost per habitat unit produced).

Table C-7 shows the array of best buy plans based upon the alternatives under consideration in this study.

This data is useful to identify the level of restoration that is worth its cost. Since the first best buy (Plan #1) is the most efficient plan, the first question is: "Is Best-Buy Plan 1 worth its cost?" If so, then the question becomes: "Is the additional output provided the most efficient plan for producing additional output (Best-Buy Plan 2) worth its additional cost?"

The data from table C-7 is presented in Figure C-2. As the slope of the incremental cost curve becomes increasingly steeper between plans, the justification for the increase in cost may require closer examination and a stronger defense. This slope reflects the relative nature of the change in output (horizontal axis) and the rate of change in cost (vertical axis).

In this study, the slope increases at a relatively low rate as output increases from Plan 1 to Plan 10. Cost then begins to increase at a faster rate relative to the increase in output moving from Plan 11 through 13, and more dramatically following Plan 13.

**Table C-7: Skagit River Restoration Analysis**
**Incremental Cost Analysis - "Best-Buy Combinations"**

| | Plan | Incremental Cost | Incremental HUs | Total HUs | Incremental Cost Per HU |
|---|---|---|---|---|---|
| 0 | A0 B0 C0 D0 E0 F0 G0 H0 I0 J0 K0 L0 M0 | $0 | - | - | $0 |
| 1 | A0 B0 C0 D2 E0 F0 G0 H0 I0 J0 K0 L0 M0 | $2,126,020 | 1,088.6 | 1,088.6 | $1,950 |
| 2 | A0 B0 C0 D3 E0 F0 G0 H0 I0 J0 K0 L0 M0 | $1,491,570 | 493.6 | 1,582.2 | $3,020 |
| 3 | A0 B0 C0 D3 E0 F0 G0 H0 I0 J0 K0 L0 M3 | $3,419,830 | 860.0 | 2,442.2 | $3,980 |
| 4 | A0 B0 C0 D3 E2 F0 G0 H0 I0 J0 K0 L0 M3 | $16,741,780 | 1,619.7 | 4,061.9 | $10,340 |
| 5 | A0 B0 C0 D3 E2 F0 G0 H0 I0 J0 K0 L3 M3 | $8,393,770 | 802.7 | 4,864.6 | $10,460 |
| 6 | A0 B0 C0 D3 E2 F0 G0 H0 I0 J0 K3 L3 M3 | $4,326,410 | 406.2 | 5,270.8 | $10,650 |
| 7 | A0 B0 C0 D3 E2 F0 G0 H0 I3 J0 K3 L3 M3 | $12,385,390 | 962.6 | 6,233.4 | $12,870 |
| 8 | A0 B3 C0 D3 E2 F0 G0 H0 I3 J0 K3 L3 M3 | $17,132,380 | 970.0 | 7,203.4 | $17,660 |
| 9 | A0 B3 C0 D3 E3 F0 G0 H0 I3 J0 K3 L3 M3 | $29,842,030 | 1,523.6 | 8,727.0 | $19,590 |
| 10 | A0 B3 C0 D3 E3 F0 G0 H3 I3 J0 K3 L3 M3 | $5,006,710 | 242.7 | 8,969.7 | $20,630 |
| 11 | A0 B3 C0 D3 E3 F0 G0 H3 I3 J3 K3 L3 M3 | $7,084,440 | 229.8 | 9,199.5 | $30,830 |
| 12 | A0 B3 C3 D3 E3 F0 G0 H3 I3 J3 K3 L3 M3 | $37,199,590 | 609.8 | 9,809.3 | $61,000 |
| 13 | A0 B3 C3 D3 E3 F3 G0 H3 I3 J3 K3 L3 M3 | $10,779,880 | 154.5 | 9,963.8 | $69,770 |
| 14 | A3 B3 C3 D3 E3 F3 G0 H3 I3 J3 K3 L3 M3 | $57,714,460 | 349.3 | 10,313.1 | $165,230 |
| 15 | A3 B3 C3 D3 E3 F3 G2 H3 I3 J3 K3 L3 M3 | $16,064,870 | 96.9 | 10,410.0 | $165,790 |
| 16 | A3 B3 C3 D3 E3 F3 G3 H3 I3 J3 K3 L3 M3 | $40,132,800 | 159.9 | 10,569.9 | $250,990 |

