**Application of the Skagit Watershed Council's Strategy**

# River Basin Analysis of the Skagit and Samish Basins: Tools for Salmon Habitat Restoration and Protection

Working Document
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Prepared by:

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## EXECUTIVE SUMMARY

This document represents the application of the Skagit Watershed Council's Salmon Habitat Restoration and Protection Strategy, which was adopted by the Council in 1998 (Skagit Watershed Council 1998). It has been developed to meet two major objectives: 1) identify where and to what extent the landscape processes that form and sustain salmon habitat are degraded in the Skagit and Samish River basins; and 2) identify specific actions to restore and protect salmon habitat in these basins, focusing on efforts to address the causes of habitat degradation rather than the symptoms. The document is organized around the landscape process screens developed in the Strategy.

For the first objective, we gathered the best available information on the existing conditions in the basin for each of these categories and used that information to identify where these processes were functioning, partially impaired, or impaired. For instance, the sediment supply screen used field-measured sediment budgets where available to determine if a sub-basin was impaired or functioning, based on its average sediment supply rate compared to the natural rate. Where field-based sediment budgets were not available, we used a combination of Geographic Information System (GIS) information on geology, vegetation, and land use to estimate the sediment supply rate. The same basic procedure was used for each of the landscape process screens. When available, field-collected information (e.g., an inventory of fish passage blockages) was used. If not, a combination of field and remotely sensed information (satellite images, for example) was used to estimate the level of impairment based on thresholds developed in the Strategy.

For each of these screens, we produced one or more maps and GIS layers that show the entire basin and the level of impairment that has been identified for that particular screen. There is, for example, a map of areas in the basin where we expect riparian conditions to be impaired. In the Isolated Habitat section, there is a map of the Skagit and Samish River delta that shows channels currently accessible to salmon as well as historical conditions. Our analysis found that only 44% of the historical channels remain accessible to salmon under present conditions. We describe the information and methods used to produce each of these maps and associated GIS layers, the expected use and limitations of that information, and the future work to improve that information.

By applying all these landscape screens together, we were able to identify salmon habitats in the basin that are functioning at or near historical conditions. That is, these habitats are critical to at least one salmonid life stage and are relatively undisturbed by man's activities. We call these habitats "key," and they are prime targets for protection efforts. In order to identify these habitat types, we also produced a map of the anadromous zone that shows the natural extent of salmon migration throughout the basin. Where landscape processes were determined to be partially impaired and impaired, we identified these habitats as "important," and "degraded," respectively. Habitat that is not used by anadromous salmon because it is disconnected through man-made blockages such as dikes, tide gates, or impassable road crossings, we identified as "isolated."

Important and degraded habitats are targets for restoration and isolated habitats are targets for reconnection.

The second main objective of this document is to produce a list of potential restoration and protection projects to address the habitat problems identified in the first section of the document. Using the habitat type identification and analysis described above, we were able to identify more than 400 individual potential projects organized in five categories: Sediment Reduction, Riparian, Isolated Habitat, Protection, and Feasibility Studies. The table below summarizes the results of our project identification efforts.

| **Project Type** | **Projects Identified** | **Future Work** |
|---|---|---|
| Sediment Reduction | Road decommissioning and storm proofing for all identified high and moderate-hazard roads at total estimated cost of nearly $12,000,000 | Complete road inventories to identify projects for entire basin, particularly for state and private roads. Implement sediment reduction projects. |
| Riparian | 122 riparian planting and fencing projects at total estimated cost of $1,687,000 | Complete field inventories for entire basin. Implement riparian projects. |
| Isolated Habitat | 229 fish-passage blocking structures identified. Total cost for fixing these blockages cannot be estimated without additional information. | Complete field inventories of barriers for rest of basin. Implement projects that fix these barriers. |
| Protection | Protection efforts directed toward critical habitat identified in document | Identify specific parcels for acquisition or easements consistent with SWC Strategy. |
| Feasibility Studies | Nearly 40 large restoration projects identified, primarily generated from data on isolated habitat in Skagit and Samish Delta. | Expand project identification to rest of basin using information in document and implement feasibility studies on high priority areas. |

The next step for the Skagit Watershed Council is to take the information and analyses presented in this document and develop an Action Plan - a long-term, strategic plan for the scientifically based and cost-efficient restoration and protection of salmon habitat in the Skagit and Samish River basins. Meanwhile, member organizations of the Skagit Watershed Council and others can use this document and the GIS data layers described in this document for identifying and implementing specific habitat restoration or protection actions.

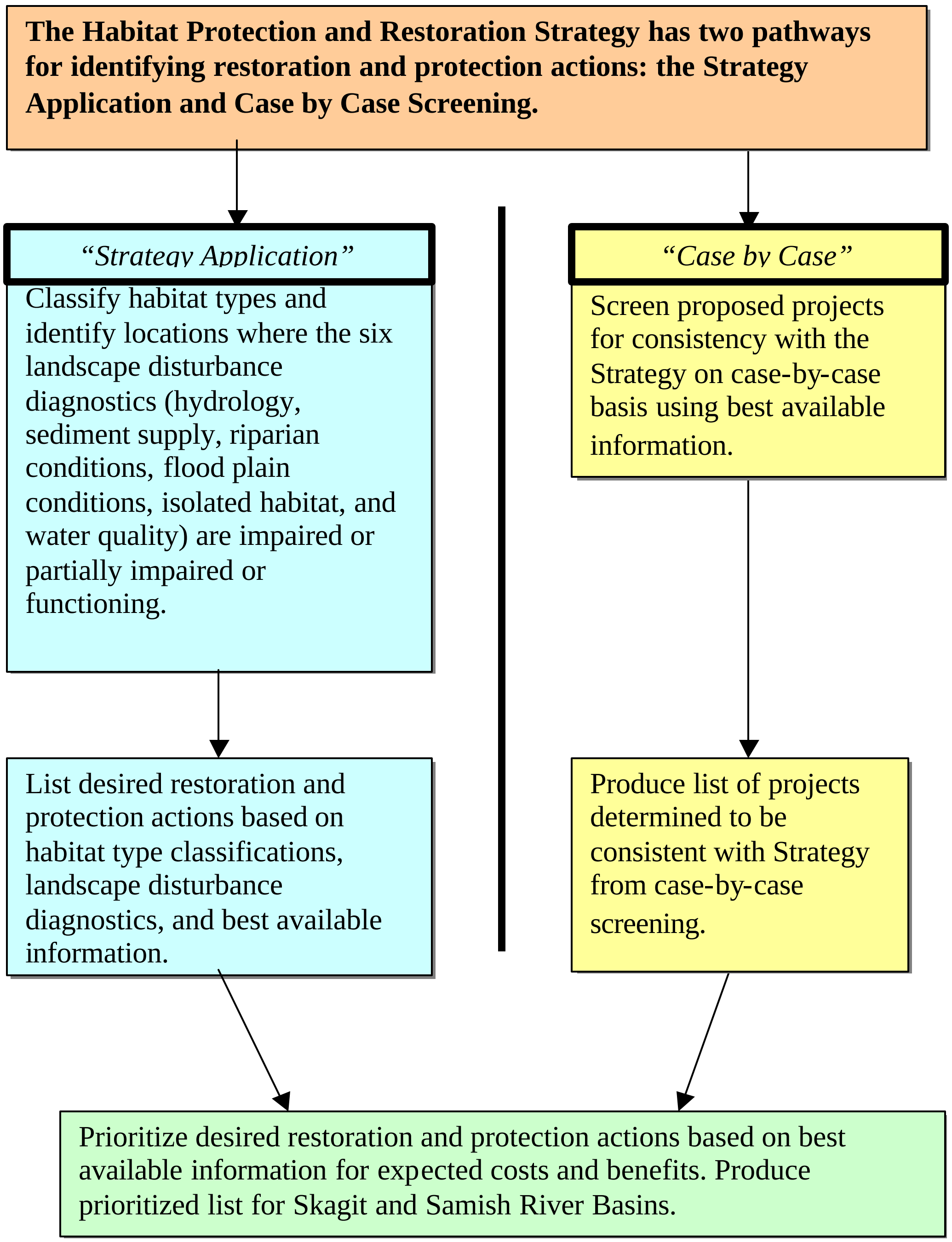
## 1.0 INTRODUCTION

In 1998, the Skagit Watershed Council (SWC) adopted a Salmon Habitat Protection and Restoration Strategy that recognizes the influence of land use and resource management activities on natural landscape processes (SWC 1998). The Strategy lays out a scientific framework and set of procedures for screening and prioritizing restoration and protection projects. The scientific framework used for restoration planning strives to identify: (1) the natural landscape processes active in a watershed, (2) the effects of land use on natural processes, and (3) the causal relationships between land use and habitat conditions. It focuses not on the symptoms of watershed degradation but on the fundamental causes, and encourages “restoration and protection of natural landscape processes that formed and sustained the habitats to which salmon stocks are adapted.” Restoration projects consistent with the goals of the Strategy aim to create the conditions necessary for natural processes to reestablish these factors at levels similar to those that existed historically. In addressing causes rather than symptoms, the Strategy should result in a high likelihood of success and ensure the most effective use of public and private restoration funds.

There are two pathways by which projects are added to the list of habitat restoration and protection projects for the Skagit River basin (Figure 1-1): the “Strategy Application” and “case-by-case screening. ” We develop the Strategy Application by systematically identifying land-use disruptions to processes that form salmon habitat. These processes include sediment supply, hydrology, riparian functions, channel-floodplain interactions, water quality, and fish access. Using a series of diagnostic screens, we locate disturbances to habitat-forming processes, and identify actions required to correct the disturbances. In case-by-case screening, we use the same process screens to evaluate proposed restoration projects, and we endorse those projects that are consistent with the Council’s objective of addressing the root causes of habitat degradation. Proposed projects that are consistent with our Strategy are added to the Council’s list of restoration and protection projects.

Development of the Strategy Application has two phases, both of which identify disturbances to watershed processes. In the first (interim) phase, we locate disturbed habitat-forming processes using a combination of existing Geographic Information System (GIS) data and field-based inventories. The second phase (to be largely completed over the next two years or so) relies solely on field-based inventories to identify disturbances to riparian functions, sediment supply, peak and low flows, channel-floodplain interactions, water quality, and blockages to salmon migration. Both phases rely on GIS to analyze and maintain landscape process data over the 8,544-km2 area of the Skagit and Samish River basins.

Figure 1-1. Overall Process Flowchart. Two pathways lead to habitat protection or restoration projects: (1) The “Strategy Application” applies all of the habitat-forming process screens to the river basin to identify and prioritize projects. (2) Case-by-case screening applies the screens to individually proposed projects to determine their consistency with the strategy.



For the first phase of the Strategy Application, we have used more than 30 different GIS themes and partial field inventories to apply 7 of the 8 landscape process screens identified in the Strategy (Table 1-1). The existing GIS themes provide low-resolution data covering the entire river basin. These data give us a good overview of habitat-forming processes in the entire basin or at the sub-basin level ($10\text{-}10^2$ $km^2$), but can give erroneous answers to our questions about specific reach level sites ($10^2\text{-}10^4$ meters linear scale). Field inventories provide high-resolution data, but with only limited coverage at present. Because field-inventories are more reliable at specific sites, the Council has made a long-term commitment to collecting field-based information basin-wide. Funding is currently secure for complete inventories of fish passage barriers and sediment budgets.

Table 1-1. Availability and uses of primary GIS themes in the Strategy Application.

| GIS Themes | Strategy Application: Landscape Screen Use? | Strategy Application: Develop Project List? | Case by Case: Landscape Screen Use? | Case by Case: Develop Project List? |
|---|---|---|---|---|
| Lowland Flooding (Section 2.2) | Yes. Reach level application | No. | Yes. Reach level application | No. |
| Mountain Basin Flooding (Section 2.2) | Yes. Sub-basin level application | No. | Yes. Limited sub-basin level application | No. |
| Low flow | Not available | No. | Not available | No. |
| Sediment Supply (Section 2.3) | Yes. Sub-basin level application | Yes. | Yes. Sub-basin level application | No. |
| Riparian (Section 2.4) | Yes. Limited reach level application | Yes. | Yes. Limited reach level application | No. |
| Floodplains (Section 2.5) | Yes. Limited mainstem level application | No. | Yes. Limited mainstem level application | No. |
| Isolated Habitat (Section 2.6) | Yes. Limited reach level application | Yes. | Yes. Limited reach level application | No. |
| Water Quality (Section 2.7) | Yes. Limited reach level application | No. | Yes. Limited reach level application | No. |

In Chapter 2 of this report, we describe each interim product, the methods used to construct each product, and their limitations for use. We also describe the Council's planned future work for each landscape process screen or project type. Chapter 3 describes how projects were identified and prioritized, and contains the interim list of salmon habitat protection and restoration projects. In the future an appendix to this Strategy Application will contain a list of the GIS themes used in its development. Each theme is described briefly, including a description of the theme, filenames, descriptions of relevant data fields, and other notes.

## 2.0 RESULTS OF SCREENING CRITERIA AND FIELD INVENTORIES THROUGHOUT THE SKAGIT AND SAMISH RIVER BASINS

This chapter describes the results of applying the landscape-level screening criteria to the Skagit and Samish River basins. Each section includes descriptions of the screening results, limitations of the analyses, methods used to generate the screen, and needed future work.

### 2.1 LOCATION OF ANADROMOUS FISH ZONE AND REACH LEVEL HABITAT TYPES

<u>Anadromous fish zone</u>

*Description and use of the anadromous zone map*
The anadromous zone polygons delineate the natural extent of salmon migration in the Skagit River basin (Figure 2-1-1). We included all areas below natural blockages to salmon migration (e.g., falls or steep cascades, Figure 2-1-2) as part of the natural anadromous zone. We also produced an arc theme that includes all stream reaches within the natural anadromous zone for subsequent analyses. This map is primarily used to distinguish stream reaches inhabited by salmon species from those that do not contain salmon species.

*Limitations*
The accuracy of the anadromous zone map is dependent primarily on the accuracy of the field notes and field maps upon which the barrier map was based. Points mapped as confirmed have a relatively high certainty that locations and descriptions are accurate. Points mapped as unconfirmed have low certainty the locations, descriptions, or both are accurate. Approximately 70% of the points are currently mapped as unconfirmed, indicating low overall certainty in barrier locations. However, locations of many unconfirmed barriers were only in question by a few tens to a few hundred meters, suggesting that boundaries of the anadromous zone will rarely change significantly as unconfirmed barriers are surveyed and confirmed in the future.

*Methods*
We created the anadromous fish zone polygons by first mapping all known and probable barriers on the GIS, and then “connecting” the natural barriers to create the anadromous zone polygons. Locations of confirmed barriers were based on stream maps or field notes in SSC files (e.g., measured distances from a known point). Locations of unconfirmed barriers were usually uncertain. Some were located based on WDFW stream catalogue, and others were approximated based on written or verbal descriptions. Some unconfirmed barriers had adequate location descriptions, but inadequate information on barrier type. In digitizing the anadromous zone polygon, we accounted for topography between points by digitizing over the USGS 30-meter digital elevation model or USGS digital raster graphics (DRG) of 7.5-minute topographic quadrangles. The completed anadromous zone polygons were then used to create a theme containing only streams within the anadromous zone by clipping the stream themes with the anadromous zone polygons.

*Future Work*
Future work includes field visits to sites that are unconfirmed at present. Data to be gathered for each site include exact location measured from a known point such as a road or highway, and a clear description of the barrier.

<u>Reach level habitat types</u>

*Description of the anadromous zone and reach level habitat type maps*
The reach-level habitat types are classifications of channel morphology that are related to salmon use. This map classifies only the types of stream channels, and does not include the estuary or main river types described in the Strategy. Reach-level habitat types are based on channel slope, with channel slopes estimated based on existing stream data and the 30-meter DEM from USGS (Figure 2-3). The most productive salmon habitats are typically found in channels with slope <4%.

*Limitations*
The accuracy of the reach-level habitat type map is a function of the accuracy of DEM-derived channel slopes and the unknown abundance of woody debris in stream reaches. The DEM-derived slopes will typically be steeper than the true slope (e.g., Montgomery and Buffington 1998), meaning that some channels identified as step-pool or cascade channels will actually be plane-bed, pool-riffle, or forced pool-riffle channels. Additionally, we do not know woody debris abundance for individual reaches, and therefore cannot accurately distinguish between plane-bed and forced pool-riffle channels. Lunetta et al. (1997) showed that the overall accuracy of a GIS-based slope classification system is 79% based on a comparison of GIS predictions to field data at 158 sites. Because we use a greater number of stream classes (5 compared to 3), overall accuracy for our predictions should be somewhat lower than 79%.

The reach-level habitat type map does not include the mainstem and estuary classifications. Each of those areas is mapped as a stream channel with a channel slope of <1%. However, channel and habitat characteristics of mainstem and estuary channels are quite different from those of tributaries with slope less than 1%. Therefore, the map should not be used to characterize habitats in the mainstem or estuary areas.

*Methods*
We based our classification of reach-level habitat types on a recent channel classification scheme and salmon use of different channel types. Montgomery et al. (1999) showed that some salmon species concentrate their spawning in forced pool-riffle and pool-riffle channels and avoid plane-bed and step-pool channels. In the absence of significant amounts of woody debris, channels with slope <1% are typically pool-riffle channels, and channels between 1% and 4% are typically plane-bed channels. Where woody debris is abundant and forms most pools in a reach, the channel is considered a *forced* pool-riffle channel. Forced pool-riffle channels occur at slopes <4%, overlapping the ranges of both pool-riffle and plane-bed channels (Montgomery and Buffington 1997). Step-pool generally have slopes between 4% and 8%, and cascade and bedrock channels have

slopes generally >8%. Channels steeper than 20% are often bedrock channels, and debris flows are the dominant sediment transporting mechanism.

Reach level habitat types were mapped by overlaying stream data on a digital elevation model to calculate channel slopes (Lunetta et al. 1997). The stream theme is the Washington Department of Natural Resources and USFS stream layers merged and edited by EPA (Lunetta et al. 1997). Channel slopes were estimated based on the USGS 30-meter digital elevation model.

*Future Work*

Slope measurements based on maps typically underestimate the slope of stream channels. Therefore, future work on tributary channel types will be a combination of map- and field-based confirmation of the classification of reach-level habitat types.

Mainstem and estuary habitat types cannot be classified by the same slope-based method as tributary channels. Future work will include field and aerial photo classification of those habitat types.

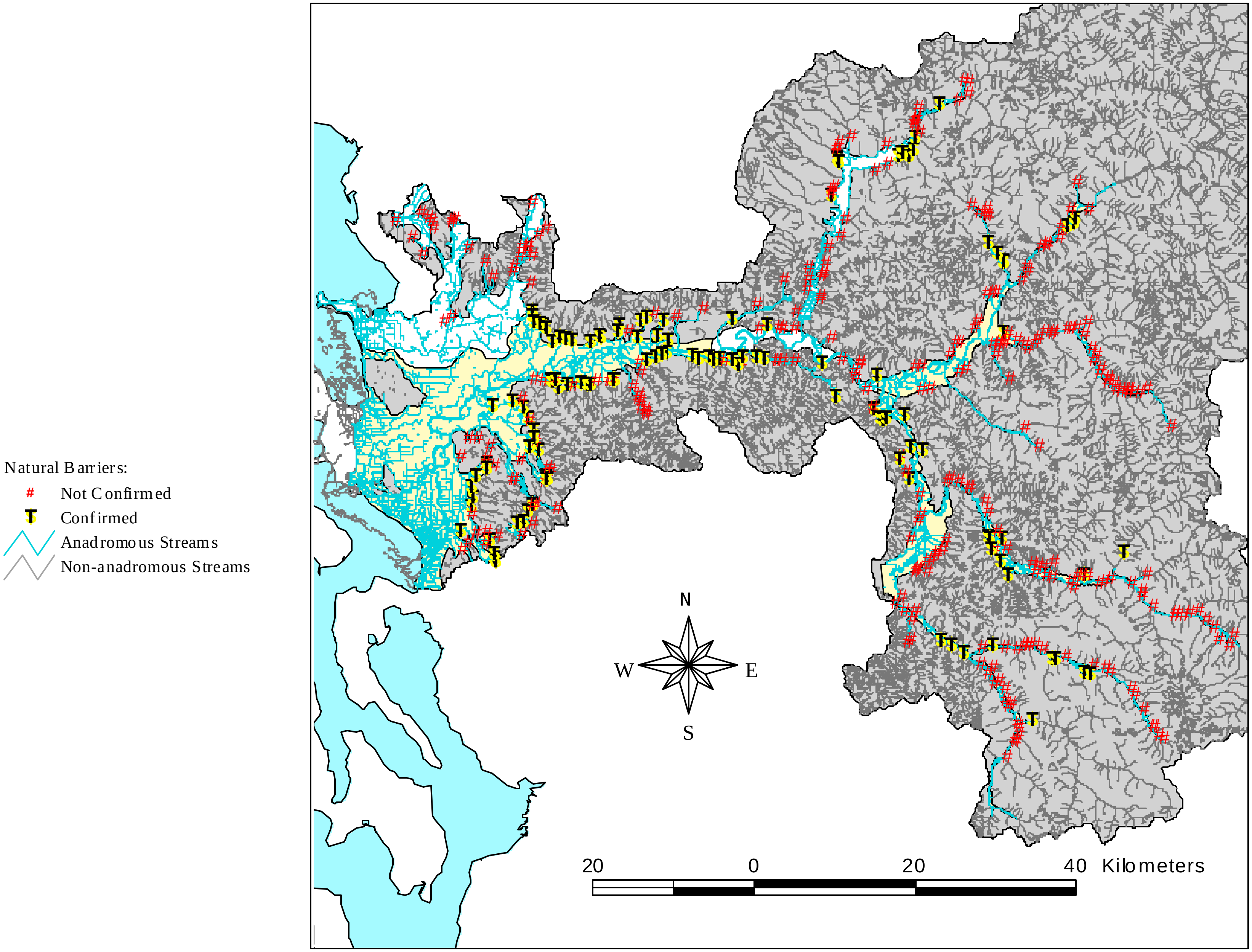



**Figure 2-1. Location of the anadromous zone and natural barriers in the Skagit and Samish River basins.**

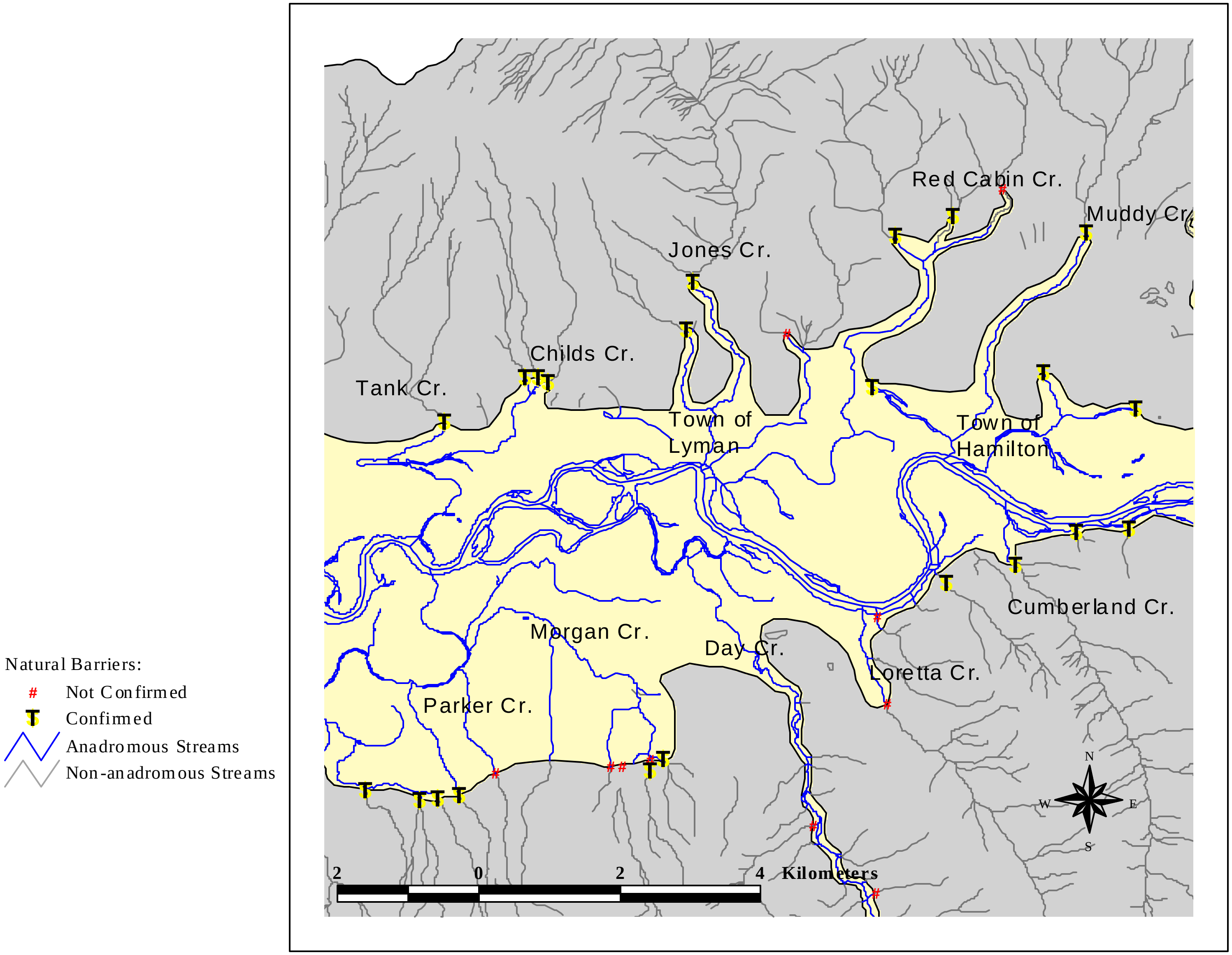



**Figure 2-2. Example of detail within anadromous zone and natural barriers GIS layers (Lyman area of the Skagit River).**

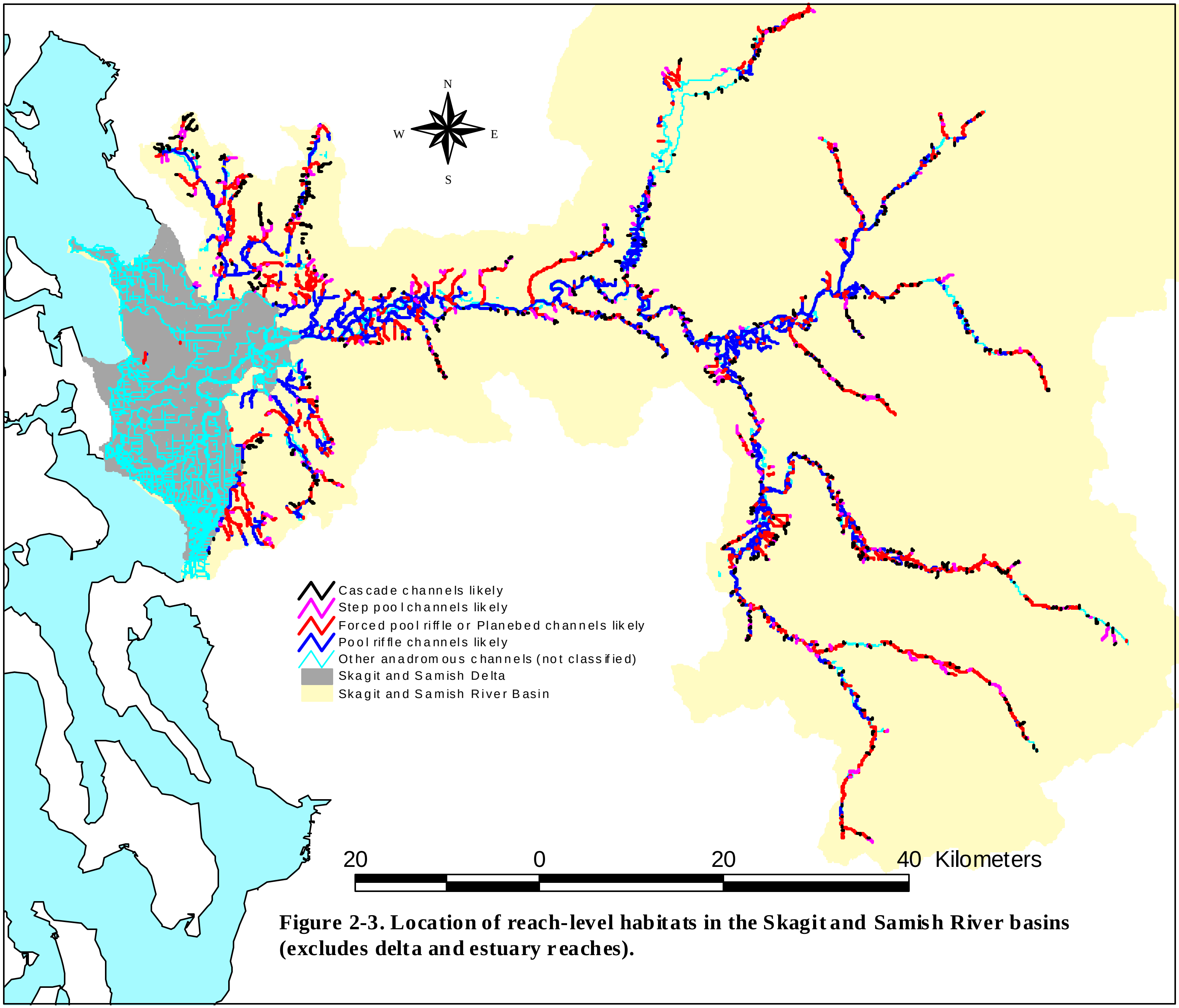



**Figure 2-3. Location of reach-level habitats in the Skagit and Samish River basins (excludes delta and estuary reaches).**

## 2.2 HYDROLOGY

### Peak Flow in Lowland Basins

*Description and use of the peak flow map for lowland basins*

As stated in the SWC Habitat Restoration and Protection Strategy, impervious area is used to evaluate disturbances to the hydrologic regime because comprehensive hydrologic records are not available. The Strategy states that reaches with watershed impervious area $\leq$ 3 % are considered functioning with respect to hydrology. Moderately impaired reaches have impervious watershed areas between 3% and 10%, and impaired reaches have impervious watershed areas greater than 10%. The peak flow map developed for the interim product shows stream reaches in the lowland basin rated as functioning, moderately impaired, or impaired based on the planned effective impervious area (EIA) percentage for the watersheds draining to those reaches (Figure 2-4). Functioning reaches are shown in blue, moderately impaired reaches are shown in green, and impaired reaches are shown in red.

