

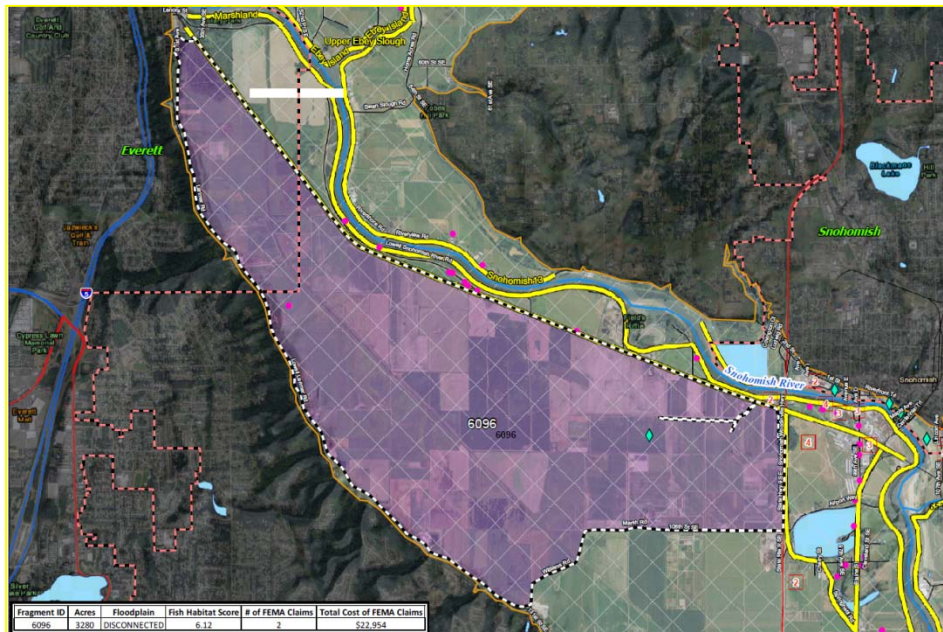
TECHNICAL METHODOLOGY REPORT

FOR

2013 Washington Silver Jackets Nonstructural Flood Risk Project

Integrating Flood Risk Management and Salmon Habitat Restoration Priorities in Puget Sound: An Early Opportunities Analysis

10 April 2015



USACE Seattle District



US Army Corps
of Engineers®

Project Background

The U.S. Army Corps of Engineers (USACE) Institute for Water Resources awarded pilot project funding to the Washington Silver Jackets team in July 2013 to advance a new integrated approach to flood risk management and habitat restoration planning in the Puget Sound region of Washington. Specifically, the project identifies “early opportunities areas” in major Puget Sound river basins (Figure 1) where agencies could apply a coordinated investment approach to reduce flood risk and advance habitat restoration goals. *Integrating Flood Risk Management and Salmon Habitat Restoration Priorities in the Puget Sound: An Early Opportunities Analysis* (Early Opps) expands on work The Nature Conservancy (TNC), Puget Sound Partnership (PSP), and Washington Department of Ecology (ECY) initiated in 2012 through the Floodplains by Design Program (FbD). More information on FbD can be found at <http://www.nature.org/ourinitiatives/habitats/riverslakes/floodplains-by-design.xml>.