**Legend:**

A = Britt
B = Browns
C = Carpenter
D = Deepwater
E = Dry
F = Edison
G = Gages
H = Hall
I = Indian
J = Joe Leary
K = No Name
L = Sullivan
M = Telegraph

0 = No Action
1 = Minimum Scale
2 = Moderate Scale
3 = Maximum Scale

**Skagit River Restoration Incremental Cost Analysis**
**Best Buy Combinations of Alternatives**

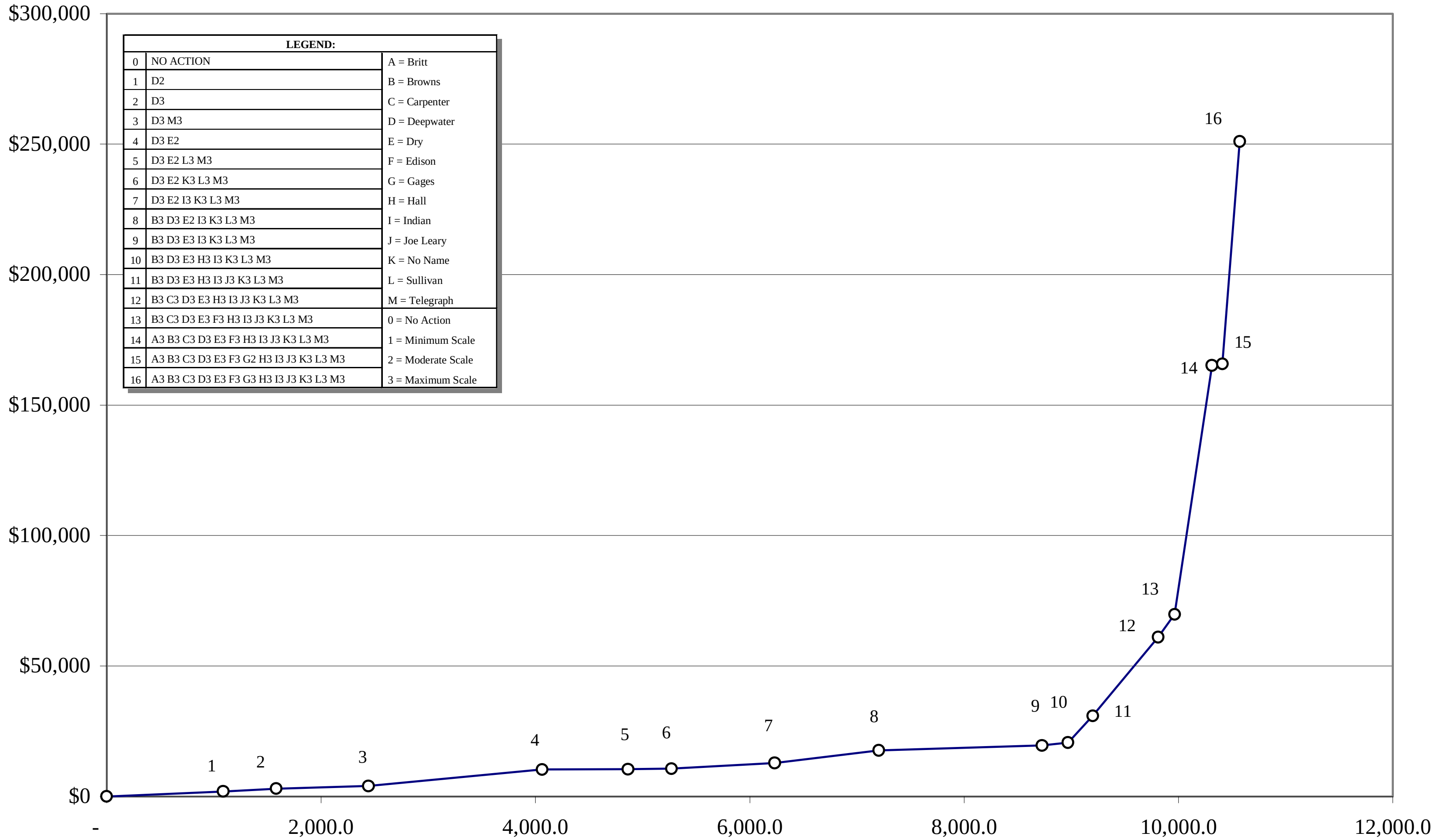


Figure C-2