The peak flow map is used for project screening where better information is not available, either in the form of field-collected hydrologic records or more accurate measures of EIA affecting the project area. Project proponents use this map to determine whether the proposed project reach is likely to be impaired due to disturbed hydrologic conditions. According to the Strategy, proponents of projects in impaired reaches need to show evidence that the work will not fail due to increased peak flows. The peak flow map and the planned EIA information that was used to develop this map can also be used to distinguish areas in need of restoration from areas in need of protection.

*Limitations*

The following are limitations of the interim product for lowland peak flows:

1) The EIA percentages used are based on land use categories for planned or future conditions in the basin (e.g., Skagit County Comprehensive Plan). They do not reflect existing conditions and are subject to the uncertainty associated with long-term planning on a county scale, as well as changing social and political conditions.
2) EIA percentages were not directly measured in this analysis. Rather, we extrapolated associations between EIA and land use derived from various investigations to the Skagit River basin (see the methods section below). Therefore, our analysis is subject to the assumptions and errors associated with these investigations.
3) The GIS analyses performed to produce these maps is limited by the resolution and accuracy of the data used. For instance, 30-meter Digital Elevation Model (DEM) data for the Skagit River basin was used for the hydrologic analysis, though higher resolution data (e.g., 10-meter DEMs) would likely provide a more accurate depiction of the hydrology of the basin.

*Methods*

We produced the interim peak flow map using an intersection of two ArcView GIS themes: the anadromous zone and a planned EIA theme classed into three categories of polygons: functioning (0-3%); moderately impaired (4-10%); and impaired (>10%). The resulting intersection allowed us to mark each stream reach into these same three categories.

To produce the planned EIA theme, we went through several steps outlined here. GIS data (both shapefiles and attribute tables) containing land use designations for the three counties (Skagit, Snohomish, and Whatcom) comprising the Skagit River Basin (WRIA 3 and WRIA 4) were obtained from the following sources:

1) Skagit County Mapping Department
2) Snohomish County Department of Information Services, GIS Division
3) Whatcom County Planning and Development Services

Working in ArcView 3.1, the county land use data layers were clipped using the WRIA 3 and WRIA 4 boundaries, creating five shapefiles corresponding to the areas of each county within WRIAs 3 and 4. We have two shapefiles for Skagit County (WRIA 3 and 4), two for Whatcom County (WRIA 3 and 4), and one for Snohomish County (WRIA 4).

Using the Skagit County Comprehensive Plan (1997), the Snohomish County General Policy Plan (1999), Snohomish County Title 18 Zoning Ordinance (1999), the Whatcom County Comprehensive Plan (1997), and the Whatcom County Title 20 Zoning Ordinance (1998), information was obtained on the density units per acre associated with the land use designations contained in the GIS layers obtained from the counties. The analysis focused strictly on the area of each of the counties that lies within the Skagit River Basin (WRIAs 3 and 4).

Within the attribute tables for the five shapefiles, an EIA percentage was assigned to each of the county land use designations based on associations between EIA and land use designations (e.g., forest, agriculture) and, where available, density units per acre (e.g., 1 density unit per acre) from the literature (Booth and Jackson 1997; Dinicola 1989). The associations used for this analysis for the three counties are summarized in Table 2-2-1.

The shapefiles with the EIA data were joined and then converted to Arc/Info polygon coverages, and then converted to Arc/Grid coverages using the impervious percent values for each cell. Cell size was set to 98.45 feet to match the 30-meter data used for the elevation analysis. The shapefiles did not join perfectly, and slivers were filled on screen by using the value of surrounding cells. A 30-meter DEM was provided by the University of Washington PRISM program, and was clipped to have the same extent as the impervious data (i.e., WRIA 3 and 4). Sinks (areas that do not flow out of a cell or group of cells, and are most commonly errors in the data) were filled in as a correction to the elevation data. The direction of flow was calculated for every cell in the watershed based on the slope of adjoining cells. The flow direction data was used to calculate the total impervious area that flows to a cell, and the total area that flows to a cell. By calculating a ratio of these two grid coverages the percent impervious area that flows to a cell (i.e., percent impervious within the watershed of a cell) was determined. Cells that are topographic ridges have no flow and were calculated as “no data,” which was felt to be misleading, so these cells were given the value of the original percent impervious land cover for that cell. The percent impervious within the watershed grid was converted to a polygon coverage with integer values classed into three categories: 1) Functioning, 0-3% EIA; 2) Moderately Impaired, 4-10% EIA; and 3) Impaired, >10% EIA. Finally, the stream reaches were classed into these categories by intersecting the hydrology theme and the planned EIA theme, as discussed above.

*Future Work*

There are a variety of methods to quantify EIA for hydrologic analysis and watershed planning (May et. al. 1997). The method we used for the interim product has a number of limitations, as discussed above. One limitation is that we produced a map of planned EIA rather than current EIA. A map of current EIA would be very helpful for both project screening and project identification. We plan to produce a peak flow map based on current EIA using a combination of recent satellite imagery and aerial photos. Such a map will entail classifying land cover based on interpretations of these images, for which a variety of methods exist. We will explore these methods and determine the best option for our needs and proceed to improve our disturbed hydrology maps and analysis. Preferably, future restoration planning will incorporate field-collected hydrologic records as well as field-verified hydrologic modeling.

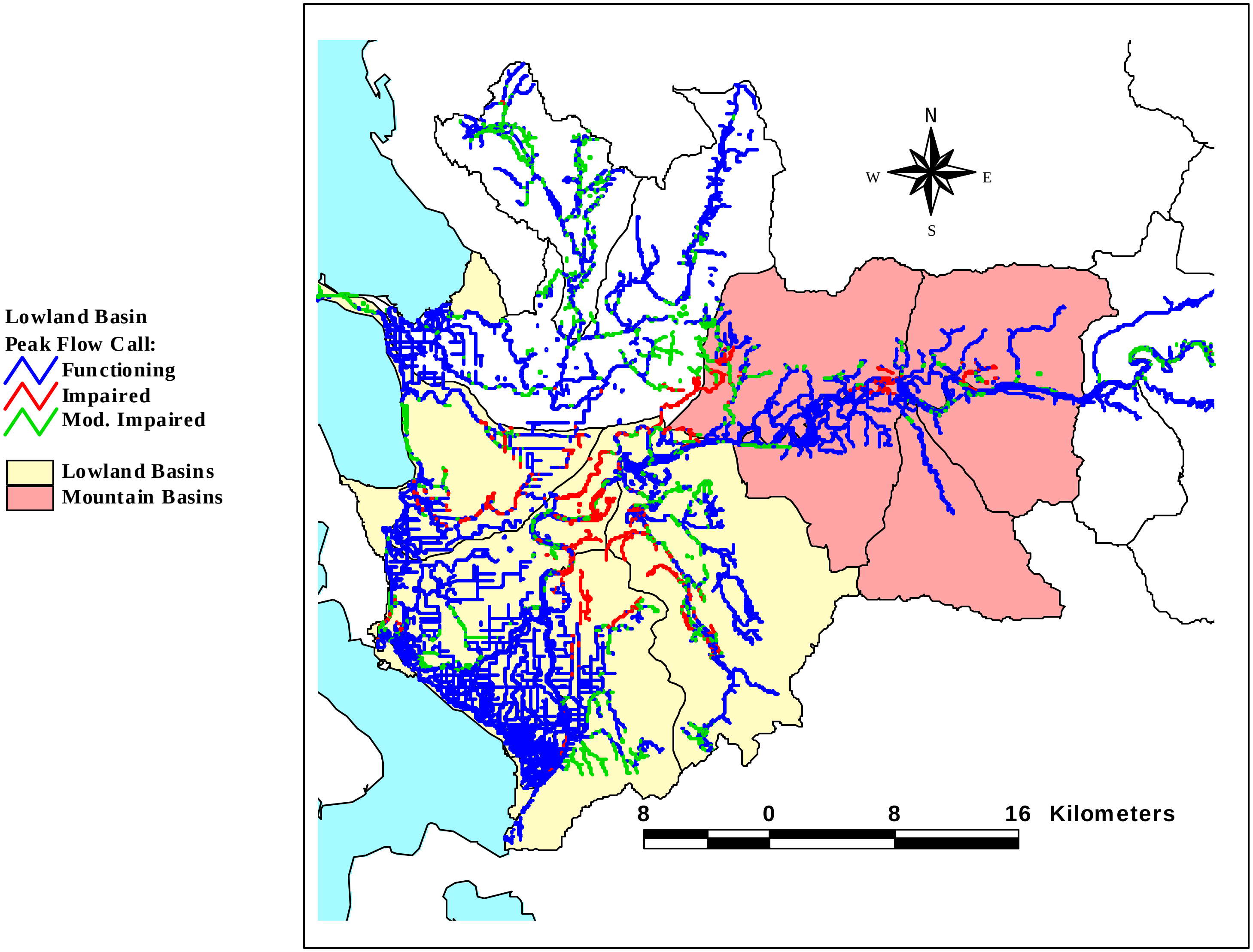



**Figure 2-4. Peak flow ratings in lowland basins based on planned effective impervious area (EIA).**

Table 2-1-1. Relationship between county land use designations and Effective Impervious Area (EIA) used for peak flow hydrology analysis.

| **County Land Use Designation** | **Maximum Density** | **EIA% Used for Analysis** |
|---|---|---|
| | | |
| SKAGIT COUNTY: 1997 Skagit County Comprehensive Plan | | |
| Incorporated | 15 units per 1 acre residential | 86 [a] |
| Urban Growth Area | 4+ units per 1 acre (average) | 24 [a] |
| Rural Village | 1 unit per 1 acre | 10 [a] |
| Rural Intermediate | 1 unit per 2.5 acres | 4 [a] |
| Rural Reserve | 1 unit per 5 acres | 4 [a] |
| Rural Resource | 1 unit per 10 acres | 3 [b] |
| Agriculture | 1 unit per 40 acres | 2 [c] |
| Industrial Forest | 1 unit per 80 acres | 2 [c] |
| Secondary Forest | 1 unit per 20 acres | 2 [c] |
| National Forest | Not specified | 2 [c] |
| National Park | Not specified | 2 [c] |
| | | |
| SNOHOMISH COUNTY: General Policy Plan (1999); Title 18 Zoning Ordinance (1999) | | |
| Urban Industrial | Not specified | 86 [a] |
| Incorporated City Area | Not specified | 86 [a] |
| Urban High Density | 12-24 units per acre | 86 [a] |
| Urban Commercial | Not specified | 86 [a] |
| Urban Med. Density Residential | 6-12 units per acre | 48 [a] |
| Rural Industrial | Not specified | 48 [a] |
| Urban Low Density Residential | 4-6 units per acre | 24 [a] |
| Rural Residential - 5 | 1 unit per 5 acres | 4 [a] |
| Rural Residential - RD | 1 unit per 5 acres | 4 [a] |
| Rural Residential - RR | 1 unit per 5 acres | 4 [a] |
| Rural Residential -10 | 1 unit per 10 acres | 3 [b] |
| Forest Transition Area | 1 unit per 10 or 20 acres | 3 [b] |
| Low Density Rural Residential | 1 unit per 20 acres | 2 [b] |
| Commercial Forest | 1 unit per 80 acres | 2 [c] |
| National Forest Land | Not specified | 2 [c] |
| | | |
| WHATCOM COUNTY: Whatcom County Comprehensive Plan (1997); Title 20 Zoning Ordinance (1998) | | |
| Tourist Commercial | Not specified | 86 [a] |
| Neighborhood Commercial | Not specified | 86 [a] |
| Recreation Open Space | Not specified | 10 [a] |
| Rural Residential 2 | 2 units per acre | 10 [a] |
| R2A-Rural | 1 unit per 2 acres | 4 [a] |
| R5A-Rural | 1 unit per 5 acres | 4 [a] |
| R10A-Rural | 1 unit per 10 acres | 3 [b] |
| Agriculture | 1 unit per 40 acres | 2 [c] |
| Rural Forest | 1 unit per 20 acres | 2 [c] |
| Commercial Forest | 1 unit per 40 acres | 2 [c] |
| National Forest | Not specified | 2 [c] |
| National Park | Not specified | 2 [c] |
| National Recreation Area-Federal | Not specified | 2 [c] |
| Wilderness Area | Not specified | 2 [c] |

a: Dinicola 1989; Booth and Jackson 1997; b: estimate based on Dinicola 1989, Beyerlein 1996;
c: estimate based on WDF (199x), road density calculations for representative sub-basins in Skagit County

Peak Flow in Mountain Basins

*Description and use of the interim peak flow map for mountain basins*
The peak flow map for mountain basins displays estimated alterations to peak flows in mountain basins due to changes in rain-on-snow runoff and extensions of drainage networks due to roads. All ratings are averaged by WAU, and based on existing GIS data for roads and land cover. Because data to identify the flood history for unregulated mountain sub-basins in the Skagit is very limited, peak flow ratings were developed based on an empirical correlation between land use and elevated peak flows in the North Fork Stillaguamish River basin, where a significant increase has been observed (see methods section). Ratings are based on land cover and road density results from the North Fork Stillaguamish River basin. WAUs with more than 50% area in hydrologically immature vegetation due to land-use and more than 2 $km/km^2$ of roads were considered *very likely impaired*. WAUs exceeding only one of the criteria were considered *likely impaired*. Remaining WAUs were considered *functioning*. Floodplain reaches were rated based on the weighted average of contributing WAUs (not including WAUs upstream of dams because of flood storage capability) (Figure 2-7).

This map is used in screening projects presented to the Skagit Watershed Council for endorsement and identifying generalized habitat areas (Section 2.8). The use of this screen for project endorsement should be limited to ensuring that designs of downstream, reach-level projects will withstand the likely elevated peak flows in impaired basins. It should not be used to stop projects in reaches that are rated impaired until further validation work is completed.

*Limitations*
The ratings are based on the assumption that elevated peak flows in the North Fork of Stillaguamish River are caused by changes in proportions of hydrologically immature vegetation and increases in road densities. However, it is not clear that there is a cause-effect relationship in the Stillaguamish River data. We believe the assumption is reasonable based on our understanding of peak flow and land use, but it has not been not explicitly tested through any scientific study.

Additionally, the roads theme upon which the screen is based is known to be incomplete and inaccurate in many areas. Because the road densities are inaccurate, it is important that road data used to apply the screen are the same data as those used to develop the screen. We have used the same DNR roads theme for both steps, and have therefore minimized errors to the extent possible with existing data.

*Methods*

The Strategy assumes channels are “peak flow impaired” in forested mountain basins when the 2-year flood magnitude under disturbed conditions equals or exceeds the 5-year flood magnitude under natural watershed conditions. The Strategy cites two common causes of increased peak flow: hydrologically immature vegetation and forest road drainage (e.g., Montgomery 1993, Washington Forest Practices Board 1995).

We tried to apply the Strategy's diagnostic with existing data and found that data to identify changes in peak flow are very limited (Table 2-2-1). Out of six gaged sites with long-term records, only three are unregulated basins (i.e., not influenced by flood storage capability). None of the unregulated basins showed a significant increasing trend in annual peak flow over their period of record using regression analysis (alpha level at 0.05).

Table 2-2-1. Currently operating gages with a long period of record in the Skagit River basin. Flow data from other gages in the Skagit Basin were not examined because the period of record was too short. Data were retrieved from USGS Web page.

| USGS Gage | Period of Record (Water Year) |
|---|---|
| Skagit River near Mount Vernon***** | 1941-present |
| Skagit River near Concrete***** | 1925-present |
| Skagit River near Marblemount***** | 1947-1957, 1977-present |
| Sauk R. above Whitechuck (Upper Sauk) | 1918-1922, 1929-present |
| Sauk River near Sauk (Lower Sauk) | 1912, 1929-present |
| Newhalem Cr. (Upper Skagit Tributary) | 1961-present |

***** gage sites influenced by flood storage capability.

Additionally, annual peak flows in the Skagit River Basin have changed since flow regulation through the construction of reservoirs capable of flood storage. Before flood storage capability, floods in the lower Skagit River commonly approached or exceeded 200,000 cfs (Figure 2-5.). Floods in water years 1815 and 1856 were estimated at 400,000 and 300,000 cfs, respectively (not shown in Figure 2-5). Since the advent of flood storage capability, a flood approaching 200,000 cfs has not yet occurred. Log-Pearson III analysis shows that the number of floods between the 2-year and 100-year return period has been reduced by roughly 50% since dams were built on the Skagit and Baker Rivers (Table 2-2-2).

Table 2-2-2. Magnitude of peak flows by return period for the Skagit River. Estimates for the period prior to flood storage capability on the Skagit are from a gage near Sedro Woolley, reported in Williams et al. (1985). Estimates for the period after flood storage capability are from USGS (1997) using data from the gage near Mount Vernon (years 1941 – 1996).

| Flood Return Period (years) | Before Flood Storage (gage near Sedro Woolley) | After Flood Storage (gage near Mount Vernon) |
|---|---|---|
| 2 | 111,145 | 64,640 |
| 5 | 167,218 | 87,560 |
| 10 | 207,020 | 103,600 |
| 25 | 259,954 | 125,000 |
| 50 | 301,145 | 141,800 |
| 100 | 343,743 | 159,200 |

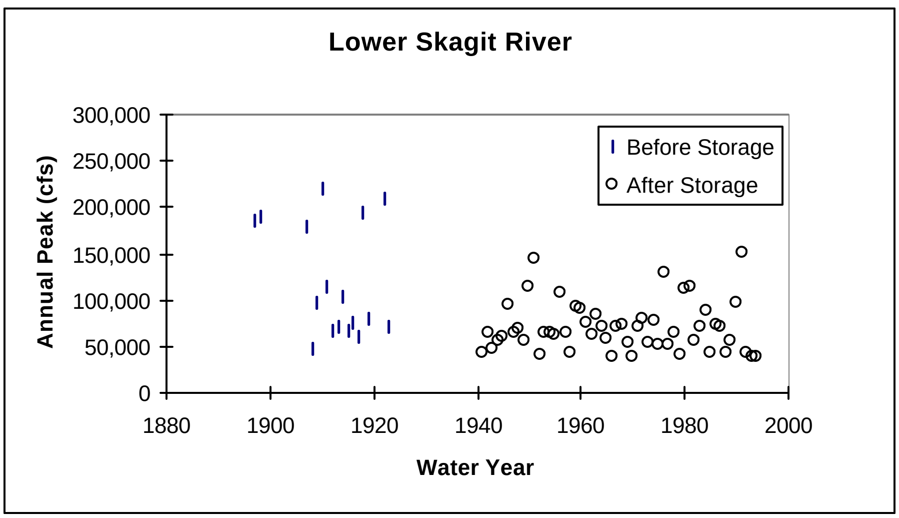



Figure 2-5. Annual peak flow in the Lower Skagit River before and after flood storage capability in the basin. Solid diamonds represent flows taken at Sedro Woolley (River mile 22.4). Open circles represent flows taken near Mount Vernon (River Mile 15.7). Only one major tributary (Nookachamps Creek) enters the Skagit between the two gage sites.

Because data to identify the flood history for unregulated mountain sub-basins in the Skagit is very limited, peak flow ratings were developed based on an empirical correlation between land use and elevated peak flows in the North Fork Stillaguamish River basin, where a significant increase has been observed (Figure 2-6). Ratings are based on land cover and road density results from the North Fork Stillaguamish River basin. WAUs with more than 50% area in hydrologically immature vegetation due to land-use and more than 2 $km/km^2$ of roads are rated *very likely impaired*. WAUs exceeding one or the other of the criteria are considered *likely impaired*. WAUs that do not exceed either criterion are considered *functioning*. Floodplain reaches were rated based on the weighted average of contributing WAUs, not including WAUs upstream of dams because of flood storage capability.

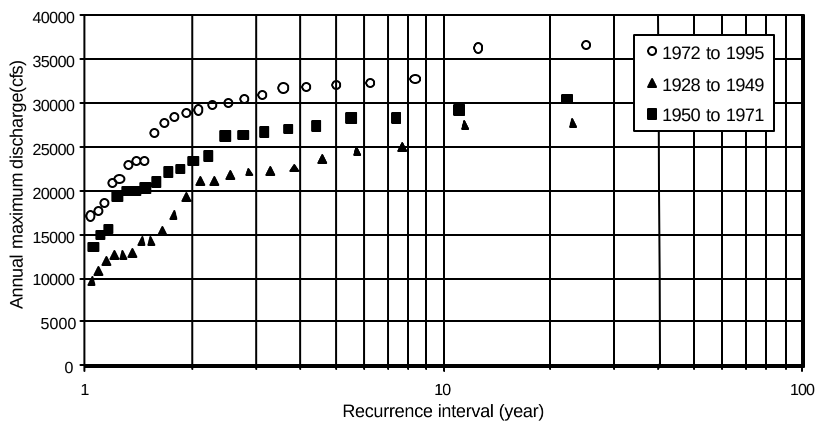



Figure 2-6. Trend in flood magnitude for the North Fork Stillaguamish River (from Beamer and Pess 1999)

*Future work*

We must first confirm that the correlations between land use and peak flows in the North Fork Stillaguamish are a cause-effect relationship, and then identify the appropriate thresholds for land use. Three steps are needed:

(1) Confirm that the trends in peak flow are not caused by an increasing trend in precipitation.
(2) Confirm that the North Fork Stillaguamish peak flow trend is positively correlated with the increasing immature vegetation percentage and/or road density.
(3) Assuming that (1) and (2) are confirmed, identify land-use thresholds for impaired peak flow hydrology.

Additional work should include long-term efforts to gage representative unregulated sub-basins in the Skagit River basin. Three sub-basins have been gaged in 1998: Bacon, Finney, and Illabot Creeks. These efforts should continue.

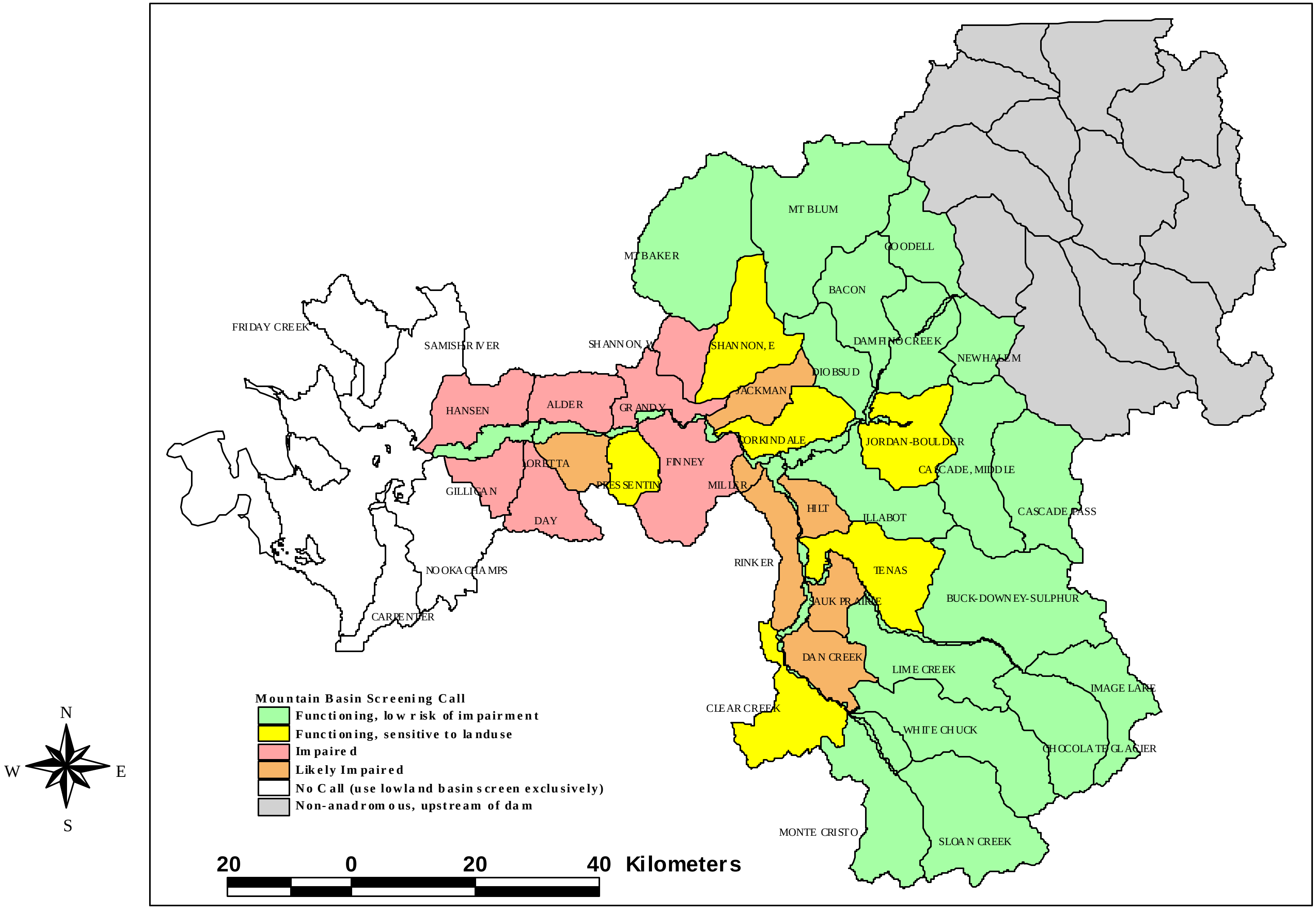



**Figure 2-7. Map of areas where peak flow in mountain basins are likely impaired or functioning.**

## 2.3 SEDIMENT

<u>Basin-wide characterization of sediment supply</u>

*Description and use of the sediment supply map*

As stated in the SWC Habitat Restoration and Protection Strategy, the sediment supply process is rated *functioning* where average sediment supply is <100 $m^3/km^2/yr$. Where average sediment supply is >100 $m^3/km^2/yr$, but is <1.5 times the natural rate, the sediment supply process is also rated *functioning*. Where average sediment supply is >100 $m^3/km^2/yr$ and is >1.5 times the natural rate, the sediment supply process is rated *impaired*. The sediment supply map developed for the interim product (Figure 2-8) shows the ratings for sediment supply averaged across WAUs. Areas shown in red are rated impaired; areas shown in green are rated functioning.

The sediment supply map is used for project screening where field-based sediment budgets are not available, as well as for planning watershed-level sediment reduction projects. For project screening, project proponents use this map to determine whether the proposed project area is likely to have an impaired (i.e., high) sediment supply. For planning of watershed-level sediment reduction projects, this map distinguishes areas in need of restoration from areas in need of protection.

*Limitations*

The method correctly estimated the sediment supply rating for 7 of the ten sub-basins where sediment budget data were available (Table 2-3-1). It over-estimated average sediment supply for 2 of the 10 test basins (i.e., rated them impaired when they are functioning), under-estimated sediment supply for one sub-basin. Some of the error may be due to the fact that the model estimates sediment supply for the entire WAU, whereas six of the ten field-based sediment budgets covered only sub-watersheds within a WAU.

Mass wasting rates are more strongly related to landform than to geology. However, our method does not incorporate landform in estimating sediment supply because but we had no automated procedure for identifying landforms on GIS. Nevertheless, geology and landform are correlated in the Skagit River basin (e.g., there tends to be a small proportion of steep inner gorges in surficial deposits and a high proportion in high-grade metamorphic rocks), and the method remains reasonably accurate.

Land-use intensity is based on Landsat data that poorly distinguish areas of low root strength (i.e., forests less than 20 years old) from mature hardwoods. Therefore, land-use categories do not accurately represent the proportion of forests less than 20 years old, and do not explicitly incorporate road areas.