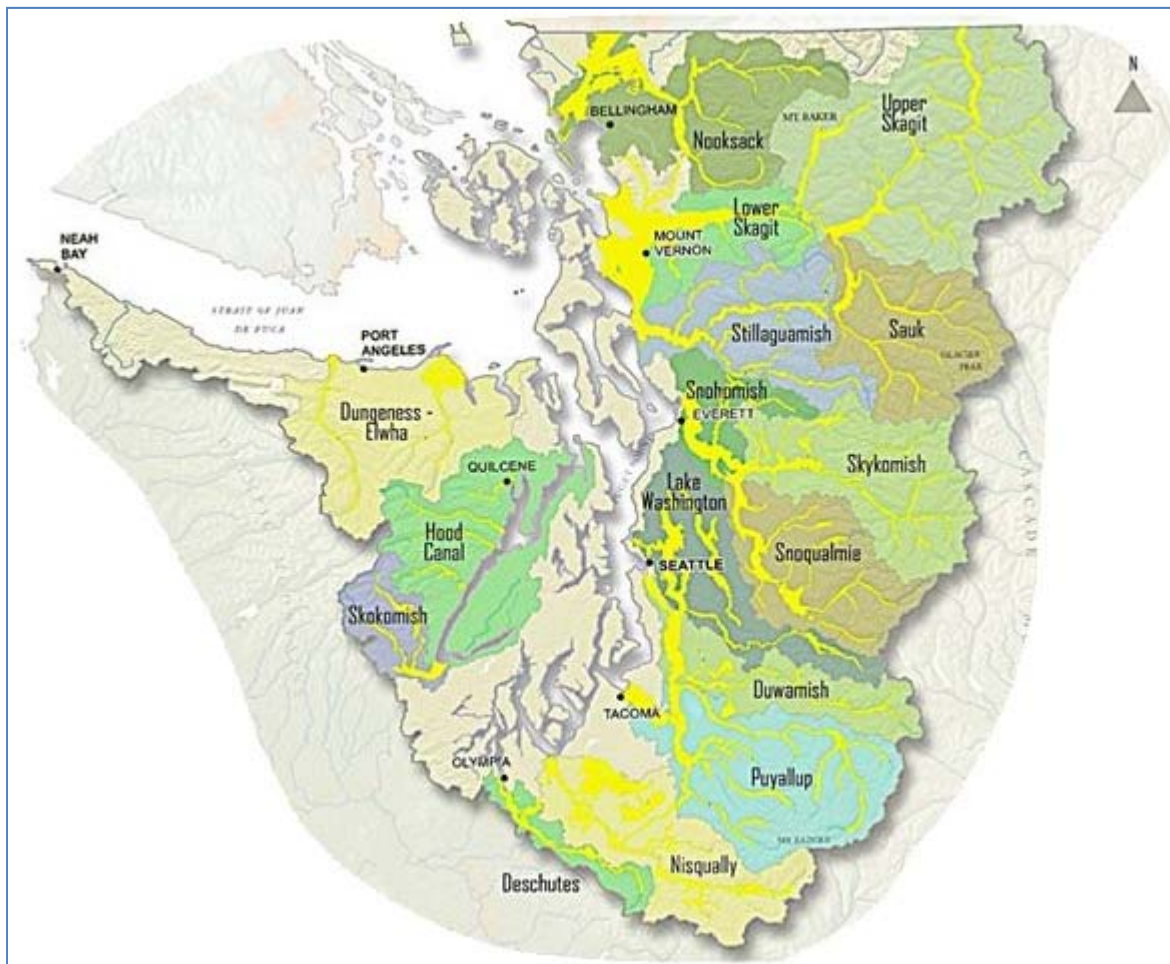


Figure 1. Major Puget Sound River Basins

The FbD program seeks to improve floodplain management by 1) identifying floodplain areas with the highest potential to advance multiple benefits (i.e. flood risk reduction and habitat recovery); 2) developing a tool to help project sponsors secure critical support and funding; and 3) initiating a multi-agency, coordinated investment approach to increase agency efficiency and effectiveness. FbD leadership had identified a study gap in regards to objective 1: the region lacked a system for linking Federal Emergency Management Agency (FEMA) hazard mitigation funding to floodplain and salmon restoration projects. The Early Opps study tries to address this opportunity by developing a

methodology to classify and rank floodplains with respect to their potential for multi-benefit project success.

Two scoring systems – one for flood risk management and one for salmon habitat restoration – were created and combined to rank Puget Sound floodplain “fragments”, which are defined in the next section. The flood risk reduction scoring system uses FEMA repetitive loss and National Flood Insurance Program (NFIP) claim databases. It takes into account both number of claims and dollars of damage. USACE staff developed the habitat restoration scoring system as a simple and defensible classification of restoration potential. It was critical to use data that is consistently available throughout the Puget Sound region for both flood risk and habitat restoration. The value of the rankings relies on a side-by-side evaluation of finite floodplain fragments against themselves. For the habitat scoring, that meant discarding some useful data because it was not available region-wide. Procedures for scoring both benefits are discussed in detail later in this report.

It is important to point out that the methodology is not intended to identify “good” or “bad” habitat. Similarly, it also should not be used to classify flood risk alone. Rather, this is a classification exercise developed to target *floodplain areas with greatest opportunity for improvement*. Fragments that have the greatest potential for *both* a reduction in flood risk and an improvement to habitat score highly.