Table 2-3-1. Error matrix comparing sediment supply ratings from field-based sediment budgets to ratings based on GIS estimates.

| | Field-based sediment budget | | | |
|---|---|---|---|---|
| GIS estimate | Functioning | Impaired | % correct | % commission |
| Functioning | 4 | 1 | 80% | 20% |
| Impaired | 2 | 3 | 60% | 40% |
| % omission | 67% | 75% | | |

Overall percent correct = 70%

*Methods*

We analyzed average sediment supply for each WAU based on the intersection of three ArcView GIS themes: geology, vegetation (LANDSAT '93), and WAUs. The geology theme displays four general lithologic groups (alluvium, surficial deposits, low-grade metamorphic and sedimentary rocks, and intrusive and high-grade metamorphic rocks) based on the Washington Division of Geology and Earth Resources 1:100,000-scale geology theme. The vegetation theme is based on the 1993 LANDSAT theme used in Lunetta et al. (1997). It includes four vegetation classes, one water class, one non-forest land use class, and one natural non-forest class. The WAU theme outlines boundaries of Watershed Administrative Units (WAUs).

We intersected the three themes in ArcView GIS to create a single theme of polygons containing data on WAUs, lithologic type, and vegetation class. We then estimated sediment supply rate for each polygon based on the natural rate of sediment supply for a given lithologic group, multiplied by a land-use factor (Figure 2-9). We used average sediment supply rates from Paulson (1997) to estimate the "natural" rate of sediment supply by geology. We used vegetation cover class (Lunetta et al. 1997) to estimate the relative increase in sediment supply due to land use (timber harvest and roads) based on Paulson (1997). Natural rates and land use factors shown in Table 2-3-2. In equation form, each polygon has a sediment supply rate calculated as:

Total sediment supply rate = (natural sediment supply rate) x (land use factor).

The estimated current sediment supply from each polygon is then (total sediment supply rate) x (area), and the estimated natural sediment supply is (natural sediment supply rate) x (area). From these estimates we calculated average current sediment supply from the WAU, and the average increase over the natural sediment supply for each WAU (current/natural).

*Future Work*

Field-based sediment budgets more accurately estimate the sediment supply in a basin, and describe the relative effects of different land uses on sediment supply. Therefore, they will provide more accurate information for project screening and planning. Skagit System Cooperative will complete field-based sediment budgets for WAUs delivering sediment to the Skagit River basin anadromous zone (5665 $km^2$) over the next 2 years.

Field-based sediment budgets have been completed for approximately 12% of the total area to date (Paulson 1997). Field-based sediment budgets for an additional 1531 $km^2$ (27%) are scheduled for completion by November of 1999.

The Council also anticipates future development of a surface erosion and sedimentation screen for low-slope areas. This screen will focus on quantifying surface erosion from agricultural or developed areas, and will most likely be based on soil characteristics, rainfall, and hillslopes.

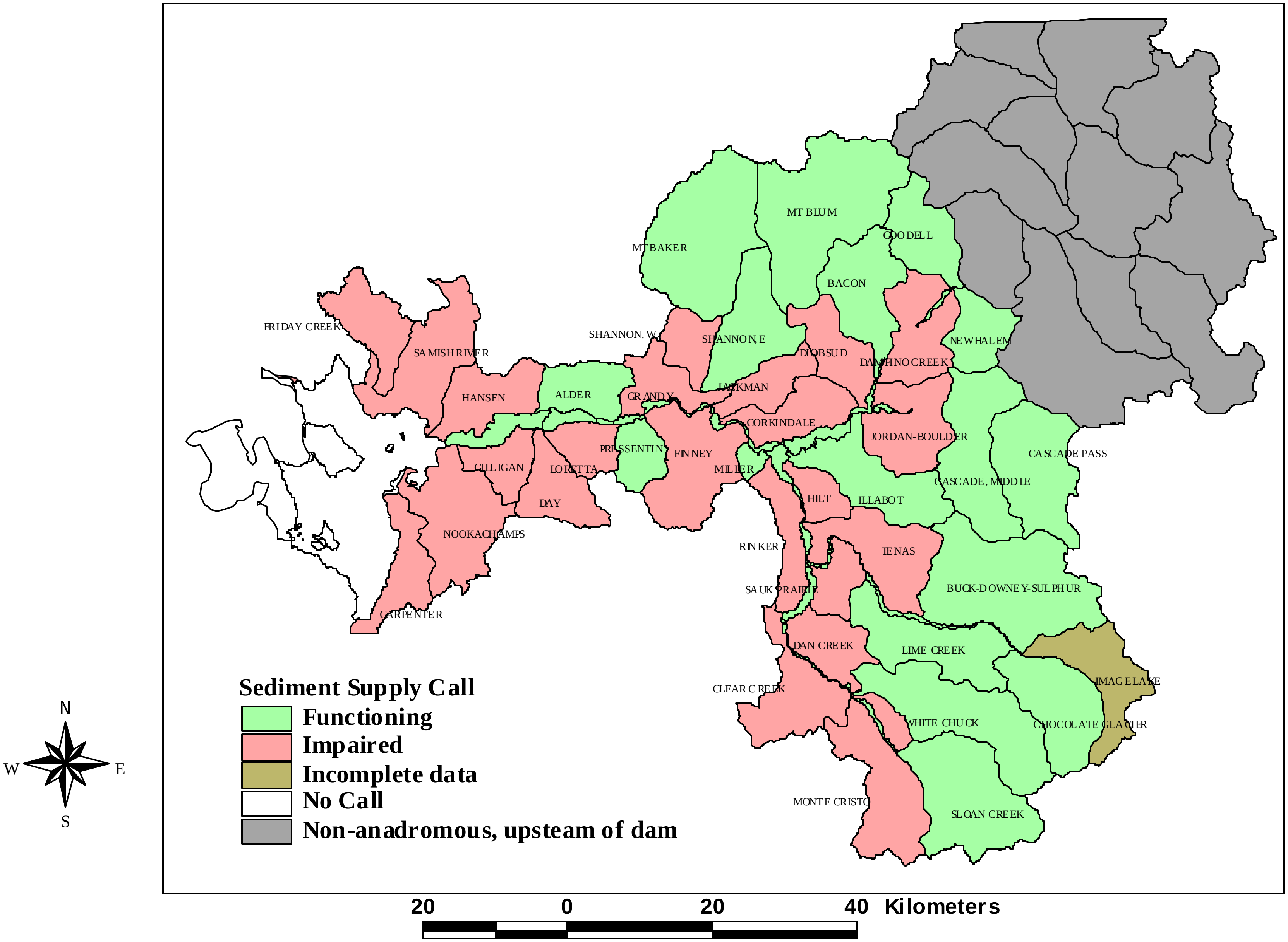



**Figure 2-8. Map of WAUs where sediment supply is likely impaired or function.**

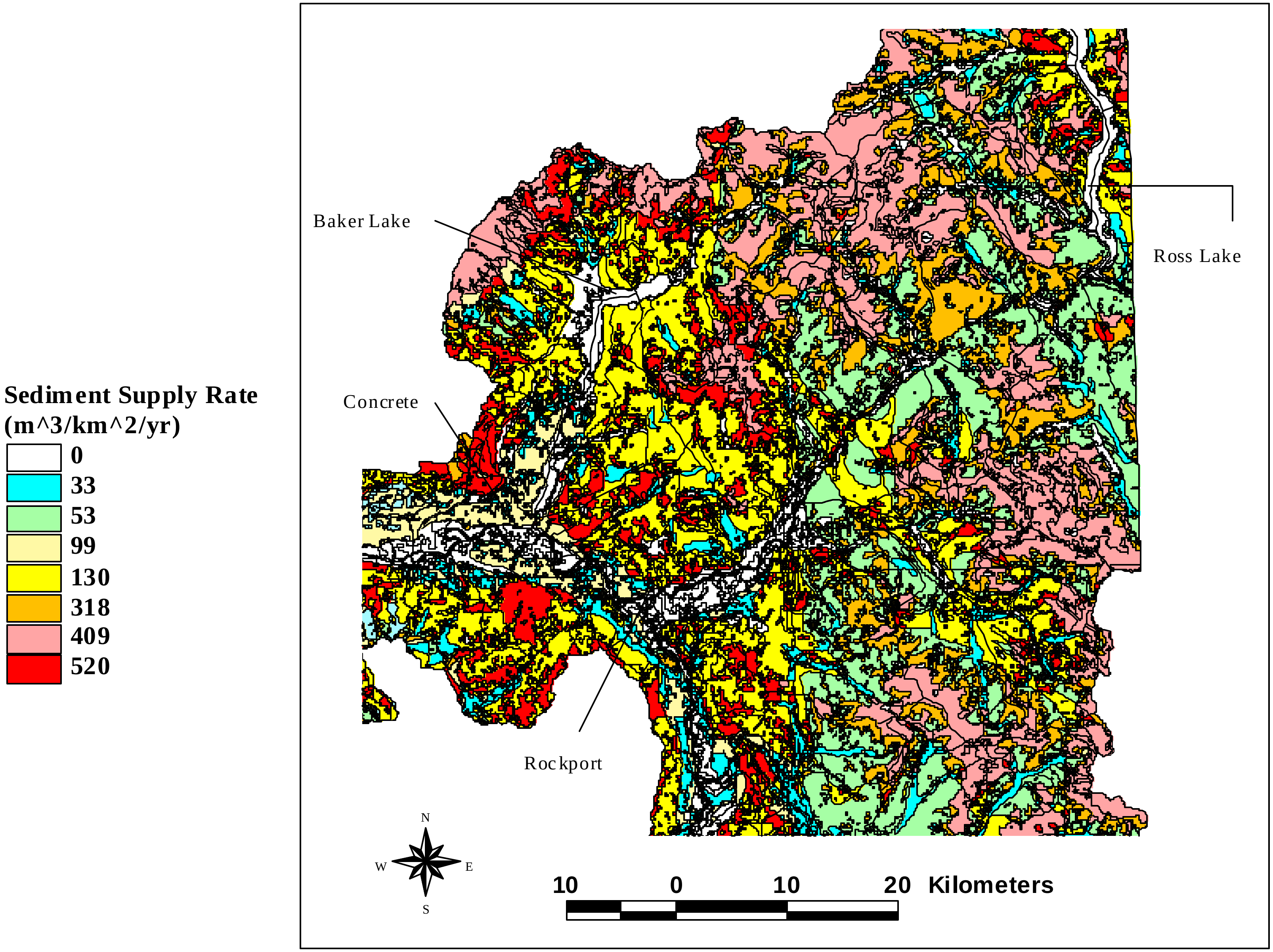



**Figure 2-9. Estimated sediment supply rates based on geology and land cover (example showing Upper Skagit River basin).**

Table 2-3-2. Average sediment supply rates and vegetation factors used in estimating current sediment supply and changes from natural sediment supply for each WAU in the Skagit River basin.

| | Lithologic group | | | | |
|---|---|---|---|---|---|
| | All rock types/alpine (applied only to vegetation class 16) | Alluvium | Surficial deposits | Low-grade metamorphic | High-grade metamorphic |
| Natural sediment supply rate ($m^3/km^2/yr$) | 409[a] | 0[b] | 33[c] | 130[d] | 53[e] |
| Land use factor for early-seral, mid-seral and late-seral. | NA | 1 | 1 | 1 | 1 |
| Land use factor for other forest (clear-cut to hardwood). | NA | 1 | 3[f] | 4[f] | 6[f] |
| Land use factor for vegetation water and non-forest. | NA | 0 | 0 | 0 | 0 |
| Land use factor for alpine areas, rock outcrops, glaciers. | 1 | NA | NA | NA | NA |

a. Average sediment supply rate from granitic rocks in alpine areas, New Zealand. Region has annual precipitation similar to that of the upper Skagit basin, and granitic rocks are prevalent in the upper Skagit basin.
b. Alluvial areas are predominantly floodplains. No mass wasting occurs.
c. Sediment supply rate for forest >20 years old in a sub-basin dominated by glacial sediments (Paulson 1997).
d. Sediment supply rate for forest >20 years old in 3 sub-basins dominated by phyllite and sandstone (Paulson 1997)
e. Sediment supply rate for forest >20 years old in sub-basins dominated by granitic and high-grade metamorphic rocks (Paulson 1997).
f. Relative increase in mass wasting rate where forests are less than 20 years old (Paulson 1997).

<u>Identification of road sediment reduction projects</u>

*Description and use of the road projects map*
The U.S. Forest Service has inventoried much of its road network in the Skagit River basin and rated the probability that various roads will cause landslides and subsequently damage important fish habitat. The inventory method combines ratings of factors that influence road-related landslides with ratings of the consequences of landslides. The final value, called the risk rating, ranks roads with respect the threat that they pose to salmon habitat. Higher risk ratings indicate greater chance that a road will fail and impact salmon habitat. Final ratings were grouped into three categories of risk in order to help identify and prioritize roads for sediment reduction projects (Figure 2-10).

We will focus initial sediment reduction projects on the high-risk and moderate-risk road segments. We prioritized WAUs by comparing the total costs of road work on high-risk and moderate-risk roads to the length of salmon stream in WAU. WAUs with the lowest total costs per kilometer of salmon stream were considered the highest priority WAUs. The prioritized interim list of USFS road projects by WAU is shown in Section 3.

*Limitations*
The risk ratings are simply a method of categorizing relative differences in risk factors among road segments. Each rating is consistent with research and empirical data on causes of road failures, and we believe that the ratings should be generally accurate in identifying roads that pose the greatest threat to stream resources. Neither the individual risk factors nor the overall risk rating have been examined for accuracy in predicting road failures. Additionally, some road ratings used in USFS inventory are assumed based on road age or location and may not be accurate.

Decommissioning of roads on Forest Service lands requires a completed Watershed Analysis and NEPA assessment. USFS watershed analyses have been completed (and road decommissioning can proceed) in the following WAUs: Finney, Pressentin, Loretta, Day, Rinker, Tenas, Dan Creek, Sauk Prairie, Clear, and Monte Cristo. Road work in the remaining WAUs cannot proceed until Watershed Analyses are completed.

*Methods*
The "risk rating" for each road is based on a variety of factors including road construction methods, locations on slopes, proximity to streams, and other factors. All ratings concerning the likelihood of landsliding are summed, and then multiplied by a rating of the likelihood that significant stream resources will be impacted. Individual data fields for the rating system are described below:

| | |
|---|---|
| Road_no. = | Road number. Seven digits, alpha. |
| Road_name = | Name of road. Alpha. |
| Begin = | Start mileage. Alpha. |
| End = | End mileage. Alpha. |
| Length = | Length of road segment in miles. Alpha. |
| Operationa = | Operation class, single digit. Alpha. |
| Objective = | Objective class, single digit. Alpha. |

| | |
|---|---|
| A = | Snow zone. Location of segment and contributing upslope area. 0 = highland or lowland, 1 = rain or snow dominated, 2 = rain-on-snow. Alpha. |
| B = | Geology and soil stability. Percent of road area on unstable soils (SRI), highly eroded surficial deposits, or highly fractured geology. Under 10% = 0, 10-30% = 2, 31-50% = 3, Over 50% = 5. Alpha. |
| C = | History of road failures from uncorrected causes. None = 0, some = 1, repeated = 2. Alpha. |
| D = | Major stream crossings (>36 inch culvert or more than 3 feet of fill over culvert). None = 0, one = 1, more than 1 = 2. Alpha. |
| E = | Number of stream channel crossings per 500 feet of road. 0-1 = 0, 2 = 1, 3+ = 2. Alpha. |
| F = | Construction method. Full bench = 0, Layer placement = 1, sidecast = 2. |
| G = | Average sideslope at road. <40% = 0, 40-60% = 1, >60% = 2. Alpha. |
| H = | Vegetative cover. Percent of contributing area with trees over 35 years old. Over 70% = 0, 50-70% = 1, 20-49% = 2, <20% = 3. Alpha. |
| I = | Road stacking. Number of road segments upslope. None = 0, mid-slope road or road above is on ridge top = 1, one road segment above = 2, two or more road segments above = 3. Alpha. |
| Sum = | Sum of ratings A through I. Alpha. |
| Failure = | Consequence of road failure. Based on several factors including proximity to stream, steepness of slope, and runout areas. Range from 1 to 3. Alpha. |
| Total = | Risk rating. *Sum* x *Failure*. Alpha. |
| Notes = | Comment field. Alpha. |
| Wauname = | Name of WAU. Alpha. |

Riskgroup = Risk rating for each road segment based on "Total". Segment where Total <= 15 are low, Total from 16 to 30 is moderate, Total >30 is high. Alpha.

*Future Work*

USFS is continuing its road inventory and will complete the Skagit basin inventory within the year. Similar road inventories have not yet been conducted on state or private timberlands. This method appears to be appropriate for identifying segments of road that pose the greatest threat to stream resources. However, it does not identify the types and locations of work needed to reduce the landslide hazard. We anticipate that some inventories will be more detailed than those used by USFS, and will better identify the specific work actions required for each segment of forest road.

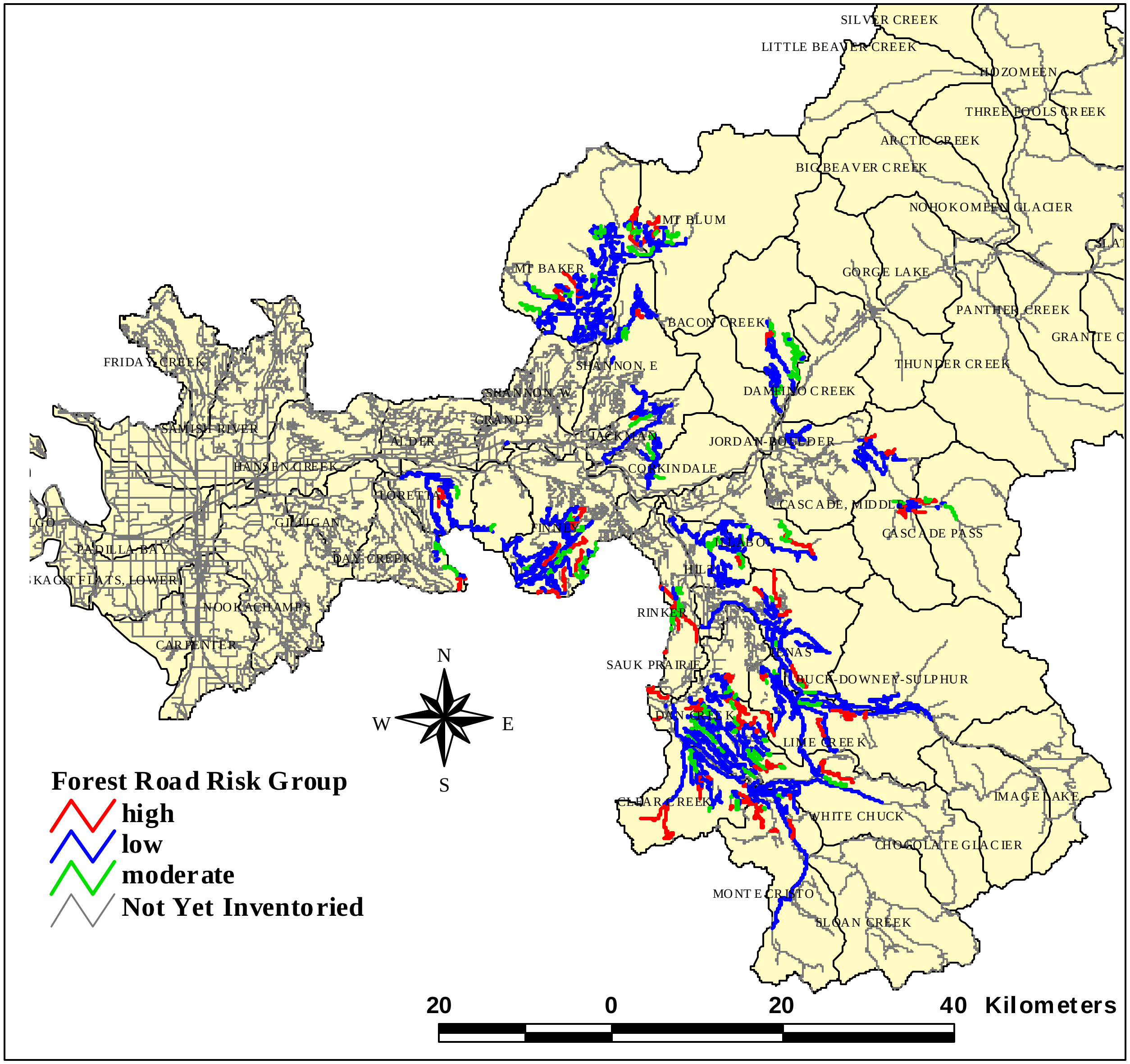



**Figure 2-10. Map of likely sediment reduction projects from forest roads.**

## 2.4 RIPARIAN

Basin-wide estimate of riparian condition from satellite data

*Description and use of interim riparian conditions map*

The interim product is a GIS-based arc theme generated from the intersection of the 1993 Landsat land cover theme (Lunetta et al. 1997) and streams clipped from within the anadromous zone. It shows the classification of land cover types along each reach within the anadromous zone (Figure 2-11). Reaches mapped as late-seral or mid-seral stage have a high likelihood of meeting the Strategy criteria for a "functioning" riparian forest, and areas mapped as non-forest land use have a high likelihood of being "impaired."

The interim riparian map will be used as one of the screens to evaluate whether case-by-case projects are consistent with the Strategy. The interim product is also useful at the basin-scale for identifying potential riparian restoration projects, based on the buffer widths of the Skagit Watershed Council screening criteria. About 42% of tributary channels in the anadromous zone (by length) are in the non-forest category, and therefore have a very high likelihood of being impaired and in need of riparian restoration.

*Limitations*

To validate the accuracy of using the land cover theme for developing a riparian screening tool and identifying restoration and protection projects we used field-based riparian inventories to compare the actual riparian condition along a stream channel to the GIS-based land cover types. Inventory data from the Nookachamps, Hansen, Illabot, Baker, and Bacon WAUs were cross-referenced with the GIS land cover type at the approximate spacing of every 400 meters on the GIS-based stream channel network.

Field inventories at 234 riparian sites show that riparian condition ratings were predicted reasonably well for most of the land cover classes (Table 2-4-1). All of the sampled late-

Table 2-4-1. Distribution of field-sampled riparian conditions for each GIS-based land cover type. Dominant percentages are shown in bold type.

| Riparian Condition based on Field Inventory and SWC Diagnostic | Class 1 Late-seral (n=24) | Class 2 Mid-seral (n=13) | Class 3 Early-seral (n=24) | Class 4 Other Forest (n=96) | Class 15 Non-forest (n=77) |
|---|---|---|---|---|---|
| impaired | 0% | 8% | 8% | **42%** | **90%** |
| moderately impaired | 0% | 0% | 4% | 15% | 6% |
| functioning | **100%** | **92%** | **88%** | **43%** | 4% |

seral forest sites and between 85% and 95% of the mid-seral and early-seral sites met the Strategy screening criteria for functioning riparian forests (mature timber stands greater than 40 meters wide). Conversely, approximately 90% of the areas mapped as non-forest did not meet the Strategy criteria and were in need of riparian restoration work (fencing, planting, or both). Areas mapped as other forest (ranging from clearcuts to mature hardwoods) were found to be 43% functioning, 15% moderately impaired, and 42% impaired.

While we can not accurately map reach-scale riparian conditions associated with channels adjacent to early seral stage (Class 3) or other forest (Class 4) vegetation cover, we can estimate with reasonable accuracy the total of each riparian category at a larger scale. Based on the results in Table 2-4-1,we estimated the percentage of anadromous zone channel length in each riparian category (impaired, moderately impaired, and functioning) for WAUs and floodplain reaches (Figures 2-12 and 2-13).

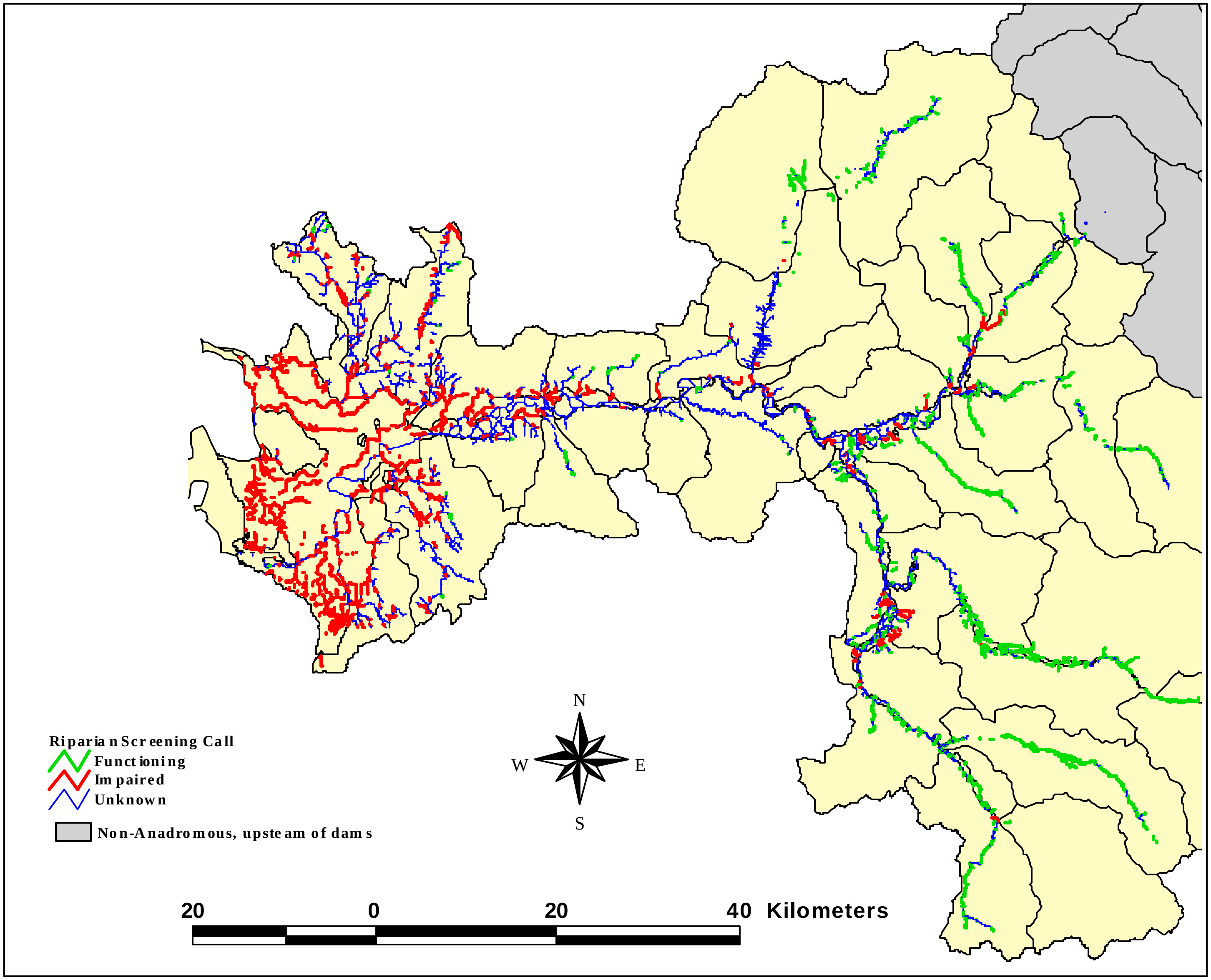



**Figure 2-11. Map of areas where riparian buffer widths are likely impaired or functioning based on 1993 Landsat data (Lunetta et al. 1997).**

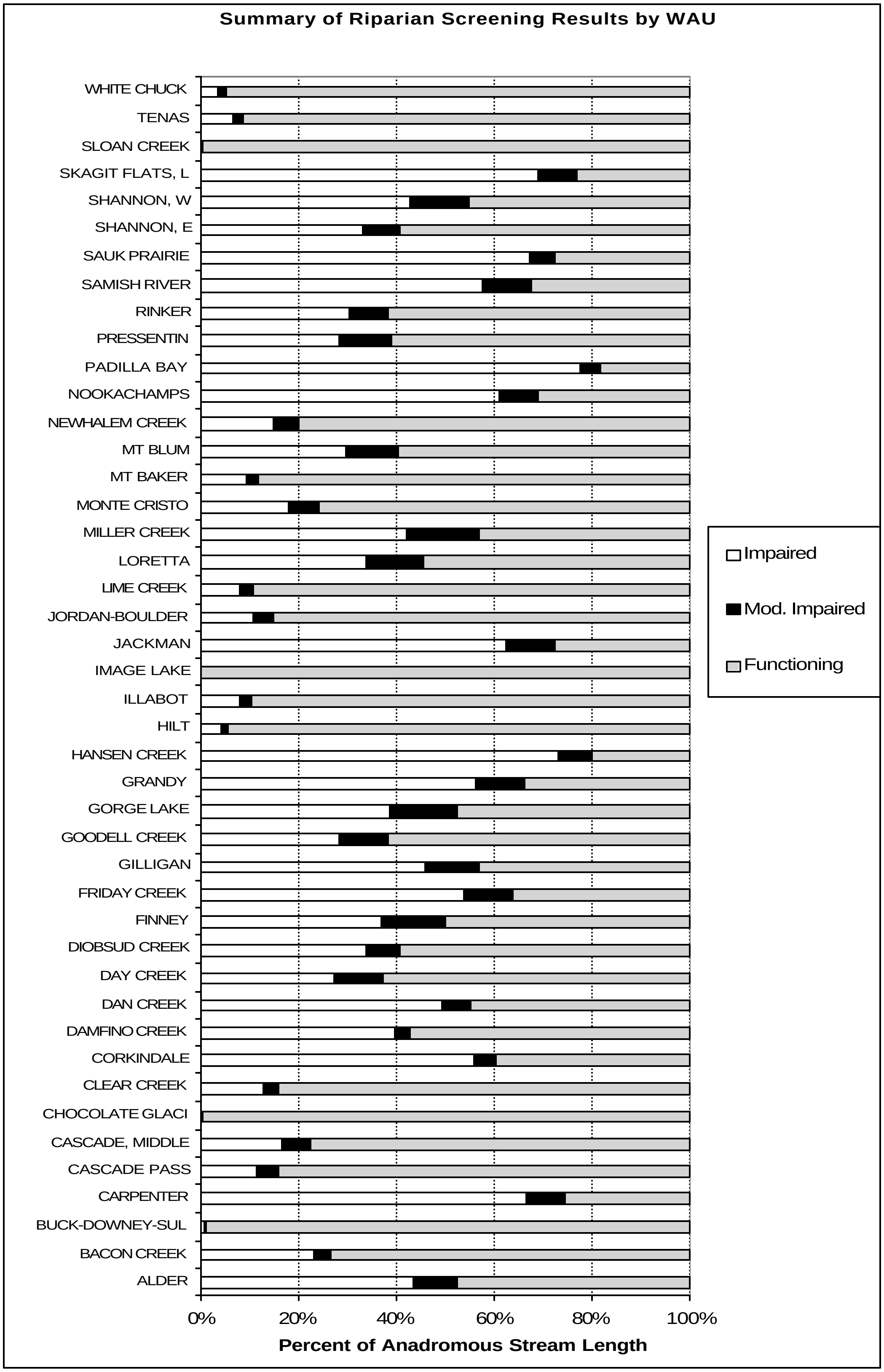



Figure 2-12. Summary of riparian screening results by WAU. WAU locations are shown in Figure 2-9.

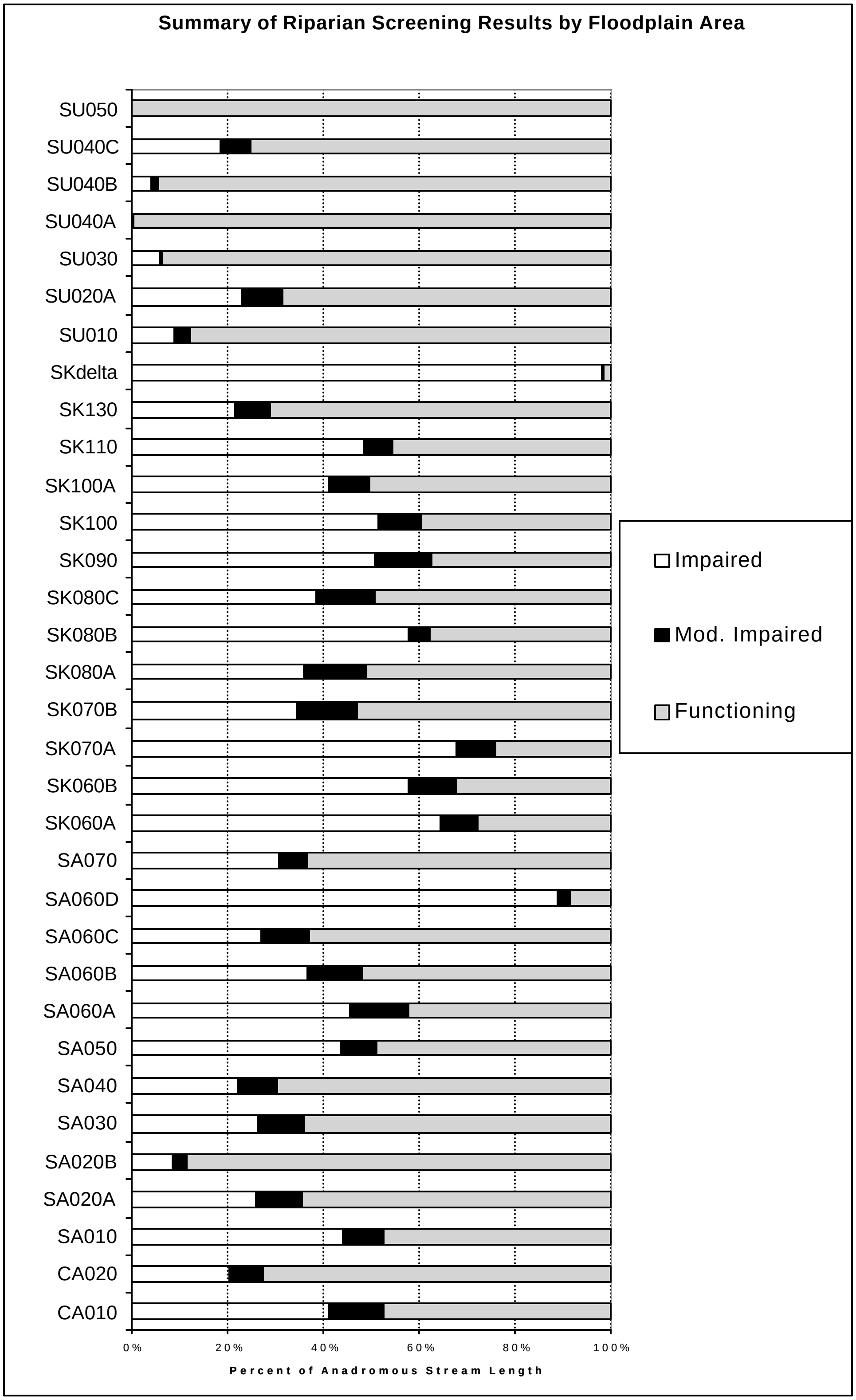



Figure 2-13. Summary of riparian screening results by floodplain reaches. Reaches are listed by river (CA=Cascade, SA=Sauk, SK=Skagit, SU=Suiattle) with the numbering system starting at the river's mouth. For "Skdelta" only freshwater non-mainstem channels were analyzed. Floodplain reach locations are shown in Figure 2-15.

*Methods*
We created this riparian map by intersecting the 1993 Landsat vegetation theme and streams within the anadromous zone. It is an arc theme with each segment defined based on changes in riparian condition from the Landsat theme. It contains a field showing the land cover class adjacent to the reach.

*Future work*
The primary task is to continue field inventory of riparian forest conditions. Satellite data do not provide sufficient information for determining riparian management needs at the reach level. Moreover, satellite data typically have a resolution of 10 to 30 meters, which is insufficient to recognize and classify narrower riparian buffers. Field inventories are far more reliable than remote sensing data, and can provide sufficient information for project planning.

A second task for updating the inventory (and possibly for monitoring progress of riparian restoration) is to search for a more reliable method of analyzing satellite and aerial photograph data. This may allow more efficient updating of the inventory than can be achieved with field-based methods.

<u>Identification of riparian projects through field inventory</u>

*Description and use of field-based riparian maps*
The field-based riparian maps (Figure 2-14) illustrate approximate locations of riparian restoration projects. Each project has a data field containing the project number. All data on the characteristics, benefits, and costs of projects are contained in separate data tables, which we store as spreadsheets for ease of exchange among user groups. The data tables also contain a field with project number so that these data may be joined to the ArcView map.

This map also displays all of the WAUs in which riparian inventories have been completed. To date we have completed riparian inventories in 9 of the 38 WAUs where riparian inventories are needed.

*Limitations*
Most WAUs in the watershed have yet to be inventoried, so the main limitation is that the inventories and mapping are incomplete. Projects have been mapped for the lower Sauk WAUs, but Hansen and Nookachamps inventories have not yet been digitized.

*Methods*
Riparian planting and restoration projects have been identified through a series of field inventories. The inventories were completed systematically as four separate projects in 1995, 1996, and 1998 in 9 of 38 Skagit River Watershed Administrative Units (WAUs). We have completed inventories in the Nookachamps WAU, Hansen Creek WAU, Illabot WAU, and the Hilt, Rinker, Clear Creek, Sauk Prairie, Dan Creek, and Monte Cristo (portion from the confluence of the North and South Forks Sauk downstream) WAUs.

We identified projects by walking all streams accessible to anadromous fish in the surveyed WAUs and assessing the riparian vegetation conditions for each stream reach. We classified riparian conditions by buffer width, stand type, and age of vegetation within 60 meters of stream channels. From these data, we selected all stream segments with forested riparian vegetation less than 40 meters wide as requiring planting, and all segments with evidence of livestock access to the stream channel as requiring fencing. The projects are prioritized and listed in section 3 of this report.

*Future Work*

Future work consists primarily of continuing the field inventories of riparian conditions in the Skagit and Samish River basins and digitizing already completed inventories.

We plan to modify the methods slightly in order to increase the efficiency of the inventory and make inventory results available through GIS technology. The most significant modification will be the addition of an aerial photo mapping of riparian conditions. Currently we map all sites in the field. In the future we will first map all sites based on 1:12,000 scale aerial photography, and limit the field effort to ground-truthing and collection of minimal additional data. Inventory maps will then be digitized.

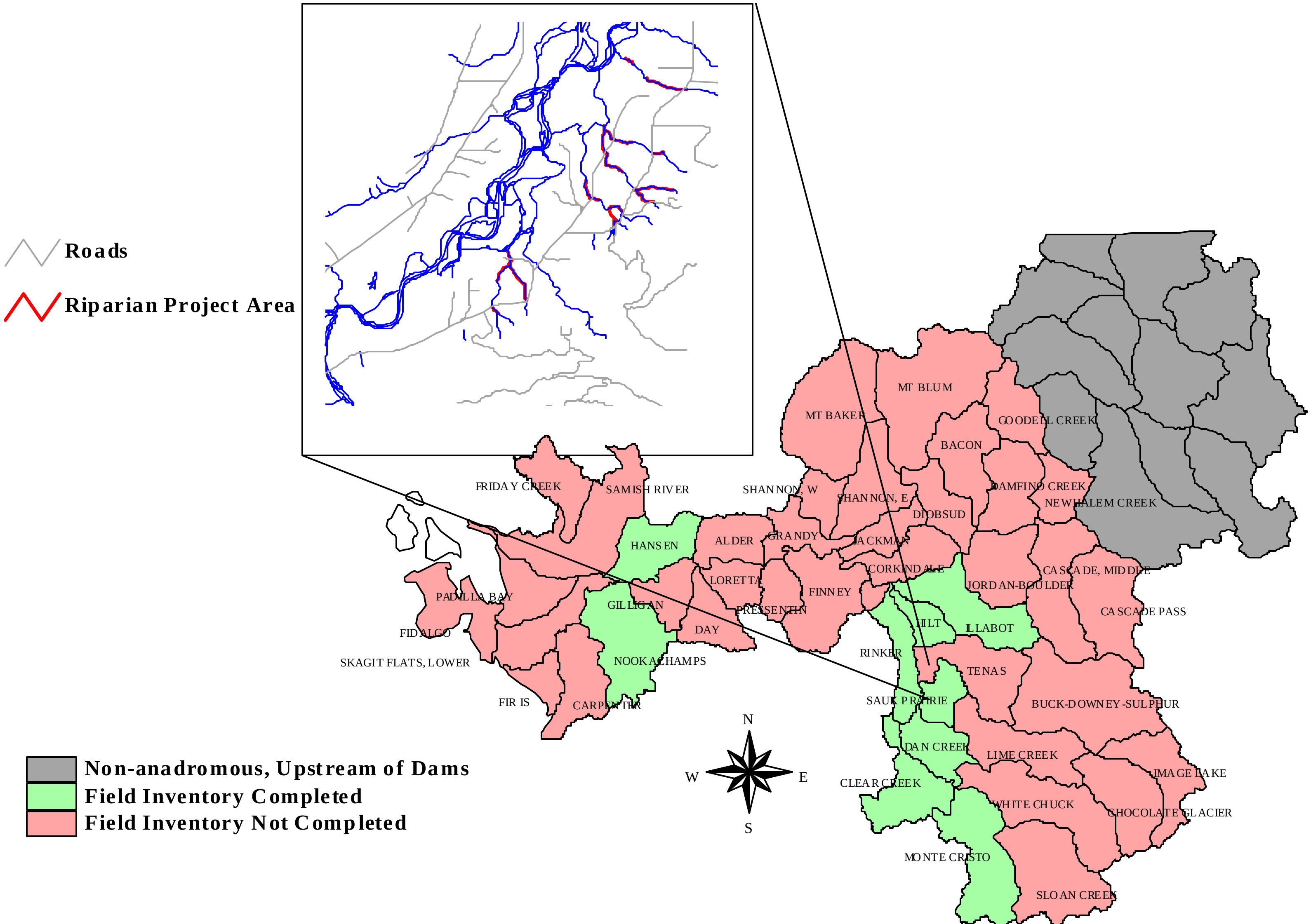



**Figure 2-14. WAUs where field-based riparian inventory has been completed and projects identified. (Example of GIS theme detail in the Sauk Prairie area).**

## 2.5 FLOODPLAIN

*Description of interim product*

Floodplain modification is a disturbance type related to hydrology, sediment, or riparian processes. That is, disturbed floodplains change a stream reach's ability to supply, transport (convey) or store one or more of the inputs: water, sediment, and wood. This has an effect on the formation and maintenance of habitat within floodplains, as well as on the characteristics of downstream reaches.

A preliminary screen has been developed to rate segments of large main channel habitat based solely on whether diking or stream bank hardening is present (Figures 2-15a and 2-15b). Figure 2-15a shows the location of 45.6 kilometers of stream channel edge that have been hydromodified upstream of the delta. Figure 2-15b shows the where mainstem channels in the Skagit Delta, which starts near Sedro Woolley, is diked or hardened. The inventory found 50.9 km (62%) of 82.4 km of mainstem channel edge is either hardened with riprap, diked within 60 meters of the channel's edge, or both.

Stream bank hardening (hydromodification) prevents channel migration and reduces LWD recruitment. Hydromodification typically narrows and steepens channels increasing both sediment and water transport rates. Hayman et al. (1996) showed that mainstem channels dominated by hydromodification exhibited less diversity in edge habitat types and less edge habitat area than non-hydromodified reaches. Beamer and Henderson (1998) showed the relative importance of natural bank areas compared to hydromodified bank areas to most species and age classes of juvenile salmon in the Skagit.

In the preliminary screen, large main channel segments where the stream bank is diked or hardened are assumed *impaired*. The determination is based on the strong difference in juvenile salmon use between the different cover types present in natural and hardened banks and our knowledge of how the diversity of flood plains habitats are created and maintained through the natural disturbance regime. Ratings for large main channel segments not diked or hardened are *unknown* at this time.

*Use and limitations*

The current use of the preliminary product should be limited to 1) prioritizing reach level projects that occur within the main channel segments delineated as impaired, and 2) delineating the generalized habitat types (Section 2.8). We recommend only these uses because we are confident that main channel areas currently identified as impaired or moderately impaired based on diking and stream bank hardening are correctly mapped.

This product may also provide the basis for identifying potential riprap removal (or modification) projects.

*Methods-Flood plain reaches*

For large rivers within the Skagit River basin, floodplain areas were delineated where the 100-year floodplain was greater than two channel widths. Where FEMA maps were unavailable, valley width polygons were delineated based on USGS 7.5-minute quads and 1996 aerial photographs. Reach breaks were based on differences in floodplain width and changes in channel pattern and the degree of hydromodification (after Hayman et al. 1996).

*Methods-Hydromodified streambank inventory*
Skagit System Cooperative collected the inventory data used in the preliminary screen. Both field and aerial photo inventory methods were used. The field inventory focused on hydromodification, not riparian conditions. Riparian conditions were delineated using the aerial photographs provided by the USFS (for the Skagit Wild and Scenic River Corridor - 1996) and ACOE (lower Skagit River -1998).

By floating each main channel shown within floodplain reaches (Figures 2-15a and 2-15b), hydromodified banks were delineated based on the categories shown in Table 2-5-1 with lines on aerial photos of the area. Each line segment was assigned a site identification number (SiteID) and the data corresponding to the categories in Table 2-5-1 were recorded on a field form for each segment. Subsequently, these data were entered into an EXCEL spreadsheet. The line segments were digitized and spreadsheet data are attached to the GIS arc theme. The length of each segment was calculated by GIS.

Table 2-5-1. Hydromodification inventory data fields.

| | |
|---|---|
| Reach | Mainstem/floodplain reach number |
| SiteID | Unique number that identifies the site |
| Location | Denotes whether the hydromodification unit is left bank (**LB**) or right bank (**RB**), facing downstream |
| Edge Type | Denotes whether the river edge is non-hardened bank (**NBK**), hardened bank (**HBK**), bar (**BR**), or backwater (**BW**). Bars and backwaters are not hardened but may be considered diked (see next row this table) |
| Levee | This field denotes whether there is a levee or not (**none**), and if a levee is present whether the toe of the levee is **adjacent** (within 0-5m from the channel's edge), **setback 5-20m**, **setback 20-40m**, **setback 40-60m**, or **setback >60m** from the unvegetated channel edge. |
| Hydromodification Type | Denotes the type of hydromodification. Fields include: **riprap**, **rubble**, **wood pilings**, **LWD**, **rock groin**, **bulkhead**, **dock**, **bridge pier**, **sheetpile**, other |
| Old or new | This is the characteristic of hardened edge: used descriptive characteristics to infer whether new or old including: voids filled with sediment, older vegetation was present at the site, rock was weathered. Fields include: **new**, **old**. |
| Placement year | The year of hydromodification, if known. |
| Dominant Size | A visual estimate of the average size of dominant particle, hydromodified segments only. |
| Riparian Stand Type | Fields include: **open** (no woody plants evident from photo), **immature** (shrub or up to sapling sized [<12" dbh] woody vegetation), **mature** (>12" dbh sized forest). We make no distinction between deciduous or conifer stands because the delineation is based on photos. |
| Riparian Buffer Width (m) | Based on photos: riparian areas **< 5m** wide, **5-<20m** wide, **20-<40m** wide, **40-<60m** wide, **>60m** wide |
| Comments | Other data unique to the site; usually landmark related |

*Future work*

Complete full floodplain habitat analysis. We anticipate the floodplain screen will be applied to areas where channels naturally would migrate or avulse over two bankfull channel widths. These areas are identified within one or more of the channel migration zone themes. We also anticipate the screen will use diking, stream bank hydromodification, and floodplain vegetation condition (theme not yet developed) variables to draw conclusions on where main channel reaches and their floodplain habitats are considered functioning, moderately impaired, or impaired.

Because floodplain forest stand characteristics are thought to be primarily shaped by relatively frequent disturbances by natural fluvial processes and beavers, we will include vegetation land cover as a factor to consider when designating floodplain areas as impaired, moderately impaired, or functioning.

Skagit System Cooperative has completed inventory of hydromodified banks in all large main channel areas of the Skagit. No inventory has been completed for the Samish River basin. Future efforts will fill these data gaps.

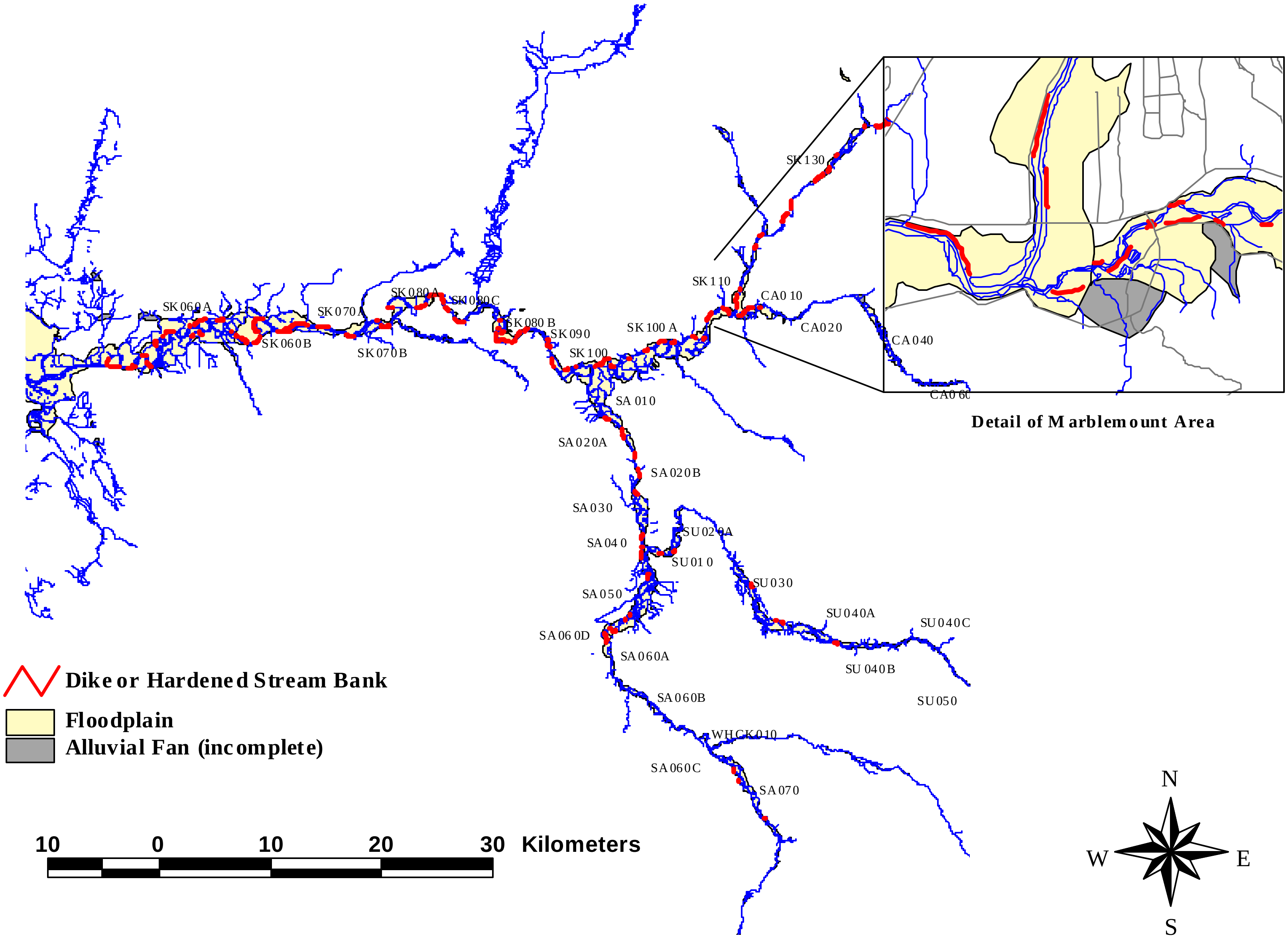



**Figure 2-15a. Map of impaired main channel areas based on diking and stream bank hardening. (upstream of delta only)**

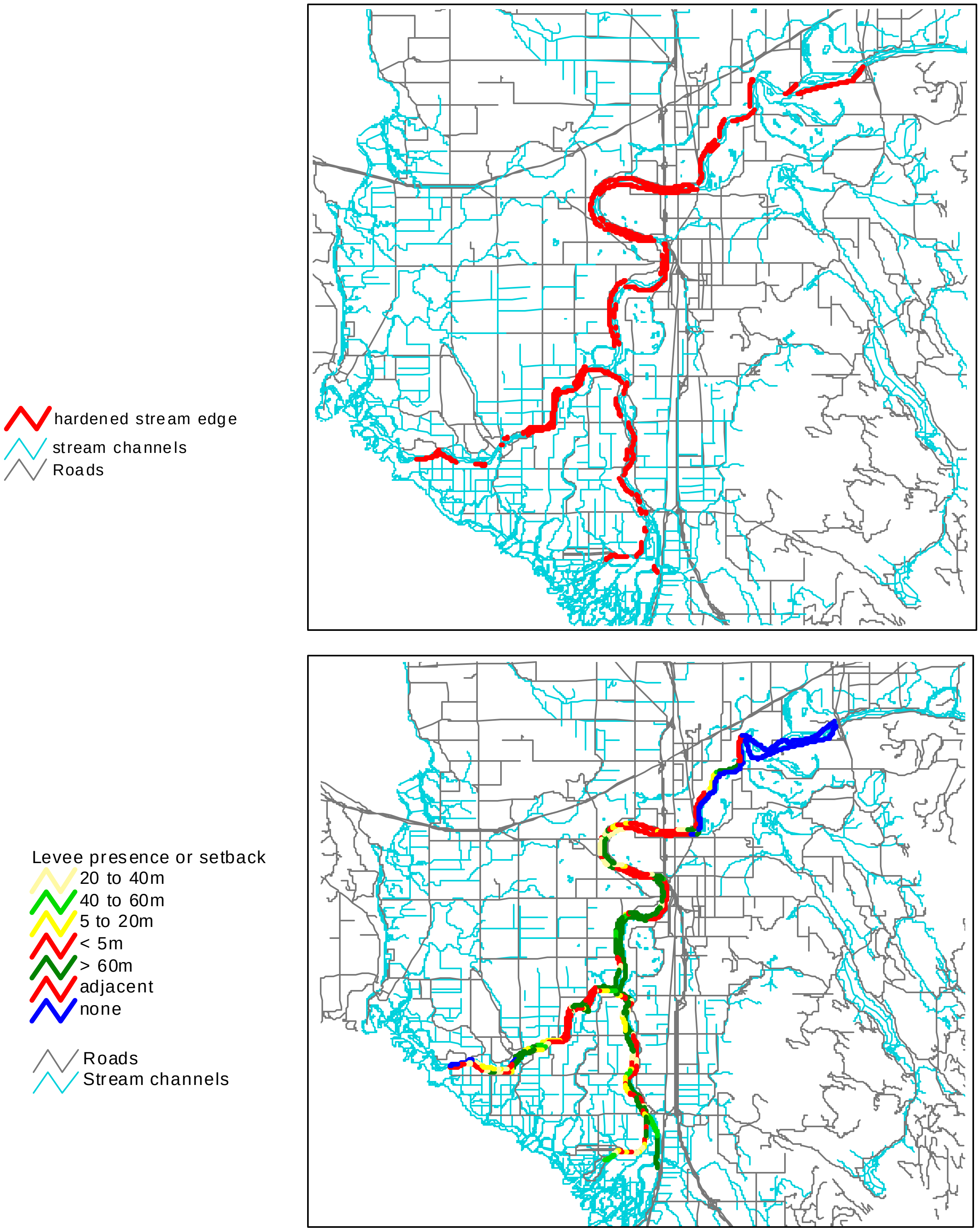



Figure 2-15b. Map of impaired main channel reaches in the lower Skagit River based on diking and stream bank hardening

## 2.6 ISOLATED HABITAT

The Strategy defines *isolated* habitat as being a migration barrier to juvenile or adult anadromous salmonids. Habitat is isolated through anthropogenic disturbances such as tide gates, impassable road crossings, dikes or other floodplain fills. We identify isolated habitat using aerial photography and field-based inventory of channel crossings.

*Description and use of the man-made fish migration barrier and isolated habitat map*
Man-made barriers to anadromous fish migration have been identified through a systematic field inventory of channel crossing structures (culverts, bridges, dams, and other manmade structures). The inventory follows the Fish Passage Barrier and Prioritization Manual of Washington Department of Fish and Wildlife (WDFW 1998). Through September 1999, Skagit System Cooperative, WDFW, and Skagit Regional Fisheries Enhancement Group have completed inventory of thirteen WAUs, encompassing 572 stream crossing structures. Each structure has been entered on ArcView GIS and all associated data are entered into database tables. The current map shows all inventoried structures, and categorizes them as *blocking* fish access, *passable* to fish, *unknown* or requiring a *Level B hydraulic analysis* (Figure 2-16). The primary use of this inventory is to locate structures in need of repair to restore anadromous salmonid access to habitat available upstream.

In the Skagit and Samish River delta, Figure 2-17 shows that much of the existing channel length has been either "lost" or "isolated" from salmon use. Isolated channels are those where a topographic channel and water exist, but juvenile or adult salmon access is blocked due to man-made disturbances. "Lost" channels are those areas that were historically channels, but currently do not have clear a topographic channel or water present. Only 44% (146 km) of the historical channels remain accessible to salmon under present conditions.

The inventory efforts through September 1999 have identified 229 manmade barriers and confirmed 164 km of channel blocked with 32% of the anadromous zone inventoried. However, because manmade barriers are not evenly distributed throughout the Skagit and Samish River landscape and our inventory efforts have focused in areas where barriers are more common, we anticipate that the majority of the isolated habitat in the basin has been found.

Based on a sub-sample of 111 inventoried structures within watersheds with similar land-use intensity as the watershed yet to be inventoried, we found that 14% of the inventoried barriers do not meet fish passage criteria (Table 2-6-1). Therefore, we expect to find about 150 more blockages in non-inventoried areas of the basin, blocking about 60 km (4%) of the estimated length of tributary habitat in the anadromous zone.

Table 2-6-1. Estimate of the number of barriers and isolated habitat length not yet identified in the Skagit and Samish River basins.

| | Inventoried | Not-Inventoried |
|---|---|---|
| Watershed Area ($km^2$) | 379 $km^2$ | 3,429 $km^2$ |
| Total Number of Stream Crossings | 111 | 1,121 (estimate) |
| Number of blockages | 15 | 151 (estimate) |
| Average length of habitat blocked by barriers | 382m | |
| Estimated length of habitat isolated yet to find | | 57.7km (estimate) |

*Limitations*

We have high confidence in the accuracy of the inventory because it is entirely based on measurements of stream crossing structures in the field. Only a small percentage of the structures are actually true “unknown” calls after inventory. Most structures identified as *unknown* are within blocked-off slough or estuary channels where passage cannot be determined until a design flow for the reconnected channel is determined.