Floodplain Fragments and Connectivity

To compare different areas within floodplains spread across these major river basins, the study team used a geospatial dataset developed by Chris Konrad, US Geologic Survey (USGS), in support of the FbD program, which defined floodplain “fragments”. The floodplain in the USGS methodology is defined by the delineation of landforms corresponding to the stage of a large flood (using National Elevation Dataset and published large flood event data). The fragments within that floodplain are delineated by topography (landforms) and anthropogenic features (roads, railroads, levees). The following steps are used to delineate fragments using GIS:

- 1) Select a threshold stage (corresponding to the large flood elevation for that basin)
- 2) Identify all grid cells where the threshold stage is greater than terrain elevation
- 3) Convert grid to polygons
- 4) Consider polygons intersecting rivers to be topographically connected
- 5) Consider polygons not intersecting rivers to be topographically disconnected
- 6) Polygons intersecting anthropogenic features above the given stage are also considered disconnected

Figure 2 below diagrams the USGS delineation of connected and disconnected floodplain fragments. The valley bottom is the bottom, most expansive layer (purple). Within the valley bottom, the USGS floodplain is topographically connected where GIS polygons intersect with the river (blue). The floodplain is disconnected where topography is higher than the threshold stage, or where anthropogenic features act as a barrier (grey).