A limitation of the field-based barrier inventory for basin-level restoration planning is that only 32% of the basin has been completed. The primary limitation of the isolated habitat map is that it is only displayed for the delta area. Therefore, some gaps are apparent in our display of information between the two figures (Figures 2-16 and 2-17). The “display gaps” are a function of our lag in making a GIS arc theme for isolated habitat in non-delta areas and a bottleneck in entering field inventory data into the GIS barrier point theme. These limitations will be addressed over time as more inventory work is completed.

*Methods*

The field-based inventory follows the Fish Passage Barrier and Prioritization Manual of Washington Department of Fish and Wildlife (WDFW 1998). The type and physical dimensions of the structure are recorded as well as other physical attributes necessary for modeling water flow conditions and comparing this to passage criteria (see manual for details).

Isolated habitat areas of the Skagit and Samish River Deltas under current (1990s) conditions shown as polygon data. Polygons were delineated from either 1:12,000 scale WDNR 1991 Orthophotos or current 1:24,000 scale USGS Quadrangles and digitized “heads-up”. Isolated habitat areas are those upstream of known barriers to juvenile or adult migration.

*Future work*

Complete the field-based inventory for the entire basin starting with entering the data from the Padilla and Samish WAUs where fieldwork has been completed.

Develop the GIS arc theme for isolated habitat outside of the delta area.

Finish quantifying anadromous accessible wetland losses in the delta. Estuarine and freshwater wetland area results for the delta should be available in the fall of 1999.

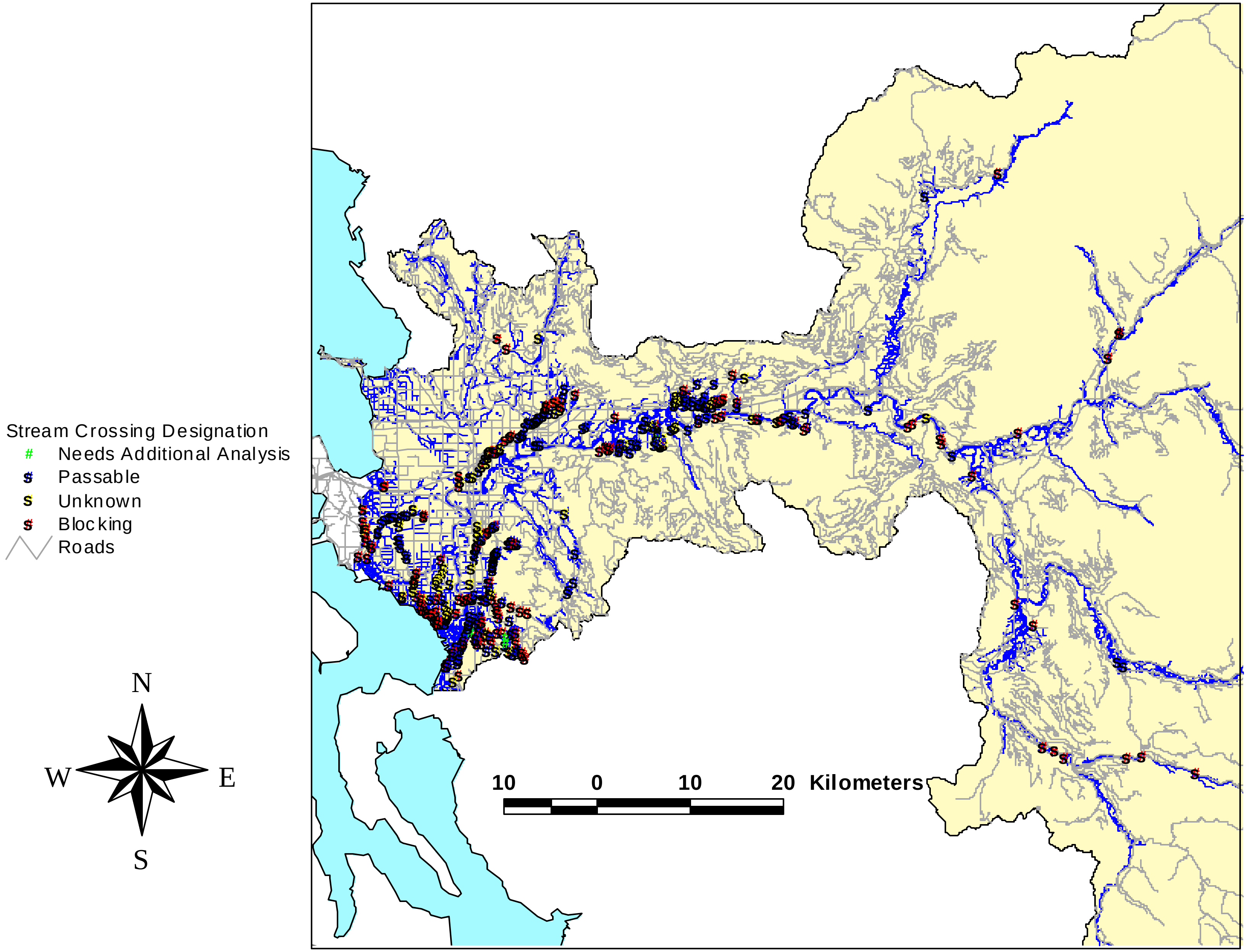



**Figure 2-16. Map of field-inventoried channel crossing structures in the Skagit and Samish River basin.**

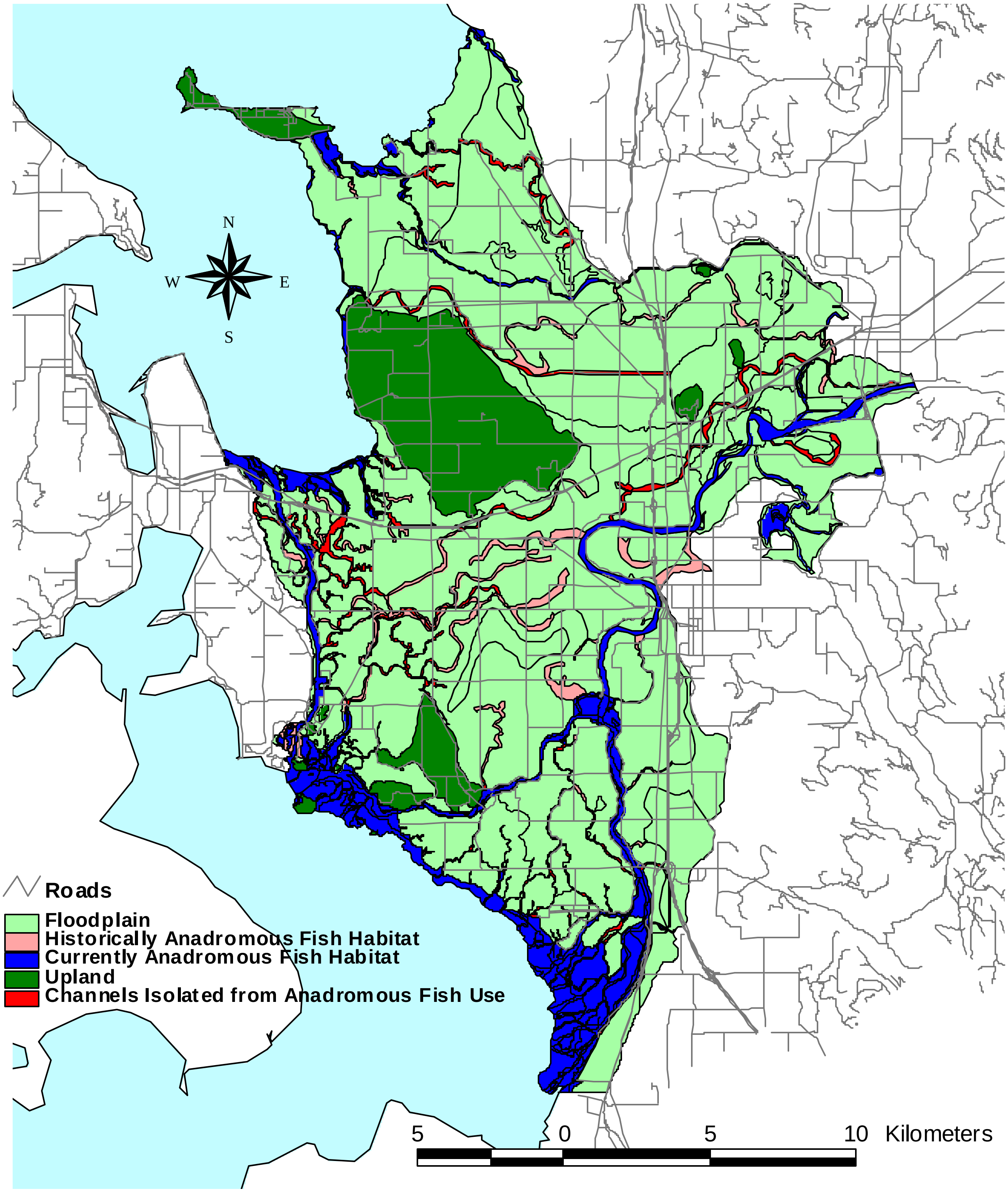



Figure 2-17. Map of isolated habitat in the Skagit and Samish River delta.

## 2.7 WATER QUALITY

*Description and use of the water quality map*
As stated in the SWC Habitat Restoration and Protection Strategy, identification of impaired or potentially impaired areas of the basin with respect to water quality will rely on a combination of land use indicators (e.g., point and non-point sources of pollution) and existing water quality data (e.g., conventional water quality parameters such as temperature and dissolved oxygen, water and sediment chemistry, fish tissue, benthic community indices). At this point, however, our water quality map is limited to identification of stream reaches in the Skagit River Basin that are included on the Washington Department of Ecology's Candidate 1998 Section 303(d) Impaired and Threatened Water Bodies listings. These "water quality limited" estuaries, lakes, and streams are those that are known to fall short of state surface water quality standards, and are not expected to improve within the next two years. Figure 2-18 shows the listed water bodies with different colors depending on the water quality parameter that is driving the listing (i.e., dissolved oxygen, fecal coliform, or temperature).

The water quality map is used for project screening as well as for planning reach-level and watershed-level water quality improvement projects. For project screening, project proponents use this map to determine whether the proposed project area is likely to be impaired due to water quality problems. For planning of reach-level or watershed-level water quality improvement projects, this map distinguishes areas in need of restoration from areas in need of protection.

*Limitations*
The interim product is limited for a number of reasons, including:
1) The 1998 Candidate 303(d) list is not the result of a comprehensive water and sediment quality survey of the entire Skagit River Basin, and so is limited by the data available to compile the list;
2) The map does not attempt to summarize all the available water or sediment quality data from recent investigations and sampling efforts, and water bodies currently identified as "unknown" with respect to water quality impairment may have sampling data and may be impaired;
3) The map does not attempt to identify the land use indicators of potential water quality impairment that are discussed in the water quality section of the SWC Restoration and Protection Strategy. Accurate locations of these indicators (both point and non-point sources of pollution) would add useful information for areas where water and sediment quality sampling data are not available.

*Methods*
The interim water quality map was produced by overlaying the GIS shapefiles containing the 303(d) listed water bodies on top of the anadromous zone layer. The shapefiles with the 303(d) data were downloaded from the Washington Department of Ecology's web site and then clipped to only include water bodies in WRIAs 3 or 4.

*Future Work*

Future versions of the water quality map will attempt to address the limitations of the interim product discussed above. For instance, future maps will include locations of known point sources (e.g., NPDES discharge locations, combined sewer outfalls, etc.) and non-point sources (e.g., failing septic systems, commercial dairy farms, landfills, hazardous waste sites, etc.) that may contribute to water quality degradation in the basin. As discussed in the SWC Strategy, these land use indicators will be used to identify areas where water quality problems may exist, and to direct further investigation (e.g., water quality sampling, benthic community analyses) to determine if water quality is actually impaired. Maps showing existing as well as planned effective impervious area percentages in the basin will be used to help identify and screen potential water quality enhancement and protection projects. Future maps will also include locations of sampling stations associated with individual studies as well as ongoing monitoring efforts. The maps will be linked to databases containing the sampling results and quality control information. The continuing objective will be to improve the quality and quantity of water quality data and land use information available to guide restoration and protection of aquatic habitats.

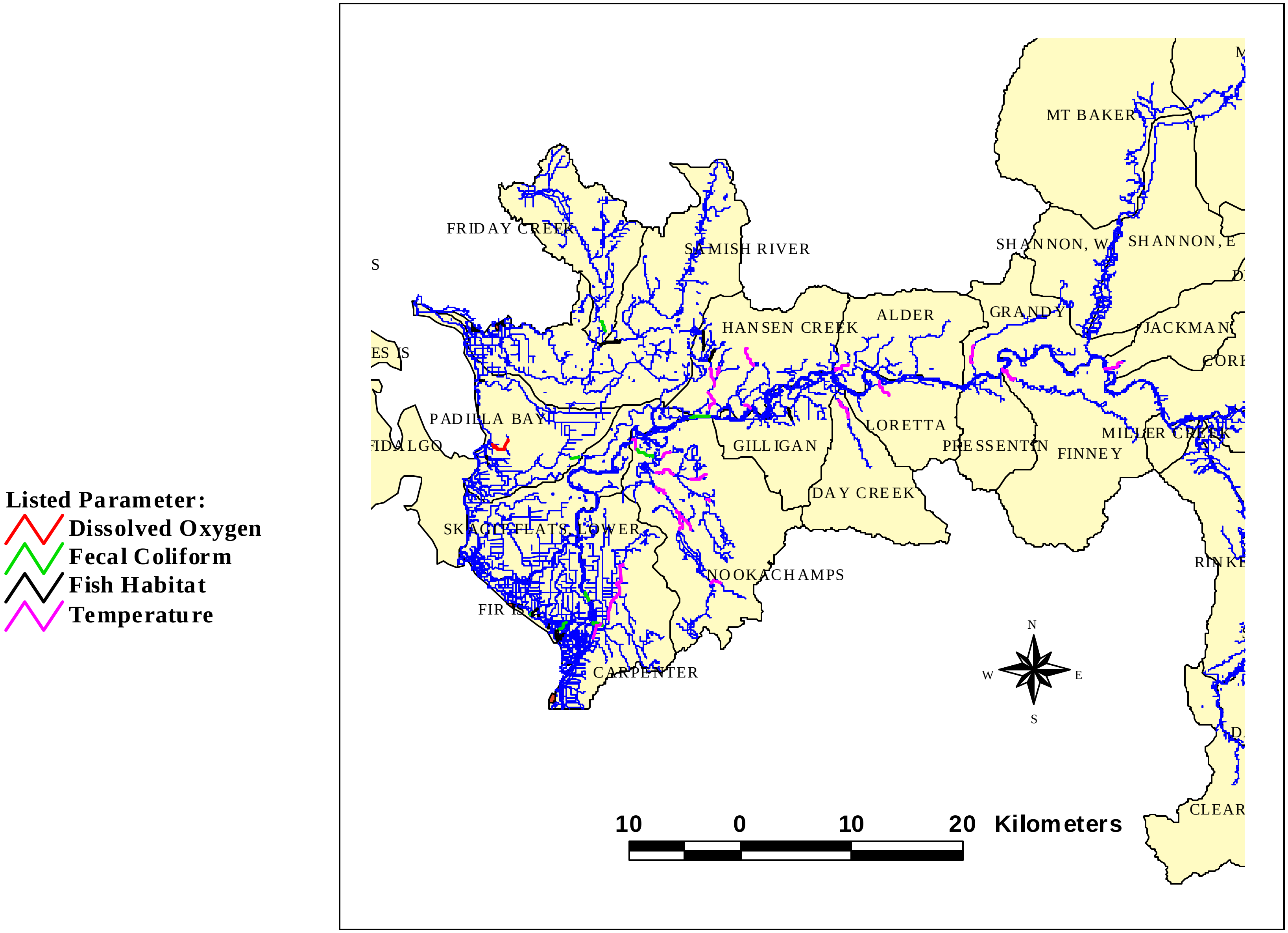



**Figure 2-18. Stream segments considered Section 303(d) Impaired and Threatened in the Skagit and Samish River basins.**

## 2.8 Synthesis of Reach-Level Habitats and Landscape Process Screening Results

*Description and use of interim product*

Figures 2-19 and 2-20 are a basin-wide application of our current understanding of generalized habitat types adopted in the Strategy and shown in Table 2-8-1. *Key* habitat is critical for at least one life stage combination considered, or is a preferred type by the majority of life stages considered. *Secondary* habitat does not provide critical habitat for any life stage combination considered and is not a preferred type by the majority of life stages considered. *Important* habitat is a disturbed key habitat that still provides significant amounts of production for most life stages considered. *Degraded* habitat is key habitat that is disturbed to such an extent that it does not have significant production or is not preferred by the majority of life stage combinations considered. *Isolated* habitat is not used by anadromous salmonids (no direct biological function) because it is disconnected through man-made blockages such as dikes, tide gates, or impassable road crossings. The derivation of the generalized habitat types and a complete description of the species and life stages considered can be found in the Skagit Watershed Council Habitat Protection and Restoration Strategy, Appendix 1.

Table 2-8-1. Relationship of reach level habitat type and generalized habitat type (from Skagit Watershed Council 1998).

| **Reach Level Habitat Type** | **if "disconnected" (human caused)** | **if "disturbed" (human caused)** | **if "relatively intact" (pristine)** |
|---|---|---|---|
| **Tributaries Reaches (channels < 50 meters bankfull width):** | | | |
| pool riffle | isolated | degraded - important | key |
| forced pool riffle | isolated | degraded - important | key |
| plane bed | isolated | degraded | secondary |
| step-pool/cascade | isolated | secondary | secondary |
| **Main River Reaches (channels > 50 meters bankfull width):** | | | |
| main channel | isolated | degraded - important | key |
| off-channel habitat (e.g., ponds, sloughs, side channels, oxbow lakes, etc.) | isolated | degraded - important | key |
| **Estuary:** | | | |
| estuarine emergent marsh | isolated | unknown[a] | key |
| blind channel | isolated | unknown[a] | key |
| subsidiary channel | isolated | unknown[a] | key |
| main channel | isolated | unknown[a] | key |

[a] Our present knowledge does not detect a difference in fish use from estuarine habitats that are relatively undisturbed.

The product is a GIS theme with reach level habitats (either arcs or polygons) assigned as one of the five generalized habitat types (key, important, degraded, secondary, or isolated) and the reason for the designation (i.e., the impaired process or processes influencing the reach). Generalized habitat results by WAU and floodplain reaches are shown in Tables 2-8-2 and Figure 2-20.

Table 2-8-2. Summary of landscape screening results and generalized habitat type by WAU and floodplain reaches.

| WAU or Floodplain | Basin Type | Anadromous Channel Density (m/ha) | Anadromous Channel Length - % of Basin | Sediment "Impaired" | Sediment "Functioning" | Peak Flow "Impaired" | Peak Flow "Moderate Impaired" | Peak Flow "Functioning" | Riparian "Impaired" | Riparian "Moderate Impaired" | Riparian "Functioning" | Generalized Habitat Call |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CARPENTER | Lowland | 5.6 | 3.0% | 100% | 0% | 8% | 48% | 44% | 67% | 8% | 26% | Degraded |
| FRIDAY CREEK | Lowland | 8.6 | 5.1% | 100% | 0% | 0% | 38% | 61% | 54% | 10% | 36% | Degraded |
| PADILLA BAY | Lowland | 0.6 | 0.2% | No Call | No Call | 29% | 40% | 31% | 77% | 4% | 18% | 77% Degraded |
| SAMISH RIVER | Lowland | 6.5 | 6.6% | 100% | 0% | 5% | 21% | 75% | 58% | 10% | 32% | 58% Degraded |
| SKAGIT FLATS, LOWER | Lowland | 0.9 | 0.1% | No Call | No Call | 9% | 49% | 41% | 69% | 8% | 23% | 69% Degraded |
| Skagit Delta (all areas) | Lowland | 8.5 | 18.5% | No Call | No Call | | | | | | | 21.1% Key |
| Non-main stem | | | | | | 10% | 6% | 84% | 98% | 0% | 2% | 98% Degraded |
| Main stem | | | | | | | | | | | | 67% Degraded |
| Estuary | | | | | | | | | | | | 27.3% Key |
| ALDER | Mountain | 2.5 | 1.2% | 0% | 100% | 100% | 0% | 0% | 43% | 9% | 48% | Degraded |
| BACON CREEK | Mountain | 1.5 | 1.3% | 0% | 100% | 0% | 0% | 100% | 23% | 4% | 73% | 73% Key |
| BUCK-DOWNEY-SULPHUR | Mountain | 0.2 | 0.4% | 0% | 100% | 0% | 0% | 100% | 1% | 0% | 99% | 99% Key |
| CA010 | Mountain | 41.9 | 0.5% | 0% | 100% | 0% | 0% | 100% | 41% | 11% | 48% | 48% Key |
| CA020 | Mountain | 81.9 | 0.2% | 0% | 100% | 0% | 0% | 100% | 20% | 7% | 73% | 73% Key |
| CASCADE PASS | Mountain | 0.7 | 0.8% | 0% | 100% | 0% | 0% | 100% | 12% | 4% | 84% | 84% Key |
| CASCADE, MIDDLE | Mountain | 0.5 | 0.6% | 0% | 100% | 0% | 0% | 100% | 17% | 6% | 77% | 77% Key |
| CHOCOLATE GLACIER | Mountain | 0.7 | 0.6% | 0% | 100% | 0% | 0% | 100% | 0% | 0% | 99% | 99% Key |
| CLEAR CREEK | Mountain | 0.9 | 0.7% | 100% | 0% | 0% | 0% | 100% | 13% | 4% | 84% | Degraded |
| CORKINDALE | Mountain | 0.6 | 0.4% | 100% | 0% | 0% | 0% | 100% | 56% | 4% | 40% | Degraded |
| DAMFINO CREEK | Mountain | 0.9 | 0.7% | 100% | 0% | 0% | 0% | 100% | 40% | 3% | 57% | Degraded |
| DAN CREEK | Mountain | 0.6 | 0.3% | 100% | 0% | 100% | 0% | 0% | 49% | 6% | 45% | Degraded |
| DAY CREEK | Mountain | 1.2 | 0.7% | 100% | 0% | 100% | 0% | 0% | 28% | 10% | 63% | Degraded |
| DIOBSUD CREEK | Mountain | 0.8 | 0.5% | 100% | 0% | 0% | 0% | 100% | 34% | 7% | 59% | Degraded |
| FINNEY | Mountain | 1.8 | 1.8% | 100% | 0% | 100% | 0% | 0% | 37% | 13% | 50% | Degraded |
| GILLIGAN | Mountain | 2.5 | 0.9% | 100% | 0% | 100% | 0% | 0% | 46% | 11% | 43% | Degraded |
| GOODELL CREEK | Mountain | 0.4 | 0.2% | 0% | 100% | 0% | 0% | 100% | 28% | 10% | 62% | 62% Key |
| GRANDY | Mountain | 3.1 | 1.4% | 100% | 0% | 100% | 0% | 0% | 56% | 10% | 34% | Degraded |
| HANSEN CREEK | Mountain | 4.8 | 3.0% | 100% | 0% | 100% | 0% | 0% | 73% | 7% | 20% | Degraded |
| HILT | Mountain | 0.3 | 0.1% | 100% | 0% | 100% | 0% | 0% | 4% | 2% | 94% | Degraded |
| ILLABOT | Mountain | 1.8 | 1.5% | 0% | 100% | 0% | 0% | 100% | 8% | 2% | 90% | 90% Key |
| IMAGE LAKE | Mountain | 0.6 | 0.5% | no data | no data | 0% | 0% | 100% | 0% | 0% | 100% | Key |
| JACKMAN | Mountain | 0.3 | 0.1% | 100% | 0% | 100% | 0% | 0% | 63% | 10% | 28% | Degraded |
| JORDAN-BOULDER | Mountain | 1.2 | 0.9% | 100% | 0% | 0% | 0% | 100% | 11% | 4% | 85% | Degraded |
| LIME CREEK | Mountain | 1.2 | 1.1% | 0% | 100% | 0% | 0% | 100% | 8% | 3% | 89% | 89% Key |
| LORETTA | Mountain | 0.6 | 0.2% | 100% | 0% | 100% | 0% | 0% | 34% | 12% | 54% | Degraded |
| MILLER CREEK | Mountain | 0.2 | 0.0% | 0% | 100% | 100% | 0% | 0% | 42% | 15% | 43% | Degraded |
| MONTE CRISTO | Mountain | 1.3 | 1.5% | 100% | 0% | 0% | 0% | 100% | 18% | 6% | 76% | Degraded |
| MT BAKER | Mountain | 0.5 | 0.8% | 0% | 100% | 0% | 0% | 100% | 9% | 3% | 88% | 88% Key |
| MT BLUM | Mountain | 1.4 | 2.7% | 0% | 100% | 0% | 0% | 100% | 30% | 11% | 60% | 60% Key |
| NEWHALEM CREEK | Mountain | 0.2 | 0.1% | 0% | 100% | 0% | 0% | 100% | 15% | 5% | 80% | 80% Key |
| NOOKACHAMPS | Mountain | 4.8 | 5.2% | 100% | 0% | 100% | 0% | 0% | 61% | 8% | 31% | Degraded |
| PRESSENTIN | Mountain | 1.2 | 0.4% | 0% | 100% | 0% | 0% | 100% | 28% | 11% | 61% | 61% Key |
| RINKER | Mountain | 3.5 | 1.6% | 100% | 0% | 100% | 0% | 0% | 30% | 8% | 62% | Degraded |

Table 2-8-2. Continued.

| WAU or Floodplain | Basin Type | Anadromous Channel Density (m/ha) | Anadromous Channel Length - % of Basin | Sediment "Impaired" | Sediment "Functioning" | Peak Flow "Impaired" | Peak Flow "Moderate Impaired" | Peak Flow "Functioning" | Riparian "Impaired" | Riparian "Moderate Impaired" | Riparian "Functioning" | Generalized Habitat Call |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SA010 | Mountain | 27.4 | 1.6% | 0% | 100% | 0% | 0% | 100% | 44% | 9% | 47% | 47% Key |
| SA020A | Mountain | 30.6 | 0.2% | 0% | 100% | 0% | 0% | 100% | 26% | 9% | 65% | 65% Key |
| SA020B | Mountain | 61.5 | 0.2% | 0% | 100% | 0% | 0% | 100% | 8% | 3% | 89% | 89% Key |
| SA030 | Mountain | 24.7 | 0.5% | 0% | 100% | 0% | 0% | 100% | 26% | 9% | 64% | 64% Key |
| SA040 | Mountain | 53.0 | 0.2% | 0% | 100% | 0% | 0% | 100% | 22% | 8% | 70% | 70% Key |
| SA050 | Mountain | 37.5 | 2.1% | 0% | 100% | 0% | 0% | 100% | 44% | 8% | 49% | 49% Key |
| SA060A | Mountain | 33.1 | 0.2% | 0% | 100% | 0% | 0% | 100% | 45% | 12% | 42% | 42% Key |
| SA060B | Mountain | 66.9 | 1.3% | 0% | 100% | 0% | 0% | 100% | 37% | 11% | 52% | 52% Key |
| SA060C | Mountain | 121.4 | 0.1% | 0% | 100% | 0% | 0% | 100% | 27% | 10% | 63% | 63% Key |
| SA060D | Mountain | 25.6 | 0.1% | 0% | 100% | 0% | 0% | 100% | 89% | 3% | 8% | 89% Degraded |
| SA070 | Mountain | 26.7 | 0.8% | 0% | 100% | 0% | 0% | 100% | 30% | 6% | 63% | 63% Key |
| SAUK PRAIRIE | Mountain | 3.4 | 1.1% | 100% | 0% | 100% | 0% | 0% | 67% | 5% | 27% | Degraded |
| SHANNON, E | Mountain | 2.1 | 1.7% | 0% | 100% | 0% | 0% | 100% | 33% | 8% | 59% | 59% Key |
| SHANNON, W | Mountain | 4.0 | 1.4% | 100% | 0% | 100% | 0% | 0% | 43% | 12% | 45% | Degraded |
| SK060A | Mountain | 23.7 | 4.8% | 0% | 100% | 0% | 0% | 100% | 64% | 8% | 28% | 64% Degraded |
| SK060B | Mountain | 16.0 | 1.2% | 0% | 100% | 0% | 0% | 100% | 58% | 10% | 32% | 58% Degraded |
| SK070A | Mountain | 26.8 | 0.2% | 0% | 100% | 0% | 0% | 100% | 68% | 8% | 24% | 68% Degraded |
| SK070B | Mountain | 24.8 | 0.5% | 0% | 100% | 0% | 0% | 100% | 34% | 13% | 53% | 53% Key |
| SK080A | Mountain | 22.2 | 0.6% | 0% | 100% | 0% | 0% | 100% | 36% | 13% | 51% | 51% Key |
| SK080B | Mountain | 31.1 | 0.6% | 0% | 100% | 0% | 0% | 100% | 58% | 4% | 38% | 58% Degraded |
| SK080C | Mountain | 43.9 | 0.6% | 0% | 100% | 0% | 0% | 100% | 39% | 12% | 49% | 49% Key |
| SK090 | Mountain | 53.4 | 0.5% | 0% | 100% | 0% | 0% | 100% | 51% | 12% | 37% | 51% Degraded |
| SK100 | Mountain | 34.4 | 0.9% | 0% | 100% | 0% | 0% | 100% | 52% | 9% | 40% | 52% Degraded |
| SK100A | Mountain | 24.2 | 2.4% | 0% | 100% | 0% | 0% | 100% | 41% | 8% | 50% | 50% Key |
| SK110 | Mountain | 33.8 | 1.1% | 0% | 100% | 0% | 0% | 100% | 48% | 6% | 45% | 48% Degraded |
| SK130 | Mountain | 24.5 | 0.5% | 0% | 100% | 0% | 0% | 100% | 21% | 8% | 71% | 71% Key |
| SLOAN CREEK | Mountain | 0.0 | 0.0% | 0% | 100% | 0% | 0% | 100% | 1% | 0% | 99% | 99% Key |
| SU010 | Mountain | 35.2 | 0.5% | 0% | 100% | 0% | 0% | 100% | 9% | 3% | 88% | 88% Key |
| SU020A | Mountain | 44.2 | 0.2% | 0% | 100% | 0% | 0% | 100% | 23% | 8% | 69% | 69% Key |
| SU030 | Mountain | 46.8 | 2.1% | 0% | 100% | 0% | 0% | 100% | 6% | 0% | 94% | 93% Key |
| SU040A | Mountain | 99.7 | 1.1% | 0% | 100% | 0% | 0% | 100% | 0% | 0% | 100% | Key |
| SU040B | Mountain | 114.0 | 0.3% | 0% | 100% | 0% | 0% | 100% | 4% | 1% | 95% | 95% Key |
| SU040C | Mountain | 169.2 | 0.5% | 0% | 100% | 0% | 0% | 100% | 18% | 6% | 76% | 76% Key |
| SU050 | Mountain | 89.1 | 0.2% | 0% | 100% | 0% | 0% | 100% | 0% | 0% | 100% | Key |
| TENAS | Mountain | 1.0 | 0.9% | 100% | 0% | 0% | 0% | 100% | 7% | 2% | 91% | Degraded |
| WHCK010 | Mountain | 75.4 | 0.1% | 0% | 100% | 0% | 0% | 100% | 17% | 6% | 77% | 77% Key |
| WHITE CHUCK | Mountain | 1.8 | 2.4% | 0% | 100% | 0% | 0% | 100% | 4% | 1% | 95% | 95% Key |

Potentially each reach (i.e., arc or polygon in the GIS layer) is targeted for either restoration or protection, depending on our analysis of its current condition or potential threat. Generally, key habitats would be targeted for protection while important, degraded and isolated habitats are targeted for restoration. The screening results guide our planning to the likely causes or threats of degradation at the reach level, so the proper restoration or protection action can be determined.

*Limitations*

The primary limitations in accurately identifying generalized habitat types are incomplete natural landscape process screens and the accuracy of individual screens used. Accuracy of individual screens is addressed in their respective sections of this report. Please refer to the "limitation" part of sections 2.1-2.7 for more detail regarding the accuracy of each screen.

The primary consequence of incomplete landscape process screens is an underestimate in the amount of "degraded" and "important" habitat, and an overestimate of the amount of "key" habitat. However, we have high confidence that areas identified as "degraded" are in fact degraded. That is, there is a very low likelihood that areas identified as "degraded" with this analysis will later be identified as "important" or "key" habitat. Conversely, we feel that many areas identified as "key" habitat with this analysis will be changed to "degraded" or "important" as more detailed information becomes available.

The interim riparian screen is applied to only about 50% of the anadromous zone (based on length). The GIS-based riparian screen is reliable for only late- and mid-seral conifer dominated forest (Class 1 and 2) and non-forest areas (Class 15). Because of the higher probability of error in rating stream reaches by the remaining land cover types, they are excluded from the interim screen and show up as "unknown" in Figure 2-19.

The floodplain screen makes calls for mainstem segments that are impaired due to hydromodification and the water quality screen only identifies impaired areas based on the 303d list (see sections 2.5 and 2.7). The low flow hydrology screen has not been developed.

With respect to "isolated" habitat, field-based inventory of man-made blockages to salmon migration has been completed for only a portion of the basin (see section 2.6). The areas identified as "isolated" are accurately characterized as upstream of man-made blockages to salmon because they are based entirely on field inventory. We assume areas yet to be inventoried are "connected" and could be shown as "secondary", "degraded", "important", or "key" habitat when they are really "isolated". Based on our current blockage inventory results however, the consequence of making this assumption is that no more than 4% of the channel length remaining to be inventoried is likely to be upstream of a man-made blockage to salmon migration.

*Methods*

The generalized habitat type layer was constructed by intersecting each of the screening layers with the anadromous zone layer to assign current generalized habitat types. The GIS theme shows the anadromous zone stream coverage with reaches designated as Functioning, Important, Degraded, Secondary, Isolated, or Unknown.

The generalized habitat type GIS theme was constructed by intersecting each of the screening layers with the anadromous zone layer to designate reaches as one of the following:

- Key (i.e., all landscape screens are Functioning);
- Important (i.e., all landscape screens are either Functioning or Moderately Impaired);
- Degraded (i.e., at least one landscape screen is Impaired),
- Secondary (i.e., tributary channel slope is step-pool or steeper);
- Isolated (i.e., upstream of a manmade barrier to fish migration); or
- Unknown.

Some reaches are designated as “unknown” because of the high probability of error in rating the riparian condition correctly by land cover types: early seral forest (Class 3), other forest (Class 4), water (Class 5). These reaches were identified as “unknown” if the other landscape screens were either Functioning or Moderately Impaired.

Water quality and hydromodification of large main channel reaches was also used as a landscape screen, however these coverages were not intersected for this theme because they use a different hydrology coverage than our current anadromous stream coverage. Degraded reaches due to water quality or hydromodification can only be viewed as an “overlay” with the generalized habitat type theme.

For areas of the Lower Skagit main stem, we used streambank hardening, riparian buffer width and levee setback data from inventories described in the floodplain section of this report (Section 2.5) to make generalized habitat delineations. Mainstem areas with <u>any</u> of the following conditions were consider *degraded*:

- Riparian buffer is less than 20 meters wide,
- Streambank edge is hardened (e.g., riprap),
- Levee is present within 60 meters of the bankfull channel edge.

All other Lower Skagit main stem areas were considered *important*.

In the estuary portion of the Skagit’s geomorphic delta (i.e., areas currently exposed to tidal hydrology), areas that are hydromodified are considered *degraded*. Those areas that are not hydromodified, but adjacent to levees are considered *important*. Those areas that are not hydromodified and at least one distributary channel away from a levee are considered *key*.

*Future Work*

Update with more completed and accurate screens.

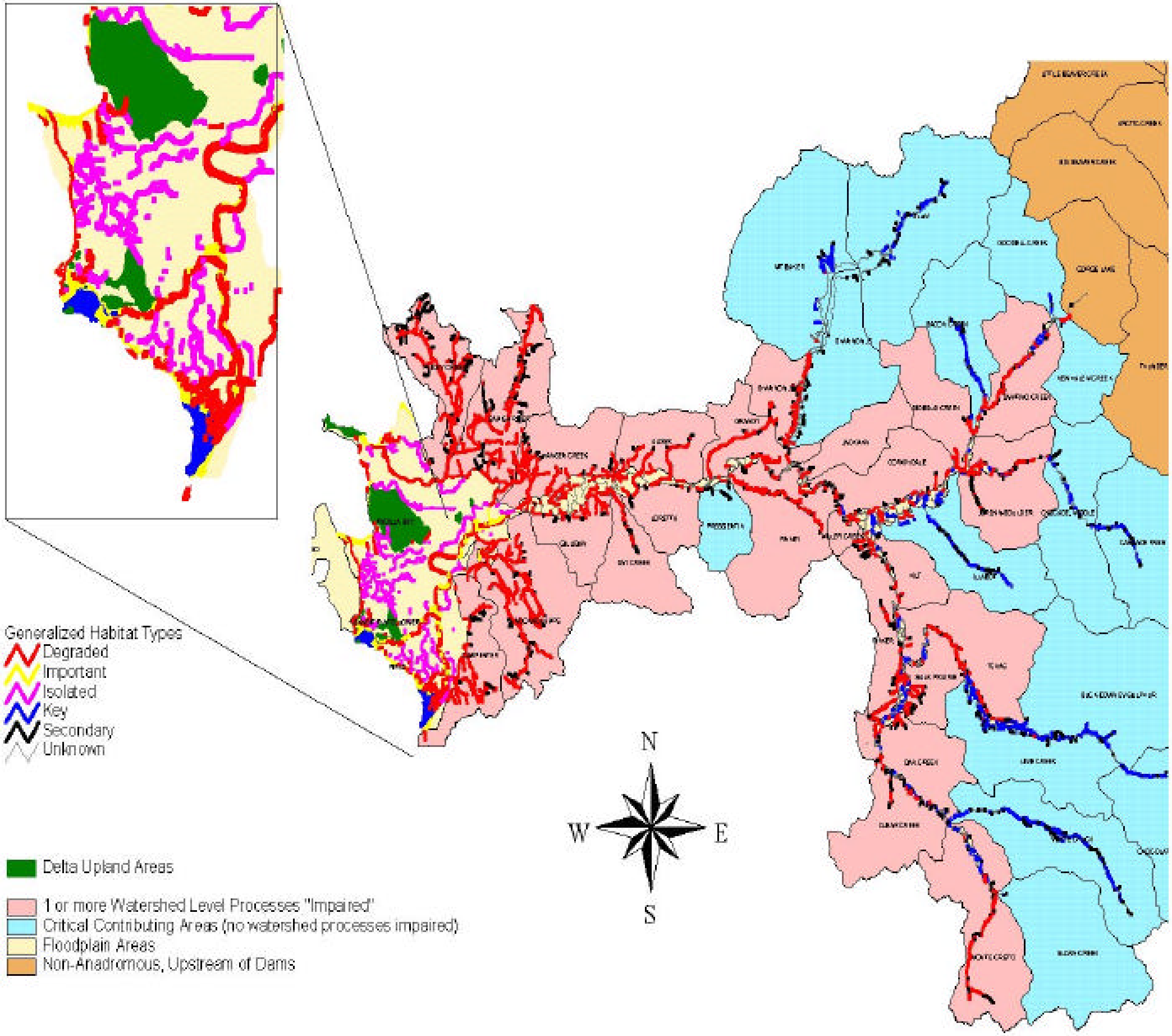



**Figure 2-19. Generalized habitat types in the Skagit and Samish River basins.**

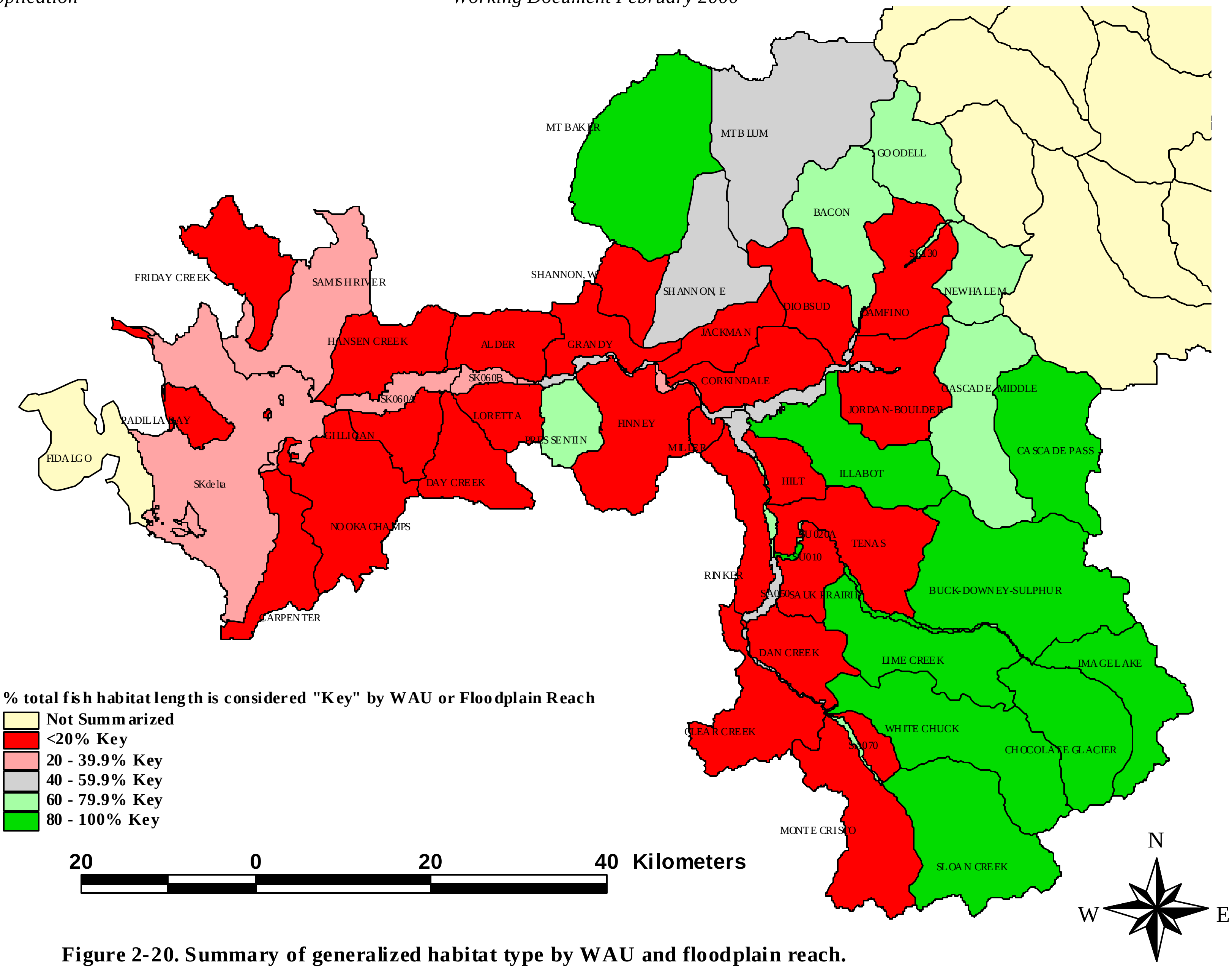



**Figure 2-20. Summary of generalized habitat type by WAU and floodplain reach. WAUs not summarized have incomplete data (Fidalgo only) or are entirely non-anadromous and upstream of dams.**

## 3.0 PRIORITIZED PROJECT LISTS, FEASIBILITY STUDIES, AND MONITORING

The main objective of the Strategy Application is to identify habitat protection and restoration projects based on application of the landscape process screens described in the Strategy. Projects are identified through GIS analyses and field-inventories that classify habitat areas as “functioning,” moderately impaired,” or “impaired.” All projects are then evaluated using a cost-effectiveness analysis. This provides a common basis for making evaluations across the entire watershed, and for prioritizing projects so that the most cost-effective projects can be implemented first.

A final and critical element of the Strategy is the requirement that restoration and protection projects include monitoring procedures. Such procedures will ensure that projects are constructed as proposed, are resulting in the anticipated habitat conditions, and are producing the expected benefits to salmon.

The following sections summarize the identification of protection and restoration projects based on the screens and inventories presented in Section 2. Each section also describes the prioritization procedures for these projects, and presents the current list of prioritized projects. To date, more than 30 different GIS themes have been used to apply six of the eight landscape process screens identified by the Strategy. We find that 23 % and 46 % of the watershed is likely impaired with respect to hydrology and sediment, respectively. Out of 2,000 km of channels in the anadromous zone, more than 42% is in need of riparian restoration. Field inventories have identified 164 km of channel blocked from anadromous fish use. Inventories of USFS roads identified more than 600 km of roads that have a high or moderate risk of creating landslides that damage salmon habitat. Together, these analyses – undertaken over the course of the past 12 months – have led to the identification of more than 400 individual restoration projects.

### 3.1 Sediment Reduction

The US Forest Service has inventoried the majority of its roads in the Skagit River basin over the past several years. The purpose of the inventory was to rate the probability that roads will cause landslides and subsequently damage important fish habitat. The inventory method combines ratings of factors that influence road-related landslides with ratings of the consequences of landslides. The final value, called the risk rating, ranks roads with respect the threat that they pose to salmon habitat. Higher risk ratings indicate greater chance that a road will fail and impact salmon habitat. (The road inventory methods are described in Section 2.3.)

Decommissioning of roads on Forest Service lands requires a completed Watershed Analysis and NEPA assessment. With these requirements, USFS can complete approximately 10 miles of road decommissioning and 20 miles of road storm proofing per year. At an average cost of $28,438 per mile of road (including costs of biological assessments, NEPA, contracting, and overhead), the work will cost approximately

$853,000 for one year. Implementation monitoring (checking to see that all planned work was completed as designed) adds an additional 1% to the cost ($8,500), for a total cost of $861,500. (The total estimated cost for all high-hazard and moderate-hazard roads is approximately $11.6 million).

USFS watershed analyses have been completed, and road decommissioning can proceed, in the following WAUs: Finney, Pressentin, Loretta, Day, Rinker, Tenas, Dan Creek, Sauk Prairie, Clear, and Monte Cristo. Based on a simplified cost-effectiveness assessment incorporating length of anadromous stream per WAU and the total cost of road work, the highest priority WAUs are Sauk Prairie, Pressentin, Loretta, and Dan Creek. Locations of the high- and moderate-hazard roads and the four highest priority WAUs are shown in Figure 2-10.

## 3.2 RIPARIAN

Riparian planting and restoration projects have been identified through a series of field inventories. The inventories were completed systematically as four separate projects in 1995, 1996, and 1998 in 9 of 38 Skagit River WAUs. Inventory has been completed for the Nookachamps WAU (1995), Hansen Creek WAU (1996), Illabot WAU (1998), and the Hilt, Rinker, Clear Creek, Sauk Prairie, Dan Creek, and Monte Cristo (portion from the confluence of the North and South Forks Sauk downstream) WAUs. Figure 2-14 shows inventory locations.

We identified projects by walking all - streams accessible to anadromous fish in the surveyed WAUs and assessing the riparian vegetation conditions for each stream reach. We identified all stream segments with forested riparian vegetation buffers of less than 40 meters as requiring planting and all segments with evidence of livestock access to the stream channel as requiring fencing. Planting costs were estimated at $2600 per hectare, or $1040 per acre. Fencing costs were estimated at $14 per linear meter or $4.30 per foot. Cost figures include implementation monitoring of each project in the first year, in accordance with the Strategy. Implementation monitoring ensures that each project was planted as designed. Effectiveness monitoring will be carried out in later years as part of an overall watershed restoration project-monitoring program.

Projects were prioritized based on cost-effectiveness, which were calculated as described in the Strategy (Section 3.2.1 of Skagit Watershed Council 1998). Cost effectiveness was calculated by multiplying benefit (B) by benefit time (T) and dividing the product by project cost (C).

$$\text{Cost Effectiveness} = BT/C$$

Benefit was calculated as benefit area (A) multiplied by benefit value ($\Delta V$).

$$\text{Benefit} = \Delta V * A$$

The area benefiting from a given project was taken to be the length of the stream segment adjacent to the project multiplied by the average width of the segment. Benefit value was assigned as 0.5 for any project for which other watershed processes would remain degraded post-project (i.e., a riparian project located within a WAU for which sediment supply and hydrology are considered degraded would get a 0.5 rating) or assigned based on Section 3.2.1 of the Strategy.

Benefit time (T) was calculated as 10 years for fencing projects (estimated fence life) and a value based on a maximum 200 years of benefit minus 50% of the time required to grow a Douglas fir large enough to supply pool-forming LWD to a channel of a given width for planting projects. For combination projects (planting and fencing) the time values were combined.

We have identified 122 riparian planting and fencing projects in the WAUs inventoried, with a total cost estimated at $1,687,000. All projects are listed in Table 3-2-1. Of these projects, 39 are already funded (shown with background shaded and in **bold** print, Table 3-2-1) and 18 were submitted for funding on June 30, 1999 (shown in ***bold italic*** print, Table 3-2-1).

Table 3-2-1. Prioritized riparian and fencing projects. Shaded rows have been funded. Rows in *italic* print have been submitted for funding.

| WAU or Stream Name | Reach # | Total Planting Area (ha) | Total Fencing Length (m) | Fencing cost ($13/LM) | Planting Cost @ $2,500/ ha | Total cost | Benefit area (A in m$^2$) | Benefit Rating (V) | Benefit (B) | Planting Time T(yrs) | Add time for Fencing, Total T (yrs) | Cost Effective-ness (BT/C) | Current Project Ranking |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Illabot | 04.1346.1 | 1.34 | 0 | $0 | $3,494 | $3,494 | 6,888 | 1 | 6888 | 125 | 125 | 246.39 | 1 |
| Illabot | 04.1346.2 | 2.93 | 0 | $0 | $7,606 | $7,606 | 13,730 | 1 | 13729.9 | 125 | 125 | 225.66 | 2 |
| Nookachamps | 03.0227.3 | 0.19 | 0 | $0 | $465 | $465 | 1,135 | 0.5 | 567.3 | 170 | 170 | 207.40 | 3 |
| Lyle Cr | 4.1067.4 | 0.09 | | $0 | $221 | $221 | 425 | 0.5 | 212.5 | 190 | 190 | 182.69 | 4 |
| Hansen | 03.0280.3 | 0.04 | 0 | $0 | $105 | $105 | 210 | 0.5 | 105 | 182.5 | 182.5 | 182.50 | 5 |
| Hansen | 03.0267.7 | 0.52 | 0 | $0 | $1,290 | $1,290 | 2,322 | 0.5 | 1161 | 182.5 | 182.5 | 164.25 | 6 |
| Hansen | 03.0267.5 | 1.09 | 0 | $0 | $2,730 | $2,730 | 4,368 | 0.5 | 2184 | 182.5 | 182.5 | 146.00 | 7 |
| Hansen | 03.0280.5 | 1.35 | 0 | $0 | $3,385 | $3,385 | 4,059 | 0.5 | 2029.5 | 170 | 170 | 101.92 | 8 |
| Nookachamps | 03.0239.2 | 0.37 | 0 | $0 | $921 | $921 | 1,095 | 0.5 | 547.4 | 170 | 170 | 101.07 | 9 |
| Hansen | 03.0280.2 | 0.79 | 139 | $1,807 | $1,970 | $3,777 | 3,940 | 0.5 | 1970 | 182.5 | 192.5 | 100.40 | 10 |
| Hansen | 03.0267.6 | 3.54 | 0 | $0 | $8,845 | $8,845 | 10,380 | 0.5 | 5190 | 170 | 170 | 99.75 | 11 |
| Hansen | 03.0332.1 | 7.12 | 140 | $1,820 | $17,805 | $19,625 | 21,600 | 0.5 | 10800 | 170 | 180 | 99.06 | 12 |
| Hansen | 03.0268.3 | 1.07 | 0 | $0 | $2,665 | $2,665 | 2,338 | 0.5 | 1169 | 182.5 | 182.5 | 80.05 | 13 |
| Hansen | Youngs.1 | 11.41 | 1637 | $21,281 | $28,525 | $49,806 | 48,930 | 0.5 | 24465 | 150 | 160 | 78.59 | 14 |
| Nookachamps | 03.0265.2 | 0.83 | 0 | $0 | $2,085 | $2,085 | 1,710 | 0.5 | 854.85 | 190 | 190 | 77.90 | 15 |
| Nookachamps | 03.0227.6 | 5.24 | 0 | $0 | $13,110 | $13,110 | 10,647 | 0.5 | 5323.35 | 182.5 | 182.5 | 74.10 | 16 |
| Nookachamps | 03.0230.4 | 16.56 | 940 | $12,223 | $41,399 | $53,623 | 48,624 | 0.5 | 24312.2 | 150 | 160 | 72.54 | 17 |
| Hansen | 03.0267.1 | 8.72 | 79 | $1,027 | $21,790 | $22,817 | 17,030 | 0.5 | 8515 | 182.5 | 192.5 | 71.84 | 18 |
| Unnamed | 4.0675.2 | 0.86 | | $0 | $2,230 | $2,230 | 1,740 | 0.5 | 869.75 | 182.5 | 182.5 | 71.20 | 19 |
| Nookachamps | 03.0239.3 | 15.42 | 0 | $0 | $38,559 | $38,559 | 28,992 | 0.5 | 14496 | 182.5 | 182.5 | 68.61 | 20 |
| Hansen | 03.0278.1 | 15.81 | 550 | $7,150 | $39,525 | $46,675 | 32,280 | 0.5 | 16140 | 182.5 | 192.5 | 66.57 | 21 |
| Hansen | 03.0267.2 | 8.66 | 0 | $0 | $21,655 | $21,655 | 15,020 | 0.5 | 7510 | 182.5 | 182.5 | 63.29 | 22 |
| Hilt Cr | 4.0678.2 | 0.84 | | $0 | $2,184 | $2,184 | 1,464 | 0.5 | 732 | 182.5 | 182.5 | 61.17 | 23 |
| Green Cr | 4.1073.7 | 0.96 | | $0 | $2,493 | $2,493 | 1,644 | 0.5 | 822 | 182.5 | 182.5 | 60.16 | 24 |
| Nookachamps | 03.0230.3 | 16.23 | 30 | $396 | $40,581 | $40,977 | 22,801 | 0.5 | 11400.4 | 182.5 | 192.5 | 53.56 | 25 |
| Nookachamps | 03.0248.2 | 0.62 | 0 | $0 | $1,538 | $1,538 | 856 | 0.5 | 427.85 | 190 | 190 | 52.85 | 26 |
| Nookachamps | 03.0231.3 | 0.40 | 0 | $0 | $1,006 | $1,006 | 576 | 0.5 | 287.85 | 182.5 | 182.5 | 52.21 | 27 |

Table 3-2-1 Continued. Prioritized riparian and fencing projects. Shaded rows have been funded. Rows in *italic* print have been submitted for funding.

| WAU or Stream Name | Reach # | Total Planting Area (ha) | Total Fencing Length (m) | Fencing cost ($13/LM) | Planting Cost @ $2,500/ ha | Total cost | Benefit area (A in m$^2$) | Benefit Rating (V) | Benefit (B) | Planting Time T(yrs) | Add time for Fencing, Total T (yrs) | Cost Effective-ness (BT/C) | Current Project Ranking |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Frustration Cr** | **4.0707.1** | **0.44** | | **$0** | **$1,138** | **$1,138** | **625** | **0.5** | **312.5** | **190** | **190** | **52.20** | 28 |
| Nookachamps | 03.0259.2 | 0.28 | 0 | $0 | $700 | $700 | 399 | 0.5 | 199.5 | 182.5 | 182.5 | 52.01 | 29 |
| Hansen | 03.0279.1 | 11.64 | 225 | $2,925 | $29,100 | $32,025 | 17,272 | 0.5 | 8636 | 182.5 | 192.5 | 51.91 | 30 |
| Nookachamps | 03.0230.1 | 12.62 | 0 | $0 | $31,553 | $31,553 | 18,354 | 0.5 | 9177 | 170 | 170 | 49.44 | 31 |
| Hansen | 03.0267.4 | 8.41 | 0 | $0 | $21,020 | $21,020 | 11,296 | 0.5 | 5648 | 182.5 | 182.5 | 49.04 | 32 |
| **Green Cr** | **4.1073.2** | **0.20** | | **$0** | **$530** | **$530** | **272** | **0.5** | **136** | **190** | **190** | **48.72** | 33 |
| Nookachamps | 03.0227A.3 | 0.82 | 134 | $1,744 | $2,056 | $3,800 | 1,816 | 0.5 | 908.2 | 190 | 200 | 47.80 | 34 |
| Hansen | 03.0280.4 | 4.41 | 0 | $0 | $11,035 | $11,035 | 5,744 | 0.5 | 2872 | 182.5 | 182.5 | 47.50 | 35 |
| Nookachamps | 03.0239.4 | 1.58 | 0 | $0 | $3,945 | $3,945 | 2,048 | 0.5 | 1024 | 182.5 | 182.5 | 47.37 | 36 |
| Nookachamps | 03.0235.1 | 5.37 | 286 | $3,714 | $13,415 | $17,128 | 8,060 | 0.5 | 4029.75 | 182.5 | 192.5 | 45.29 | 37 |
| Nookachamps | 03.0227.5 | 14.65 | 1474 | $19,162 | $36,630 | $55,792 | 27,922 | 0.5 | 13961 | 170 | 180 | 45.04 | 38 |
| **Osterman Cr** | **4.0686.1** | **1.60** | | **$0** | **$4,160** | **$4,160** | **2,040** | **0.5** | **1020** | **182.5** | **182.5** | **44.75** | 39 |
| Hansen | 03.0279.2 | 8.51 | 0 | $0 | $21,285 | $21,285 | 10,377 | 0.5 | 5188.5 | 182.5 | 182.5 | 44.49 | 40 |
| **Gravel Cr** | **4.1071.5** | **1.19** | | **$0** | **$3,085** | **$3,085** | **1,491** | **0.5** | **745.3** | **182.5** | **182.5** | **44.09** | 41 |
| Nookachamps | 03.0227.1 | 35.68 | 4098 | $53,274 | $89,210 | $142,484 | 64,400 | 0.5 | 32200 | 182.5 | 192.5 | 43.50 | 42 |
| Hansen | 03.0280.1 | 10.54 | 2186 | $28,418 | $26,345 | $54,763 | 23,880 | 0.5 | 11940 | 182.5 | 192.5 | 41.97 | 43 |
| Nookachamps | 03.0265.3 | 0.18 | 0 | $0 | $450 | $450 | 198 | 0.5 | 99 | 190 | 190 | 41.83 | 44 |
| **Green Cr** | **4.1073.1** | **0.32** | **0** | **$0** | **$837** | **$837** | **368** | **0.5** | **184** | **190** | **190** | **41.76** | 45 |
| **Unnamed** | **4.0674.1** | **0.28** | | **$0** | **$728** | **$728** | **312** | **0.5** | **156** | **190** | **190** | **40.71** | 46 |
| Nookachamps | 03.0230.2 | 6.59 | 342 | $4,447 | $16,468 | $20,915 | 9,151 | 0.5 | 4575.3 | 170 | 180 | 39.38 | 47 |
| Nookachamps | 03.0259.3 | 1.46 | 0 | $0 | $3,650 | $3,650 | 1,571 | 0.5 | 785.4 | 182.5 | 182.5 | 39.27 | 48 |
| Nookachamps | 03.0239.1 | 6.28 | 951 | $12,358 | $15,707 | $28,065 | 12,003 | 0.5 | 6001.6 | 170 | 180 | 38.49 | 49 |
| Nookachamps | 03.0263.1 | 1.05 | 0 | $0 | $2,620 | $2,620 | 1,034 | 0.5 | 516.8 | 190 | 190 | 37.48 | 50 |
| Nookachamps | 03.0243.1 | 1.32 | 0 | $0 | $3,290 | $3,290 | 1,320 | 0.5 | 660 | 182.5 | 182.5 | 36.62 | 51 |
| **Unnamed** | **4.1094.1** | **0.04** | | **$0** | **$104** | **$104** | **40** | **0.5** | **20** | **190** | **190** | **36.54** | 52 |
| **Unnamed** | **4.1094.2** | **0.54** | | **$0** | **$1,404** | **$1,404** | **540** | **0.5** | **270** | **190** | **190** | **36.54** | 53 |
| Hansen | 03.0267.3 | 16.41 | 0 | $0 | $41,015 | $41,015 | 16,256 | 0.5 | 8128 | 182.5 | 182.5 | 36.17 | 54 |
| **Hatchery Cr** | **4.1062.3** | **0.14** | | **$0** | **$374** | **$374** | **140** | **0.5** | **70** | **190** | **190** | **35.52** | 55 |
| Nookachamps | 03.0261.1 | 1.34 | 0 | $0 | $3,360 | $3,360 | 1,235 | 0.5 | 617.7 | 182.5 | 182.5 | 33.55 | 56 |
| Nookachamps | 03.0227.4 | 30.29 | 3424 | $44,512 | $75,715 | $120,227 | 41,858 | 0.5 | 20929.1 | 182.5 | 192.5 | 33.51 | 57 |