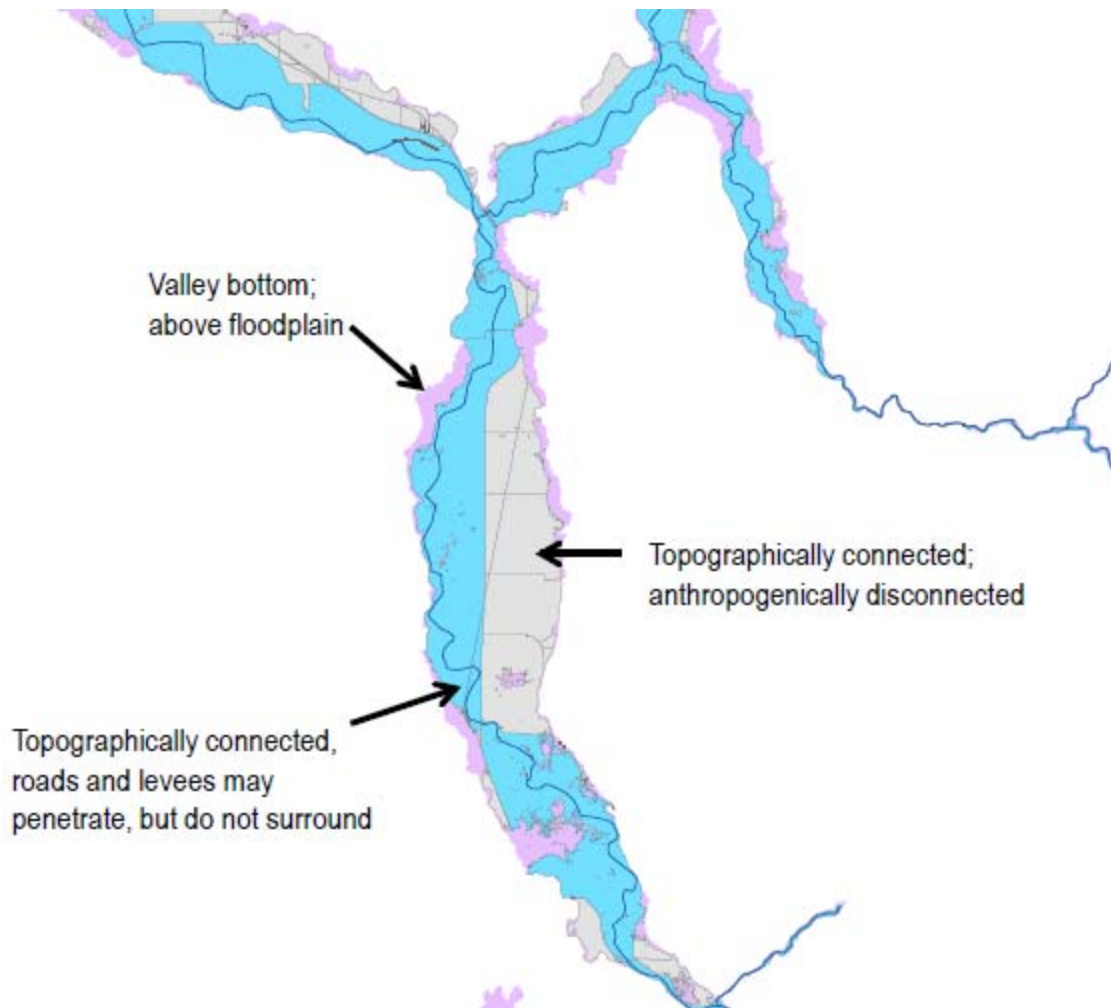


Figure 2. Example of Connected/Disconnected Floodplain Fragments

Flood Risk Reduction Criteria and Scoring

USACE acquired FEMA Region X data in October 2013 including NFIP claims and Repetitive and Severe Repetitive Loss properties (RL/SRL). These GIS datasets are point shapefiles that can be added to the floodplain fragments base map (Figure 3). The number of claims within a fragment was multiplied by the dollar value of damages. This step was included in an attempt to capture both flood frequency and severity. Number of claims alone may not paint an accurate picture of flood risk. Several small floods could be *more* damaging from an economic standpoint than one large event. The product of the claims and damages is the best available proxy representation of flood risk given the limited amount of datasets at our disposal. GIS analysis is used to calculate a claims x damages score for all Puget Sound floodplain fragments. All fragments are then grouped into 10 equal bins based on rank. Where each fragment falls in the bin ranking is its flood risk score – 1 through 10 with 10 being the most strategic for flood risk reduction projects. The flood risk scoring workflow is diagrammed in Figure 3 below.

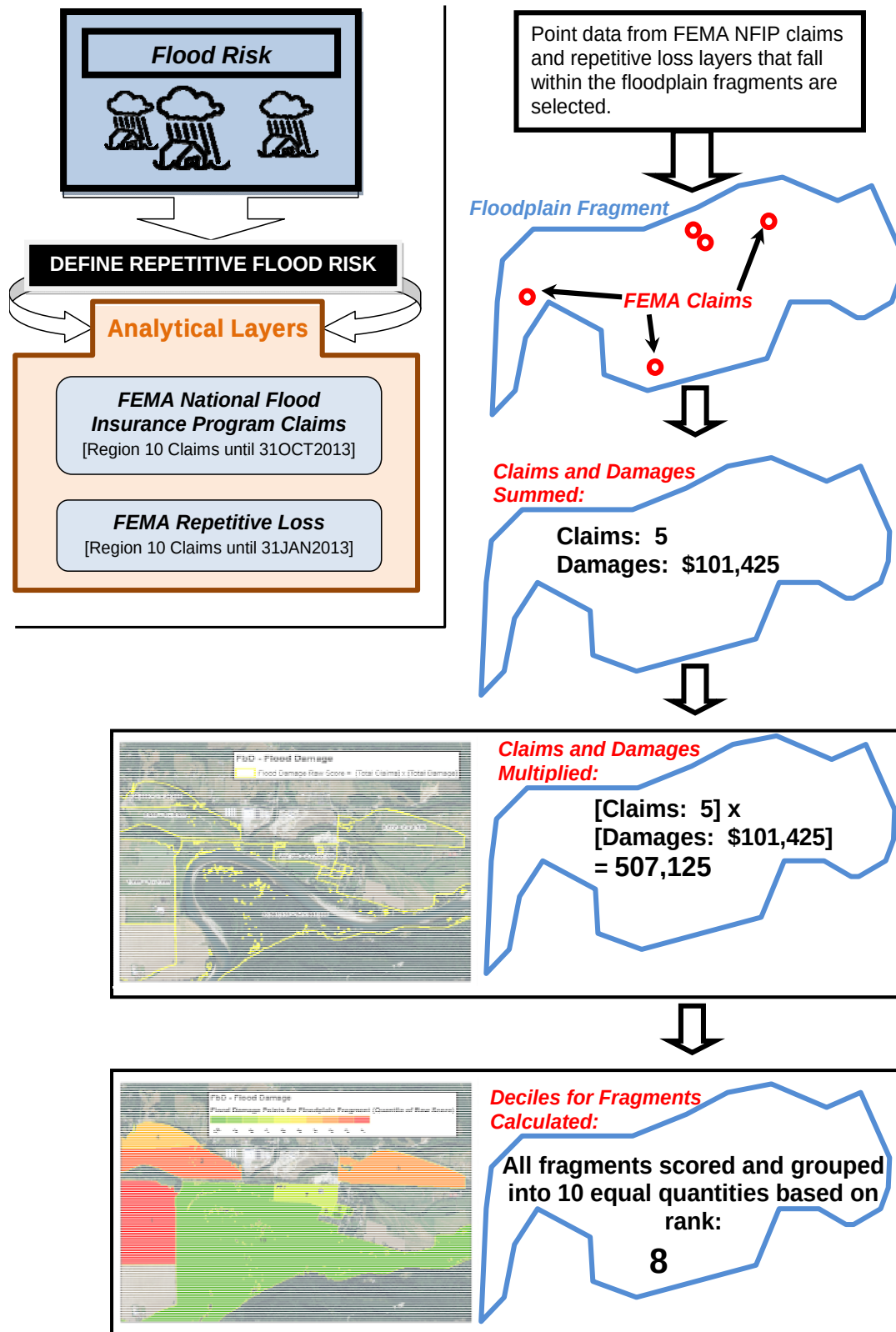


Figure 3. Flood Risk Scoring Workflow

Salmon Habitat Criteria and Scoring

Ten salmon and steelhead datasets were acquired and included in a GIS analysis of habitat scoring. Similar to the flood risk system, the fragments were scored 1-10 based on the GIS analysis. The criteria and their application to the scoring system are summarized below.

1. **Distribution of 3 Endangered Species Act (ESA)-listed salmonid species – bull trout, steelhead, and Chinook – according to the Salmon and Steelhead Stock Inventory Assessment Program (SSHAP) database.** Scoring prioritizes fragments having the most ESA-listed species. One point is assigned for fragments having a documented distribution of each of these three species. For example, if the GIS distribution layer from SSHAP shows all three species in the same floodplain fragment, that fragment would be assigned 3 points for this criterion. This step assumes it is most strategic to propose projects which benefit the most species possible.
2. **Verified spawning locations from WDFW survey data for bull trout, steelhead, and Chinook.** The same prioritization rationale is used for spawning as it was for fish distribution: a point for each species with spawning locations within a floodplain fragment. Spawning habitat for these three species does not often overlap. Spawning habitat is more difficult to re-create through ecosystem restoration construction projects, so it is important to prioritize areas where spawning already occurs so a floodplain improvement measure could add benefit to an area of critical habitat.
3. **Proximity to wetlands identified in the National Wetlands Inventory database maintained by the U.S. Fish and Wildlife Service.** The scoring system prioritizes areas with freshwater wetlands, which include emergent wetlands, forested/shrub wetlands, and freshwater ponds. A point is assigned to fragments intersecting wetlands.
4. **Floodplain connectivity.** As discussed earlier, floodplain connectivity/disconnectivity has been defined in previous FbD efforts by the USGS. Scoring preference is given to 1) fragments connected to the river, where there is potential for improved salmon habitat without needing to address disconnecting features (topography or anthropogenic); and 2) fragments that could be reconnected relatively easily (undeveloped areas with few major anthropogenic disconnections). Both categories include fragments with no impervious surface or unmodified cover. Fragments meeting either of these criteria are assigned one point.
5. **Edge Analysis.** The interface between aquatic habitat and land scores a point if the area has been modified from natural conditions. Impervious or non-forested edges are marked for restoration opportunities.
6. **Water quality based on Washington Department of Ecology's Clean Water Act 303(d) list of impaired waters for the parameters of dissolved oxygen (DO) and temperature.** DO and temperature are two of the most important aspects of water quality for healthy salmonid habitat; therefore, opportunities to restore degraded water quality are considered strategically important. Areas where pH is impaired were not included in the prioritization because it is not likely to change with the type of structural/non-structural flood risk management projects likely to be proposed and implemented. Impairment of dissolved oxygen and/or temperature resulted in one point total.

In summary, there can be 10 total points assigned to a floodplain fragment regarding potential for salmon habitat restoration: distribution of bull trout (1), steelhead (2), and Chinook (3); spawning locations for bull trout (4), steelhead (5), and Chinook (6); proximity to wetlands (7); floodplain connectivity (8); edge analysis (9); and impairment of water quality determined by dissolved oxygen and/or temperature (10). Note the final habitat score will likely be a decimal. The scoring system assigns integer values of 0 or 1 for each criterion outlined above to each 10m x 10m raster cell within a floodplain fragment. Each raster cell will have a cumulative integer value between 0 and 10. But the habitat score is based on the mean of all raster cells within a fragment and will likely be a decimal. Figures 4 and 5 below further outline the habitat criteria and GIS scoring workflow.