Table 3-2-1 Continued. Prioritized riparian and fencing projects. Shaded rows have been funded. Rows in *italic* print have been submitted for funding.

| WAU or Stream Name | Reach # | Total Planting Area (ha) | Total Fencing Length (m) | Fencing cost ($13/LM) | Planting Cost @ $2,500/ ha | Total cost | Benefit area (A in m$^2$) | Benefit Rating (V) | Benefit (B) | Planting Time T(yrs) | Add time for Fencing, Total T (yrs) | Cost Effective-ness (BT/C) | Current Project Ranking |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nookachamps | 03.0241.2 | 3.73 | 0 | $0 | $9,320 | $9,320 | 3,123 | 0.5 | 1561.6 | 190 | 190 | 31.84 | 58 |
| Hansen | 03.0294.1 | 12.75 | 0 | $0 | $31,870 | $31,870 | 11,055 | 0.5 | 5527.5 | 182.5 | 182.5 | 31.65 | 59 |
| **Green Cr** | **4.1073.4** | **0.96** | | **$0** | **$2,490** | **$2,490** | **825** | **0.5** | **412.5** | **190** | **190** | **31.48** | 60 |
| **Hatchery Cr** | **4.1062.1** | **0.20** | | **$0** | **$519** | **$519** | **171** | **0.5** | **85.5** | **190** | **190** | **31.32** | 61 |
| **Dutch Cr** | **4.1076.5** | **0.50** | | **$0** | **$1,287** | **$1,287** | **413** | **0.5** | **206.25** | **190** | **190** | **30.45** | 62 |
| Nookachamps | 03.0231.1 | 15.01 | 0 | $0 | $37,527 | $37,527 | 12,482 | 0.5 | 6241.2 | 182.5 | 182.5 | 30.35 | 63 |
| Nookachamps | 03.0227.2 | 0.78 | 220 | $2,860 | $1,940 | $4,800 | 1,529 | 0.5 | 764.5 | 170 | 180 | 28.67 | 64 |
| Nookachamps | 03.0257.1 | 4.13 | 0 | $0 | $10,317 | $10,317 | 3,028 | 0.5 | 1514 | 190 | 190 | 27.88 | 65 |
| **Everett Cr** | **4.1074.3** | **1.93** | | **$0** | **$5,015** | **$5,015** | **1,404** | **0.5** | **702** | **190** | **190** | **26.59** | 66 |
| **Green Cr** | **4.1073.5** | **0.43** | | **$0** | **$1,112** | **$1,112** | **314** | **0.5** | **156.75** | **182.5** | **182.5** | **25.74** | 67 |
| **Green Cr** | **4.1073.6** | **1.27** | | **$0** | **$3,295** | **$3,295** | **886** | **0.5** | **442.75** | **190** | **190** | **25.53** | 68 |
| Nookachamps | 03.0248.3 | 6.25 | 0 | $0 | $15,625 | $15,625 | 4,030 | 0.5 | 2015 | 190 | 190 | 24.50 | 69 |
| **Everett Cr** | **4.1074.4** | **1.31** | **55** | **$770** | **$3,400** | **$4,170** | **1,020** | **0.5** | **510** | **190** | **200** | **24.46** | 70 |
| Hansen | 03.0268.1 | 6.03 | 0 | $0 | $15,085 | $15,085 | 3,870 | 0.5 | 1935 | 190 | 190 | 24.37 | 71 |
| **Martin Cr** | **4.1203.3** | **2.34** | | **$0** | **$6,084** | **$6,084** | **1,500** | **0.5** | **750** | **190** | **190** | **23.42** | 72 |
| **Mouse Cr** | **4.1087.1** | **1.24** | **45** | **$630** | **$3,221** | **$3,851** | **885** | **0.5** | **442.5** | **190** | **200** | **22.98** | 73 |
| Nookachamps | 03.0232.4 | 0.22 | 0 | $0 | $549 | $549 | 130 | 0.5 | 64.8 | 190 | 190 | 22.44 | 74 |
| Nookachamps | 03.0253.1 | 19.77 | 183 | $2,378 | $49,422 | $51,800 | 11,601 | 0.5 | 5800.7 | 190 | 200 | 22.40 | 75 |
| Nookachamps | 03.0264.1 | 0.36 | 0 | $0 | $890 | $890 | 207 | 0.5 | 103.5 | 190 | 190 | 22.09 | 76 |
| Nookachamps | 03.0237.1 | 5.59 | 611 | $7,943 | $13,986 | $21,929 | 4,595 | 0.5 | 2297.25 | 190 | 200 | 20.95 | 77 |
| Nookachamps | 03.0232.1 | 6.75 | 380 | $4,940 | $16,880 | $21,820 | 4,570 | 0.5 | 2285 | 190 | 200 | 20.94 | 78 |
| **Skull Cr** | **4.1197.1** | **2.10** | | **$0** | **$5,460** | **$5,460** | **1,200** | **0.5** | **600** | **190** | **190** | **20.88** | 79 |
| Nookachamps | 03.0231.2 | 7.09 | 0 | $0 | $17,732 | $17,732 | 3,725 | 0.5 | 1862.7 | 190 | 190 | 19.96 | 80 |
| **Green Cr** | **4.1073.8** | **0.61** | **80** | **$1,120** | **$1,587** | **$2,707** | **538** | **0.5** | **268.75** | **190** | **200** | **19.85** | 81 |
| Nookachamps | 03.0233.1 | 0.22 | 0 | $0 | $543 | $543 | 111 | 0.5 | 55.35 | 190 | 190 | 19.38 | 82 |
| **Gravel Cr** | **4.1071.4** | **0.56** | **280** | **$3,920** | **$1,456** | **$5,376** | **1,064** | **0.5** | **532** | **182.5** | **192.5** | **19.05** | 83 |
| Nookachamps | 03.0260.1 | 3.49 | 0 | $0 | $8,723 | $8,723 | 1,699 | 0.5 | 849.6 | 190 | 190 | 18.51 | 84 |
| **Mouse Cr** | **4.1087.8** | **0.98** | | **$0** | **$2,561** | **$2,561** | **412** | **0.5** | **205.8** | **190** | **190** | **15.27** | 85 |

Table 3-2-1 Continued. Prioritized riparian and fencing projects. Shaded rows have been funded. Rows in *italic* print have been submitted for funding.

| WAU or Stream Name | Reach # | Total Planting Area (ha) | Total Fencing Length (m) | Fencing cost ($13/LM) | Planting Cost @ $2,500/ ha | Total cost | Benefit area (A in m$^2$) | Benefit Rating (V) | Benefit (B) | Planting Time T(yrs) | Add time for Fencing, Total T (yrs) | Cost Effective-ness (BT/C) | Current Project Ranking |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nookachamps | 03.0241.1 | 5.48 | 719 | $9,347 | $13,695 | $23,042 | 3,468 | 0.5 | 1734.2 | 190 | 200 | 15.05 | 86 |
| Nookachamps | 03.0227A.1 | 3.45 | 0 | $0 | $8,616 | $8,616 | 1,293 | 0.5 | 646.5 | 190 | 190 | 14.26 | 87 |
| **Hatchery Cr** | **4.1062.2** | **0.25** | | **$0** | **$641** | **$641** | **96** | **0.5** | **48** | **190** | **190** | **14.24** | 88 |
| **Unnamed** | **4.1201.1** | **0.70** | | **$0** | **$1,830** | **$1,830** | **273** | **0.5** | **136.4** | **190** | **190** | **14.16** | 89 |
| Nookachamps | 03.0229.1 | 23.84 | 705 | $9,170 | $59,612 | $68,782 | 9,546 | 0.5 | 4773 | 190 | 200 | 13.88 | 90 |
| Nookachamps | 03.0233.2 | 0.60 | 0 | $0 | $1,488 | $1,488 | 215 | 0.5 | 107.3 | 190 | 190 | 13.70 | 91 |
| **Mouse Cr** | **4.1087.4** | **0.76** | | **$0** | **$1,976** | **$1,976** | **285** | **0.5** | **142.5** | **190** | **190** | **13.70** | 92 |
| **Lyle Cr** | **4.1067.5** | **1.48** | | **$0** | **$3,848** | **$3,848** | **555** | **0.5** | **277.5** | **190** | **190** | **13.70** | 93 |
| Nookachamps | 03.0254.1 | 6.63 | 0 | $0 | $16,572 | $16,572 | 2,241 | 0.5 | 1120.35 | 190 | 190 | 12.85 | 94 |
| Nookachamps | 03.0259.1 | 3.78 | 885 | $11,505 | $9,445 | $20,950 | 2,615 | 0.5 | 1307.5 | 190 | 200 | 12.48 | 95 |
| **Green Cr** | **4.1073.3** | **0.35** | | **$0** | **$897** | **$897** | **115** | **0.5** | **57.5** | **190** | **190** | **12.18** | 96 |
| Nookachamps | 03.0256.1 | 12.85 | 0 | $0 | $32,122 | $32,122 | 4,015 | 0.5 | 2007.5 | 190 | 190 | 11.87 | 97 |
| Hansen | 03.0268.5 | 1.00 | 554 | $7,202 | $2,500 | $9,702 | 1,108 | 0.5 | 554 | 190 | 200 | 11.42 | 98 |
| Hansen | 03.0268.2 | 6.72 | 1080 | $14,040 | $16,800 | $30,840 | 3,460 | 0.5 | 1730 | 190 | 200 | 11.22 | 99 |
| Nookachamps | 03.0227A.2 | 10.90 | 853 | $11,094 | $27,241 | $38,334 | 4,256 | 0.5 | 2128 | 190 | 200 | 11.10 | 100 |
| **Unnamed Green Cr trib** | **4.1077.1** | **1.61** | **560** | **$7,840** | **$4,186** | **$12,026** | **1,232** | **0.5** | **616** | **190** | **200** | **10.24** | 101 |
| **Dutch Cr** | **4.1076.2** | **1.36** | **716** | **$10,024** | **$3,544** | **$13,568** | **1,360** | **0.5** | **680.2** | **190** | **200** | **10.03** | 102 |
| Nookachamps | 03.0228.1 | 3.01 | 384 | $4,986 | $7,518 | $12,504 | 1,253 | 0.5 | 626.25 | 190 | 200 | 10.02 | 103 |
| **Lyle Cr** | **4.1067.3** | **2.80** | **800** | **$11,200** | **$7,280** | **$18,480** | **1,800** | **0.5** | **900** | **190** | **200** | **9.74** | 104 |
| Nookachamps | 03.0232.3 | 3.06 | 618 | $8,030 | $7,640 | $15,670 | 1,513 | 0.5 | 756.65 | 190 | 200 | 9.66 | 105 |

Table 3-2-1 Continued. Prioritized riparian and fencing projects. Shaded rows have been funded. Rows in *italic* print have been submitted for funding.

| WAU or Stream Name | Reach # | Total Planting Area (ha) | Total Fencing Length (m) | Fencing cost ($13/LM) | Planting Cost @ $2,500/ ha | Total cost | Benefit area (A in $m^2$) | Benefit Rating (V) | Benefit (B) | Planting Time T(yrs) | Add time for Fencing, Total T (yrs) | Cost Effective-ness (BT/C) | Current Project Ranking |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nookachamps | 03.0255.1 | 0.78 | 0 | $0 | $1,951 | $1,951 | 196 | 0.5 | 98 | 190 | 190 | 9.54 | 106 |
| Nookachamps | 03.0254.2 | 0.92 | 0 | $0 | $2,311 | $2,311 | 232 | 0.5 | 116 | 190 | 190 | 9.54 | 107 |
| **Mouse Cr** | **4.1087.9** | **1.02** | | **$0** | **$2,657** | **$2,657** | **262** | **0.5** | **131** | **190** | **190** | **9.37** | 108 |
| Unnamed | 4.1201.2 | 0.13 | | $0 | $333 | $333 | 32 | 0.5 | 16 | 190 | 190 | 9.13 | 109 |
| Lyle Cr | 4.1067.2 | 0.38 | 108 | $1,512 | $983 | $2,495 | 216 | 0.5 | 108 | 190 | 200 | 8.66 | 110 |
| Green Cr | 4.1073.9 | 1.86 | 596 | $8,344 | $4,829 | $13,173 | 983 | 0.5 | 491.7 | 190 | 200 | 7.47 | 111 |
| Unnamed Mouse Cr Trib | 4.1088.1 | 4.74 | 290 | $4,060 | $12,334 | $16,394 | 1,186 | 0.5 | 593 | 190 | 200 | 7.23 | 112 |
| Mouse Cr | 4.1087.2 | 1.30 | 90 | $1,260 | $3,390 | $4,650 | 326 | 0.5 | 163 | 190 | 200 | 7.01 | 113 |
| Dutch Cr | 4.1076.1 | 1.58 | 198 | $2,772 | $4,118 | $6,890 | 475 | 0.5 | 237.6 | 190 | 200 | 6.90 | 114 |
| Mouse Cr | 4.1087.3 | 0.48 | | $0 | $1,248 | $1,248 | 90 | 0.5 | 45 | 190 | 190 | 6.85 | 115 |
| Unnamed Everett Cr Trib | 4.1074a.1 | 0.55 | 158 | $2,212 | $1,438 | $3,650 | 237 | 0.5 | 118.5 | 190 | 200 | 6.49 | 116 |
| Everett Cr | 4.1074.5 | 0.80 | 100 | $1,400 | $2,080 | $3,480 | 200 | 0.5 | 100 | 190 | 200 | 5.75 | 117 |
| Nookachamps | 03.0265.1 | 1.73 | 0 | $0 | $4,320 | $4,320 | 259 | 0.5 | 129.6 | 190 | 190 | 5.70 | 118 |
| Unnamed Everett Cr Trib | 4.1074a.2 | 0.69 | 402 | $5,628 | $1,802 | $7,430 | 402 | 0.5 | 201 | 190 | 200 | 5.41 | 119 |
| Unnamed Everett Cr. trib | 4.1075.? | 1.60 | 200 | $2,800 | $4,160 | $6,960 | 300 | 0.5 | 150 | 190 | 200 | 4.31 | 120 |
| Dutch Cr | 4.1076.4 | 1.07 | 274 | $3,836 | $2,778 | $6,614 | 274 | 0.5 | 137 | 190 | 200 | 4.14 | 121 |
| Gravel Cr | 4.1071.3 | 0.00 | 214 | $2,996 | $0 | $2,996 | 556 | 0.5 | 278.2 | 0 | 10 | 0.93 | 122 |

## 3.3 Isolated Habitat

The Skagit Watershed Council has identified isolated habitat projects through a systematic field inventory of stream crossing structures (culverts, bridges, dams, and other manmade structures), following the Fish Passage Barrier and Prioritization Manual of Washington Department of Fish and Wildlife (WDFW 1998). The Manual uses standard fish passage criteria (e.g., outfall drop, culvert slope, culvert width, and water depth and velocity) to determine whether salmon can migrate upstream through a stream crossing structure. All structures that do not meet fish passage criteria are classified as blocking, although some are only partial blockages to salmon migration. Partial blockages usually allow most adult salmon to move upstream, but not juveniles. Complete blockages preclude both adult and juvenile passage.

Through September 1999, we have completed field inventory of 13 out of 38 Watershed Administrative Units (WAUs) and identified 229 blockages (Figure 2-16). However, in this report we are only able to present project tables accounting for 101 of these blockages due to lags between collecting the field inventory data and entering the data in spreadsheets and GIS themes. Of the 101 blocking structures, 30 are partial blockages on tributaries, 8 are considered complete blockages on tributaries, and 63 are blockages on sloughs that must be treated as portions of larger restoration projects.

Projects with uncomplicated designs and relatively clear benefits are listed in Tables 3-3-1 and 3-3-2. The partial blockages (Table 3-3-1) can each be considered independently of other culverts because salmon currently access the culvert sites, and repair of the structures will provide benefits commensurate with the amount of habitat upstream. Groups of completely blocking structures on the same watercourse should be considered either in combination or sequentially (Table 3-3-2). For these groups of blockages, downstream culverts must be repaired before upstream culverts in order to realize fish passage benefits.

Projects that involve flood protection levees, coordination of numerous landowners, or watershed analysis to identify other habitat issues are listed in Table 3-3-3. Such complex projects require feasibility studies to determine suitable restoration actions, and are set on a longer-term path for design and implementation. Feasibility study areas are discussed in Section 3.6 of this report. Currently we have a list of 63 blockages that were determined to be blocking using the Level A survey. Numerous other culverts on the sloughs will require a hydraulic analysis (Level B survey) to determine if flow velocities are too high for fish passage. Hydraulic analyses cannot be completed until design flows are selected for each slough.

Cost-effectiveness for a project is the habitat area upstream of the project, multiplied by the average life span of a culvert (50 years), divided by the cost of the project. We estimated costs by type of road, with forest roads and driveways at $30,000, USFS roads and county roads at $100,000, and state and local highways at $250,000. The habitat area affected by each project is the average channel width multiplied by the length of stream accessible to salmon upstream of the blockage.

Table 3-3-1. Partial blockages to salmon migration. These crossing structures do not meet WDFW criteria for fish passage. Juvenile salmon typically cannot pass upstream, and delays to adult migration may occur at some locations. The "Project group" column shows the sequence of projects for projects on the same system (the first number indicates which group a project belongs to, and the second number indicates the sequence from downstream to upstream).

| Partial block stream crossings | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | W | L | A | V | C | T | | | | |
| Project Group | Site | Width (m) | Length (m) | Area (m^2) | value | cost | Time (years) | B/C | Road Name | Stream | WRIA |
| 1.1 | AR25.1.1 | 4 | 890 | 3560 | 1 | $100,000 | 50 | 1.8 | Maple St. | Careys Cr | 03.0354 |
| 1.2 | AR39.1.2 | 45 | 1354 | 60930 | 1 | $100,000 | 50 | 30.5 | Pettit Road | Careys Slough | 03.0354 |
| 1.3 | AR38.2.2 | 4 | 1000 | 4000 | 1 | $30,000 | 50 | 6.7 | none | Careys Cr | 03.0354 |
| 2 | AR9.1.1 | 5.8 | 5345 | 31001 | 1 | $100,000 | 50 | 15.5 | Hamilton Cemetery Rd | Red Cabin Cr | 03.0343 |
| 3 | GN34.1.1 | 6 | 620 | 3720 | 1 | $30,000 | 50 | 6.2 | none | unnamed | 03.0286X |
| 4 | LA6.1.1 | 4 | 3200 | 12800 | 1 | $250,000 | 50 | 2.6 | South Skagit Highway | Davis Slough | 03.0176G |
| 5 | PN5.1.1 | 1.9 | 495 | 941 | 1 | $30,000 | 50 | 1.6 | none | unnamed | 04.0384X |
| 6 | GN18.1.1 | 6 | 750 | 4500 | 1 | $250,000 | 50 | 0.9 | South Skagit Highway | Gilligan Cr | 03.0281 |
| 7 | GN14.1.1 | 2.5 | 170 | 425 | 1 | $30,000 | 50 | 0.7 | none | unnamed | 03.0293B |
| 8.1 | PN10.1.1 | | 160 | 0 | 1 | $250,000 | 50 | 0.0 | South Skagit Highway | unnamed | 04.0373 |
| 8.2 | PN11.1.1 | 2.2 | 173 | 381 | 1 | $30,000 | 50 | 0.6 | none | unnamed | 04.0373 |
| 39 | AR45.1.1 | 3.8 | 65 | 247 | 1 | $30,000 | 50 | 0.4 | SW-HO-1000 Rd | West Fork Alder | 03.0360 |
| 40 | PN7.1.1 | 1.1 | 170 | 187 | 1 | $30,000 | 50 | 0.3 | none | unnamed | 04.0384X |
| 41 | GN20.2.2 | 2 | 300 | 600 | 1 | $100,000 | 50 | 0.3 | West Gilligan Cr Road | Stevens Cr | 03.0280A |
| 42.1 | GN19.1.1 | 2 | 460 | 920 | 1 | $250,000 | 50 | 0.2 | South Skagit Highway | Stevens Cr | 03.0280A |
| 42.2 | GN21.1.1 | 1.83 | 565 | 1034 | 1 | $250,000 | 50 | 0.2 | South Skagit Highway | Salmon Cr | 03.0280B |
| 43 | AR33.1.1 | 0.9 | 110 | 99 | 1 | $30,000 | 50 | 0.2 | Crown Pacific 800 Rd | none | 03.0354X |
| 44 | AR34.1.1 | 0.9 | 110 | 99 | 1 | $30,000 | 50 | 0.2 | Crown Pacific 800 Rd | none | 03.0354X |
| 45 | AR35.1.1 | 0.9 | 60 | 54 | 1 | $30,000 | 50 | 0.1 | Crown Pacific 800 Rd | none | 03.0354X |
| 46 | AR36.1.1 | 1 | 50 | 50 | 1 | $30,000 | 50 | 0.1 | Crown Pacific 800 Rd | none | 03.0354X |
| 47 | AR37.1.1 | 1 | 50 | 50 | 1 | $30,000 | 50 | 0.1 | Crown Pacific 800 Rd | none | 03.0354X |
| 48 | LA2.1.1 | 2.3 | 210 | 483 | 1 | $250,000 | 50 | 0.1 | South Skagit Highway | unnamed | 03.0176X |
| 49 | GN7.1.1 | 0.9 | 40 | 36 | 1 | $30,000 | 50 | 0.1 | none | unnamed | 03.0293D |
| 50 | LA8.1.1 | 1.4 | 180 | 252 | 1 | $250,000 | 50 | 0.1 | South Skagit Highway | unnamed | 03.0371A |
| 51 | GN26.1.1 | 0.65 | 40 | 26 | 1 | $30,000 | 50 | 0.0 | none | unnamed | 03.0287X |
| 52 | LA11.1.1 | 1.4 | 100 | 140 | 1 | $250,000 | 50 | 0.0 | South Skagit Highway | unnamed | 03.0176X |
| 53 | LA5.1.1 | 0.8 | 125 | 100 | 1 | $250,000 | 50 | 0.0 | South Skagit Highway | Nettles Pond | 03.0176X |
| 54 | AR6.1.1 | | 100 | 0 | 1 | $30,000 | 50 | 0.0 | Abandoned Rd | Unnamed | 03.0339A |
| 55 | AR44.1.1 | | | 0 | 1 | $30,000 | 50 | 0.0 | None | Mannser Cr | 03.0339 |

Table 3-3-2. Complete blockages to salmon migration. Downstream culverts must be repaired before upstream culverts in order to realize benefits of upstream habitat. The "Project group" column shows the sequence of projects for projects on the same system (the first number indicates which group a project belongs to, and the second number indicates the sequence from downstream to upstream).

| Isolated Tributary Reaches | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | W | L | A | V | C | T | | | | |
| Project Group | Site | Width (m) | Length (m) | Area (m^2) | value | cost | Time (years) | B/C | Road Name | Stream | WRIA |
| 9.1 | SF94.1.1 | 2.5 | 1300 | 3250 | 1 | $550,000 | 50 | 0.3 | Northern State Rd | Brickyard Cr | none |
| 9.2 | SF95.1.1 | 2.5 | | | 1 | | 50 | | none | Brickyard Cr | none |
| 9.3 | SF96.1.2 | 2.5 | | | 1 | | 50 | | Fruitdale Rd. | Brickyard Cr | none |
| 9.4 | SF96.2.2 | 2.5 | | | 1 | | 50 | | Fruitdale Rd. | Brickyard Cr | none |
| 9.5 | SF99.1.1 | 2.5 | | | 1 | | 50 | | none | Brickyard Cr | none |
| 10.1 | SF103.1.1 | 2 | 1550 | 3100 | 1 | $160,000 | 50 | 1.0 | driveway | Wollard Cr | 03.0012 |
| 10.2 | SF104.1.1 | 2 | | | 1 | | 50 | | Bassett Rd | Wollard Cr | 03.0012 |
| 10.3 | SF107.1.1 | 2 | | | 1 | | 50 | | none | Wollard Cr | 03.0012 |

Table 3-3-3. Isolated sloughs. Shading of rows indicates projects that are on the same tributary system. The "Project group" column shows the sequence of projects for projects on the same system (the first number indicates which group a project belongs to, and the second number indicates the sequence from downstream to upstream). Costs are "pending" for all the barriers listed in this table because solutions for each barrier are dependent on the design flow which have not been selected for each slough.

| Isolated Sloughs | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | W | L | A | V | C | T | | | | |
| Project Group | Site | Width (m) | Length (m) | Area (m^2) | value | cost | Time (years) | B/C | Road Name | Stream | WRIA |
| 11.1 | FI1.1.1 | 15.8 | 7900 | 124820 | 1 | pending | 50 | NA | driveway | Dry Slough | 03.0220 |
| 11.2 | FI8.1.1 | 15.8 | | | 1 | | 50 | | Fir Island Road | Dry Slough | 03.0220 |
| 11.3 | FI9.1.2 | 15.8 | | | 1 | | 50 | | seawall | Dry Slough | 03.0220 |
| 11.4 | FI9.2.2 | 15.8 | | | 1 | | 50 | | seawall | Dry Slough | 03.0220 |
| 12.1 | FI15.1.6 | 10 | 4800 | 48000 | 1 | pending | 50 | NA | seawall | Wiley Slough | 03.0171 |
| 12.2 | FI15.26 | 10 | | | 1 | | 50 | | seawall | Wiley Slough | 03.0171 |
| 12.3 | FI15.3.6 | 10 | | | 1 | | 50 | | seawall | Wiley Slough | 03.0171 |
| 12.4 | FI15.4.6 | 10 | | | 1 | | 50 | | seawall | Wiley Slough | 03.0171 |
| 12.5 | FI15.5.6 | 10 | | | 1 | | 50 | | seawall | Wiley Slough | 03.0171 |
| 12.6 | FI15.6.6 | 10 | | | 1 | | 50 | | seawall | Wiley Slough | 03.0171 |
| 13.1 | FI38.1.1 | 10.5 | 3400 | 35700 | 1 | pending | 50 | NA | Mann Road | unnamed | 03.0000 |
| 13.2 | FI39.1.1 | 10.5 | | | 1 | | 50 | | Fir Island Road | unnamed | 03.0000 |
| 14.1 | FI12.1.1 | 10 | 2280 | 22800 | 1 | pending | 50 | NA | driveway | unnamed | 03.0000 |
| 14.2 | FI13.1.1 | 9 | | | 1 | | 50 | | access road for field | unnamed | 03.0000 |
| 14.3 | FI14.1.1 | 3 | | | 1 | | 50 | | access road for field | unnamed | 03.0000 |
| 15.1 | FI41.1.2 | 13 | 500 | 6500 | 1 | pending | 50 | NA | seawall | unnamed | 03.0000 |
| 15.2 | FI41.2.2 | 13 | | | 1 | | 50 | | seawall | unnamed | 03.0000 |
| 16.1 | FI47.1.3 | 15.7 | 3800 | 59660 | 1 | pending | 50 | NA | seawall | Brown's Slough | 03.0168 |
| 16.2 | FI47.2.3 | 15.7 | | | 1 | | 50 | | seawall | Brown's Slough | 03.0168 |
| 16.3 | FI47.3.3 | 15.7 | | | 1 | | 50 | | seawall | Brown's Slough | 03.0168 |
| 16.4 | FI48.1.1 | 15.7 | | | 1 | | 50 | | Fir Island Road | Brown's Slough | 03.0168 |
| 16.5 | FI50.1.1 | 15.7 | | | 1 | | 50 | | access road for field | Brown's Slough | 03.0168 |
| 16.6 | FI53.1.1 | 15.7 | | | 1 | | 50 | | Rawlins Road | Brown's Slough | 03.0168 |
| 16.7 | FI54.1.1 | 15.7 | | | 1 | | 50 | | seawall | Brown's Slough | 03.0168 |
| 17.1 | SF10.1.3 | 3.7 | 22500 | 83250 | 1 | pending | 50 | NA | Chilberg Road | Sullivan Slough | 03.0162 |
| 17.2 | SF10.2.3 | 3.7 | | | 1 | | 50 | | Chilberg Road | Sullivan Slough | 03.0162 |
| 17.3 | SF10.3.3 | 3.7 | | | 1 | | 50 | | Chilberg Road | Sullivan Slough | 03.0162 |
| 17.4 | SF12.1.1 | 3.7 | | | 1 | | 50 | | none | Sullivan Slough | 03.0162 |
| 17.5 | SF13.1.4 | 3.7 | | | 1 | | 50 | | 3rd St | Sullivan Slough | 03.0162 |
| 17.6 | SF13.2.4 | 3.7 | | | 1 | | 50 | | 3rd St | Sullivan Slough | 03.0162 |
| 17.7 | SF13.3.4 | 3.7 | | | 1 | | 50 | | 3rd St | Sullivan Slough | 03.0162 |
| 17.8 | SF13.4.4 | 3.7 | | | 1 | | 50 | | 3rd St | Sullivan Slough | 03.0162 |
| 18.1 | SF36.1.1 | 12 | 11500 | 138000 | 1 | pending | 50 | NA | Pulver Rd | Gages Slough | 03.0224 |
| 18.2 | SF38.1.1 | 12 | | | 1 | | 50 | | Pulver Rd | Gages Lake | 03.0000 |
| 18.3 | SF44.1.1 | 12 | | | 1 | | 50 | | S Skagit St | Gages Slough | 03.0224 |
| 18.4 | SF49.1.1 | 12 | | | 1 | | 50 | | Hwy 20 | Gages Slough | 03.0224 |
| 18.5 | SF50.1.1 | 12 | | | 1 | | 50 | | Lei Garden Rd | Gages Slough | 03.0224 |
| 18.6 | SF53.1.1 | 12 | | | 1 | | 50 | | Gardner Rd | Gages Slough | 03.0224 |
| 18.7 | SF54.1.1 | 12 | | | 1 | | 50 | | parking lot | Gages Slough | 03.0224 |
| 18.8 | SF57.1.1 | 12 | | | 1 | | 50 | | Pete Anderson Rd | Gages Slough | 03.0224 |
| 18.9 | SF60.1.1 | 12 | | | 1 | | 50 | | District Line Rd | Gages Slough | 03.0224 |
| 18 | SF62.1.1 | 12 | | | 1 | | 50 | | Collins Rd | Gages Slough | 03.0224 |
| 19.1 | SF69.1.2 | 5 | 700 | 3500 | 1 | pending | 50 | NA | Summers Dr | Unnamed | 03.0140 |
| 19.2 | SF69.2.2 | 5 | | | 1 | | 50 | | Summers Dr | Unnamed | 03.0140 |
| 20 | FI16.1.1 | 4.5 | 780 | 3510 | 1 | pending | 50 | NA | seawall | drainage ditch | 03.0000 |
| 21 | FI19.1.1 | 1.4 | 75 | 105 | 1 | pending | 50 | NA | levee | ditch | 03.0000 |
| 22 | FI24.1.1 | 15 | 1000 | 15000 | 1 | pending | 50 | NA | seawall | Teal Slough | 03.0000 |
| 23 | FI30.1.1 | 8 | 1100 | 8800 | 1 | pending | 50 | NA | levee | Teal Slough | 03.0000 |
| 24 | FI29.1.1 | 10 | 3300 | 33000 | 1 | pending | 50 | NA | levee | Wiley Slough | 03.0171 |
| 25 | FI37.1. 1 | 9.5 | 1300 | 12350 | 1 | pending | 50 | NA | Mann Road | unnamed | 03.0000 |
| 26 | FI42.1.1 | 4.5 | 560 | 2520 | 1 | $30,000 | 50 | 4.2 | access road for field | unnamed | 03.0000 |
| 27 | FI44.1.1 | 11 | 2675 | 29425 | 1 | pending | 50 | NA | seawall | borrow ditch | 03.0000 |
| 28 | FI55.1.1 | 2 | 350 | 700 | 1 | pending | 50 | NA | seawall | unnamed | 03.0000 |
| 29 | FI56.1.1 | 10 | 1300 | 13000 | 1 | pending | 50 | NA | seawall | Hall Slough | 03.0217 |
| 30 | SF2.1.1 | 2 | 200 | 400 | 1 | $30,000 | 50 | 0.7 | access road for field | Unnamed | 03.0000 |
| 21 | SF3.1.1 | 13 | 500 | 6500 | 1 | pending | 50 | NA | seawall | Unnamed | 03.0132 |

Table 3-3-3 Cont.

| Project Group | Site | W Width (m) | L Length (m) | A Area (m^2) | V value | C cost | T Time (years) | B/C | Road Name | Stream | WRIA |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 32 | SF7.1.1 | 3 | 500 | 1500 | 1 | pending | 50 | NA | seawall | Unnamed | 03.0136 |
| 33 | SF9.1.1 | 5 | 850 | 4250 | 1 | $30,000 | 50 | 7.1 | access road for field | Unnamed | 03.0139 |
| 34 | SF27.1.1 | 2.5 | 975 | 2438 | 1 | $30,000 | 50 | 4.1 | driveway | Unnamed | 03.0143 |
| 35 | SF30.1.1 | 1.5 | 280 | 420 | 1 | $30,000 | 50 | 0.7 | access road for field | Unnamed | 03.0143 |
| 36 | SF31.1.1 | 1.5 | 250 | 375 | 1 | $30,000 | 50 | 0.6 | none | Unnamed | 03.0143 |
| 37 | SF105.1.1 | 2 | | 0 | 1 | pending | 50 | NA | seawall | Unnamed | 03.0000 |
| 38 | SF106.1.1 | | 500 | 0 | 1 | pending | 50 | NA | seawall | Unnamed | 03.0000 |
| Total | | | 73,875 | 656,523 | | | | | | | |

## 3.4 WATER QUALITY

No projects have yet been identified in the Strategy Application that specifically target water quality improvement for fish habitat enhancement, either on the reach or watershed level. Many of the potential projects identified in other categories (e.g., sediment reduction and riparian) will ultimately have positive impacts on water quality in the reaches affected by these projects, though these projects are not identified as “water quality” projects at this time. Future versions of the Strategy Application will include potential projects specifically identified to address habitats that have been identified as impaired or moderately impaired because of water quality degradation. Our initial list of these habitats is limited to water bodies listed under the Washington Department of Ecology’s Candidate 1998 Section 303(d) Impaired and Threatened Water Bodies listings, though future Strategy Applications will expand upon this list based on more extensive water quality and land use information (see Section 2.7).

## 3.5 PROTECTION

The overall approach of the SWC Habitat Protection and Restoration Strategy is to identify the types of areas within the Skagit River basin where salmon historically or currently live, and to identify the natural landscape processes that must be protected or reestablished to insure the successful protection or rehabilitation of habitats to which salmon stocks are adapted. Salmon have adapted to those stream characteristics that exist in areas where there has been little disturbance by the activities of man. These areas in the basin, which are similar to what existed historically, are called “key” habitat in the Strategy and are considered high priority for protection through land acquisition or easements. In our initial funding request based on the Strategy Application (6/30/99), the Council requested $500,000 for the first funding year and $1,500,000 in the following year in order to acquire land and develop conservation easements in areas targeted as high priority for protection in the Skagit River basin using the approach described below. We believe this amount is only a small percentage of the total amount necessary to acquire or conserve habitats targeted for protection and/or restoration involving land acquisition. However, no estimate of this total amount has been developed to date.

The SWC has developed a protocol in the Strategy for systematically identifying key habitat areas, as well as areas that are considered important, degraded, isolated, and secondary. The following are the definition of these habitat types from the Strategy:

- *Key* habitat is defined more specifically as critical for at least one salmonid life stage combination considered, or is a preferred type by the majority of life stages considered.
- *Secondary* habitat does not provide critical habitat for any life stage combination considered and is not a preferred type by the majority of life stages considered.
- *Important* habitat is a disturbed key habitat that still provides significant amounts of production for most life stages considered.
- *Degraded* habitat is key habitat that is disturbed to such an extent that it does not have significant production or is not preferred by the majority of life stage combinations considered.
- *Isolated* habitat is not used by anadromous salmonids (no direct biological function) because it is disconnected through man-made blockages such as dikes, tide gates, or impassable road crossings

The Strategy Application summarizes the information collected and analyses performed to identify the areas described above (see Section 2.8). The process adopted by the Skagit Watershed Council to identify areas for protection from a basin-wide approach begins with these habitat designations. Generally, key habitats are targeted for protection while important and degraded habitats are targeted for restoration. The screening results guide the Council's planning to the likely causes or threats of degradation at the reach level, so the proper restoration or protection action can be determined. Because of various limitations associated with the assumptions and information used to produce these screens, the Council also directs protection efforts toward areas currently designated as important. Further analysis of these areas primarily through field investigations would likely reveal in some cases that the landscape processes are functioning rather than partially impaired, and thus should be targeted for protection.

The following is a process to be used next as part of a systematic approach to land protection in the Skagit River basin that is consistent with the goals and objectives of the Habitat Protection and Restoration Strategy:

1. Using the habitat designations identified by the Strategy Application and shown in Figures 2-19 and 2-20, a list of specific land parcels will be identified within each priority WAU or floodplain reach.
2. A preliminary sort of these parcels will be made to select the most important parcels based on size, condition, threat, etc.
3. Informational mailings will be sent to these landowners with follow-up personal contacts made with individual landowners where possible. Small informational meetings may be held with landowners and representatives of SWC. Voluntary protection options for the landowners will be presented. These will include fee acquisition (offer to purchase property out-right), and less than fee acquisition (offer

to purchase a conservation easement on all or a portion of the property). Other available programs may be promoted at the same time, where appropriate, such as Conservation Reserve Enhancement Program, Wetland Reserve Program, Farmland Legacy Program, etc.

4. A shorter list of landowners will be made of those who have indicated an interest in selling fee interest or a conservation easement on their property. A non-binding letter of intent may be requested from these landowners.
5. This short list of potentially available parcels will be rated using the Reach-Level Protection module for prioritizing protection projects, which was adopted by the SWC as part of the overall Habitat Protection and Restoration Strategy in May 1999.
6. This will provide a prioritized list of projects for the Skagit Land Trust, The Nature Conservancy, and other SWC partners to use to select specific properties to make offers on, using available funding.

## 3.6 Feasibility Studies

The Skagit Watershed Council has decided to pursue feasibility studies for more complex projects involving multiple watershed process disturbances, complex land use issues, or restoration solutions that take large amounts of time and resources to develop. Also, areas proposed for feasibility studies are generally much larger than other reach level restoration projects[5]. Often the habitat type being considered is in short supply or impossible to replace by restoration efforts in other parts of the basin (e.g., estuary habitat can only be restored in the lower delta, not other areas of the river basin).

Studies will be conducted as outlined in the framework for feasibility studies developed by the Council. Studies will describe the issue/problem in question, identify and quantify disturbed watershed processes, identify causes of disturbances, compare current to historical habitat conditions, address other issues on a case-by-case basis, and propose several restoration alternatives.

For this Strategy Application, the feasibility study areas are primarily generated from our knowledge of currently isolated habitat located in the Skagit and Samish River delta. Two non-delta sites are also listed from the case-by-case screening of project ideas.

Preliminary cost effectiveness used indices of project of costs and benefits to help order the priority of each proposed project area. We estimated the benefit area using the following approach because we did not have field-based estimates from each site. Channel length, calculated from the GIS theme, was multiplied by an average channel width taken from Table 3-6-1 to estimate the benefit area. GIS estimated the area of large wetlands if they were within the project site.

Table 3-6-1. Average channel width by type for GIS generated reach level projects, or where field data are absent. The average widths are based on field data from 367 channels within the Skagit (SSC unpublished data).

| Gradient Class | Channel Type | average channel width (m) | standard deviation (m) | sample size |
|---|---|---|---|---|
| Flat | Estuary Distributary Channel | 43.8 | 8.9 | 6 |
| Flat | Estuary Subsidiary Channel | 15.4 | 6.0 | 8 |
| Flat | Estuary Blind Channel* | 12.0 | 5.8 | 15 |
| <2% | Freshwater Slough in CMZ | 7.8 | 4.8 | 30 |
| <2% | pool riffle | 5.5 | 5.3 | 192 |
| 2-4% | forced pool riffle or plane-bed | 6.2 | 4.3 | 72 |
| >4% | Step pool | 5.1 | 2.5 | 44 |

* These are larger blind channels only, observable on 7.5-minute quads and historical surveys maps. The average does not represent smaller dendritic channels occurring throughout estuarine emergent marsh areas. These smaller channels are accounted for in the estimated wetland area.

[5] For example, the average potential habitat area gained by projects from the delta project list (Table 3-6-) is 60,000 $m^2$ compared to average gains of 4,000 $m^2$ from the culvert list in non-delta areas (Table 3-3-1) and 5,800 $m^2$ from the riparian project list (Table 3-2-1).

Most project areas deal with blockages to fish access, so we developed an index of potential cost by the number of blockages within the project site, multiplied by $250,000 per blockage. Because we did not have field inventory data at all sites, we developed a regression estimate of the actual number of blockages at each project site based on the number of road and levee crossings shown on GIS themes. We regressed the number of blockages from field inventory data for 38 delta reaches on the number of blockages from GIS themes for those reaches and found:

# Blockages = 1.45*(# Blockages on GIS theme) + 0.5 ($r^2$=0.77)

These preliminary cost effectiveness estimates are subject to errors in both estimated cost and estimated benefit. However, we applied the same assumptions and data to each project area for the analysis, and the result should be reasonable for evaluating relative differences between projects. Results are shown in Figure 3-1 and Table 3-6-2. The current rank based on preliminary cost-effectiveness is shown in both the table and figure.

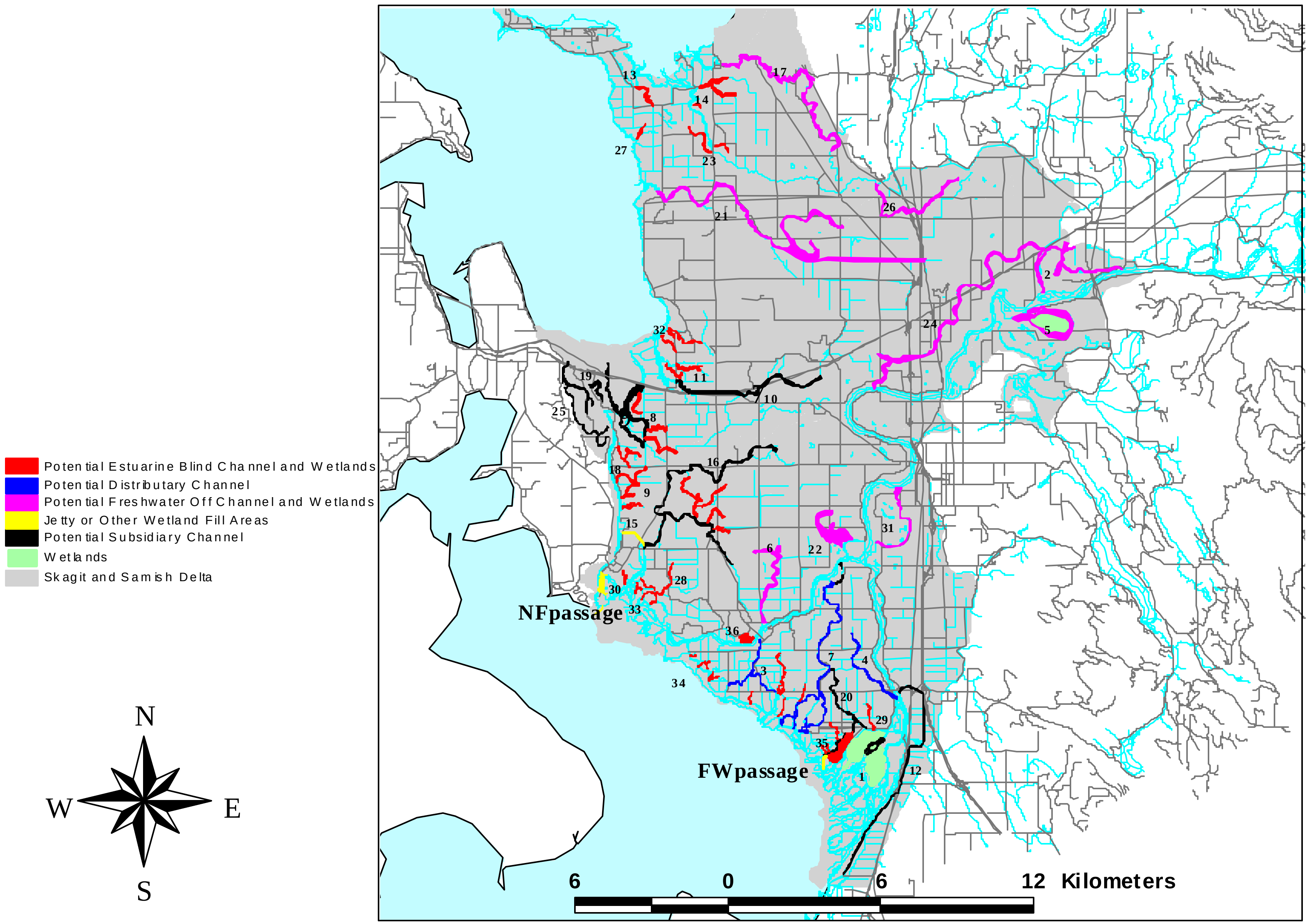



**Figure 3-1. Isolated habitat project areas in the Skagit and Samish River delta.**

Table 3-6-2. Summary of isolated habitat areas in the delta and other feasibility study areas from case by case screening. Shaded rows have been funded. Rows in ***bold italic*** print have been submitted for funding. The rank column corresponds to labels in Fig 3-1.

| Project Area | Potential habitat / issue description | Preliminary Cost Effectiveness Index (B/C*100) | Current Rank based on Preliminary Cost Effectiveness |
|---|---|---|---|
| **Deepwater Slough Complex[1]** | **Restoration of isolated distributary channel, blind channel and wetlands in the tidally influenced South Fork Skagit estuary. Project is funded and under construction.** | **10.68** | **1** |
| ***Hart Slough Complex*** | ***Feasibility of restoring habitat and flow to side channel slough system near Sedro Woolley. Isolation, channel migration, fish passage, riparian, water quality and land use issues*** | ***9.62*** | ***2*** |
| Browns and Hall Slough Complex | Isolated tidally influenced distributary slough in agricultural area on Fir Island. Land use, water quality, fish passage, flow, riparian vegetation issues. | 7.57 | 3 |
| Conway Distributary | Isolated partially tidally influenced distributary slough in agricultural area opposite of Conway on Fir Island. Land use, water quality, fish passage, flow, riparian vegetation issues. | 7.03 | 4 |
| Debay's Slough Complex | Feasibility of restoring habitat and flow to side channel slough system near Sedro Woolley. Isolation, channel migration, fish passage, riparian, water quality and land use issues | 6.07 | 5 |
| Beaver Marsh | Feasibility of restoring habitat and flow to a partially tidally influenced slough and wetland system east of Pleasant Ridge. Isolation, fish passage, riparian, water quality and land use issues | 5.47 | 6 |
| ***Dry Slough Complex*** | ***Isolated tidally influenced distributary slough system in agricultural area on Fir Island. Land use, water quality, fish passage, flow, riparian vegetation issues.*** | ***4.60*** | ***7*** |
| Telegraph Slough Complex | Isolated tidally influenced slough in agricultural area of Swinomish Channel and southern Padilla Bay. Land use, water quality, fish passage, flow, riparian vegetation issues. | 3.69 | 8 |
| Swinomish Channel Blind Channel #2 | Isolated estuarine blind channel system in agricultural area on west side of Swinomish Channel. Land use, water quality, fish passage, flow, riparian vegetation issues. | 3.69 | 9 |

Table 3-6-2 Continued

| Project Area | Potential habitat / issue description | Preliminary Cost Effectiveness Index (B/C*100) | Current Rank based on Preliminary Cost Effectiveness |
|---|---|---|---|
| Indian Slough | Partially tidally influenced and isolated slough system in agricultural area of southern Padilla Bay. Land use, water quality, fish passage, flow, riparian vegetation issues. | 3.56 | 10 |
| Little Indian Slough | Isolated estuarine blind channel system in agricultural area on southern end of Padilla Bay. Land use, water quality, fish passage, flow, riparian vegetation issues. | 3.24 | 11 |
| Big Ditch Complex | Isolated tidally influenced subsidiary channel system in agricultural area near Conway. Land use, water quality, fish passage, flow, riparian vegetation issues. | 3.11 | 12 |
| West Samish Bay Blind Channel | Isolated estuarine blind channel system in agricultural area on the southwest side of Samish Bay. Land use, water quality, fish passage, flow, riparian vegetation issues. | 2.62 | 13 |
| Lower Samish Blind Channels | Isolated estuarine blind channel system in agricultural area near Edison. Land use, water quality, fish passage, flow, riparian vegetation issues. | 2.59 | 14 |
| Swinomish Channel Blind Channel #1 | Isolated estuarine blind channel system in agricultural area on west side of Swinomish Channel. Land use, water quality, fish passage, flow, riparian vegetation issues. | 2.58 | 15 |
| Sullivan Slough Complex | Isolated subsidiary and blind channel system in agricultural area near La Conner. Land use, water quality, fish passage, flow, riparian vegetation issues. | 2.53 | 16 |
| Edison Slough | Isolated, partial tidally influenced slough in agricultural area of Samish Bay. Land use, water quality, fish passage, flow, riparian vegetation issues. | 2.45 | 17 |
| Swinomish Channel Blind Channel #3 | Isolated estuarine blind channel system in agricultural area on west side of Swinomish Channel. Land use, water quality, fish passage, flow, riparian vegetation issues. | 2.08 | 18 |
| Old Swinomish Channel | Isolated subsidiary channel system in agricultural area on east side of Swinomish Channel. Land use, water quality, fish passage, flow, riparian vegetation issues. | 2.04 | 19 |
| Dry Sl. Distributary | Isolated distributary of Dry Slough in agricultural area on Fir Island. Land use, water quality, fish passage, flow, riparian vegetation issues. | 1.98 | 20 |
| ***Joe Leary Slough and Olympia Marsh Complex*** | ***Slough system partially influenced by tides in agricultural area of northern Padilla Bay. Land use, water quality, fish passage, and riparian vegetation issues.*** | ***1.81*** | ***21*** |

Table 3-6-2 Continued

| Project Area | Potential habitat / issue description | Preliminary Cost Effectiveness Index (B/C*100) | Current Rank based on Preliminary Cost Effectiveness |
|---|---|---|---|
| Beaver Marsh at Skagit Forks | Feasibility of restoring habitat and flow to slough and wetland system near Skagit Forks. Isolation, fish passage, riparian, water quality and land use issues | 1.74 | 22 |
| Lower Samish Off-Channel | Isolated tidally influenced off-channel slough habitat in agricultural area of lower Samish River. Land use, water quality, fish passage, flow, riparian vegetation issues. | 1.22 | 23 |
| Gages Slough | Isolated off-channel slough habitat in agricultural and urban area of Skagit River near Burlington. Land use, water quality, fish passage, flow, riparian vegetation issues. | 1.18 | 24 |
| Fidalgo Flats Complex | Isolated tidally influenced subsidiary and blind channel habitat in agricultural area on the west side of Swinomish Channel. Land use, water quality, fish passage, flow, riparian vegetation issues. | 1.18 | 25 |
| Old Thomas Creek | Isolated slough system in agricultural area of old Olympia Marsh. Land use, water quality, fish passage, flow, riparian vegetation issues. | 1.11 | 26 |
| North Padilla Bay Blind Channel | Isolated estuarine blind channel system in agricultural area on the northern end of Padilla Bay. Land use, water quality, fish passage, flow, riparian vegetation issues. | 1.06 | 27 |
| Dodge Valley Slough | Isolated tidally influenced blind channel system in Dodge Valley Area. Land use, water quality, fish passage, flow, riparian vegetation issues. | 0.97 | 28 |
| Freshwater Slough Off-Channel | Isolated tidally influenced blind channel system in near Skagit Wildlife Area on Fir Island. Land use, water quality, fish passage, flow, riparian vegetation issues. | 0.89 | 29 |
| LaConner Blind Channels | Isolated estuarine blind channel system in agricultural area near La Conner connecting to Lower Sullivan Slough. Land use, water quality, fish passage, flow, riparian issues. | 0.80 | 30 |
| Britt Slough | Isolated off-channel slough habitat in agricultural and urban area of Skagit River near Mt. Vernon. Land use, water quality, fish passage, flow, riparian vegetation issues. | 0.77 | 31 |
| No Name Slough Complex | Isolated estuarine blind channel system in agricultural area on southern end of Padilla Bay. Land use, water quality, fish passage, flow, and riparian vegetation issues. | 0.71 | 32 |

Table 3-6-2 Continued

| Project Area | Potential habitat / issue description | Preliminary Cost Effectiveness Index (B/C*100) | Current Rank based on Preliminary Cost Effectiveness |
|---|---|---|---|
| Lower Sullivan Slough Blind Channels | Isolated estuarine blind channel system in agricultural area on the lower end of Sullivan Slough. Land use, water quality, fish passage, flow, riparian vegetation issues. | 0.65 | 33 |
| Skagit Bayfront Blind Channels | 3 small isolated estuarine blind channel systems in agricultural area along the Skagit bayfront of Fir Island. Land use, water quality, fish passage, flow, riparian vegetation issues. | 0.43 | 34 |
| Wiley Slough Complex | Isolated tidally influenced subsidiary and blind channel system in Skagit Wildlife Area on Fir Island. | 0.42 | 35 |
| Unnamed NF Off-Channel | Isolated tidally influence wetland and blind channel area south of Pleasant Ridge on the North Fork Skagit River. Land use, water quality, fish passage, riparian vegetation issues. | 0.27 | 36 |
| Swinomish Channel Fish Access | Improve juvenile salmon access to available habitat in Swinomish Channel and Padilla Bay. Some gain of wetland or channel habitat may be possible. | No estimate[3] | Not Ranked |
| Freshwater Slough Jetty | Improve juvenile salmon access to available habitat along the Skagit's bayfront. Some gain of wetland or channel habitat is possible. | No Estimate[3] | Not Ranked |
| Non-Delta[2] | | | |
| ***Hansen Creek*** | ***Degraded historic low gradient channel/wetland area. Land use, sediment supply/transport/storage, hydromodification, and riparian issues.*** | ***No estimate[3]*** | ***Not Ranked*** |
| ***Little Baker Side Channel*** | ***Isolated side channel on Baker River alluvial fan. Altered hydrology, sediment supply, land use, hydromodification, fish passage/isolation, and FERC licensing issues.*** | ***1.98*** | ***Rank equivalent to 20*** |

[1] The Deepwater Slough project has been funded. The ACOE and WDFW began construction during the summer of 1999.

[2] These project sites are located upstream of the Delta and were previously listed in the Skagit Watershed Council's June 30, 1999 Funding Proposal.

[3] Cost effectiveness cannot be estimated with the same methods as other projects in this table because the primary objectives are different than reconnecting specifically identified isolated habitat.

## 3.7 MONITORING PROGRAM

The Skagit Watershed Council is committed to the development of a comprehensive monitoring program in order to ensure that: 1) projects endorsed by the Council are monitored using a scientifically sound approach; 2) monitoring information is collected, organized, maintained, and shared in a consistent, scientifically valid format; and 3) monitoring results are integrated into an effective adaptive management approach so that we learn from our successes as well as our mistakes and apply that information in future actions. The program will be consistent with the Council's Strategy, which employs the use of implementation, effectiveness, and validation monitoring.

We expect this program to play a long-term, integral role in the restoration and protection of salmon habitats in the Skagit River basin. The Council as Lead Entity with 36 member organizations throughout the basin is uniquely positioned to function as the center of this monitoring program. The monitoring program and the information it will generate will be a critical element of the activities already performed by the Council and its member organizations, such as project identification, evaluation, and tracking.

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