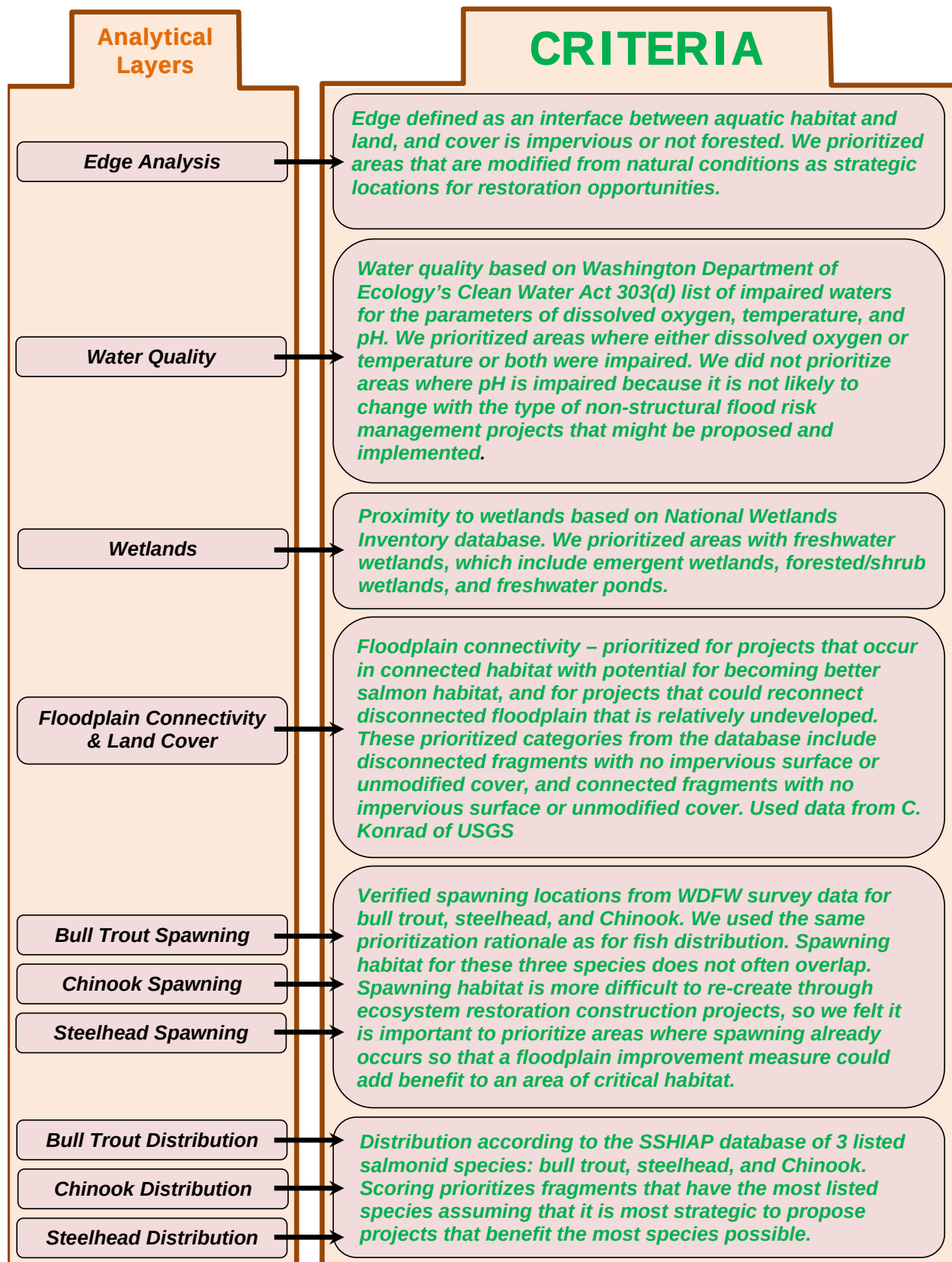


Figure 4. Salmon Habitat Layers and Criteria for GIS Analysis

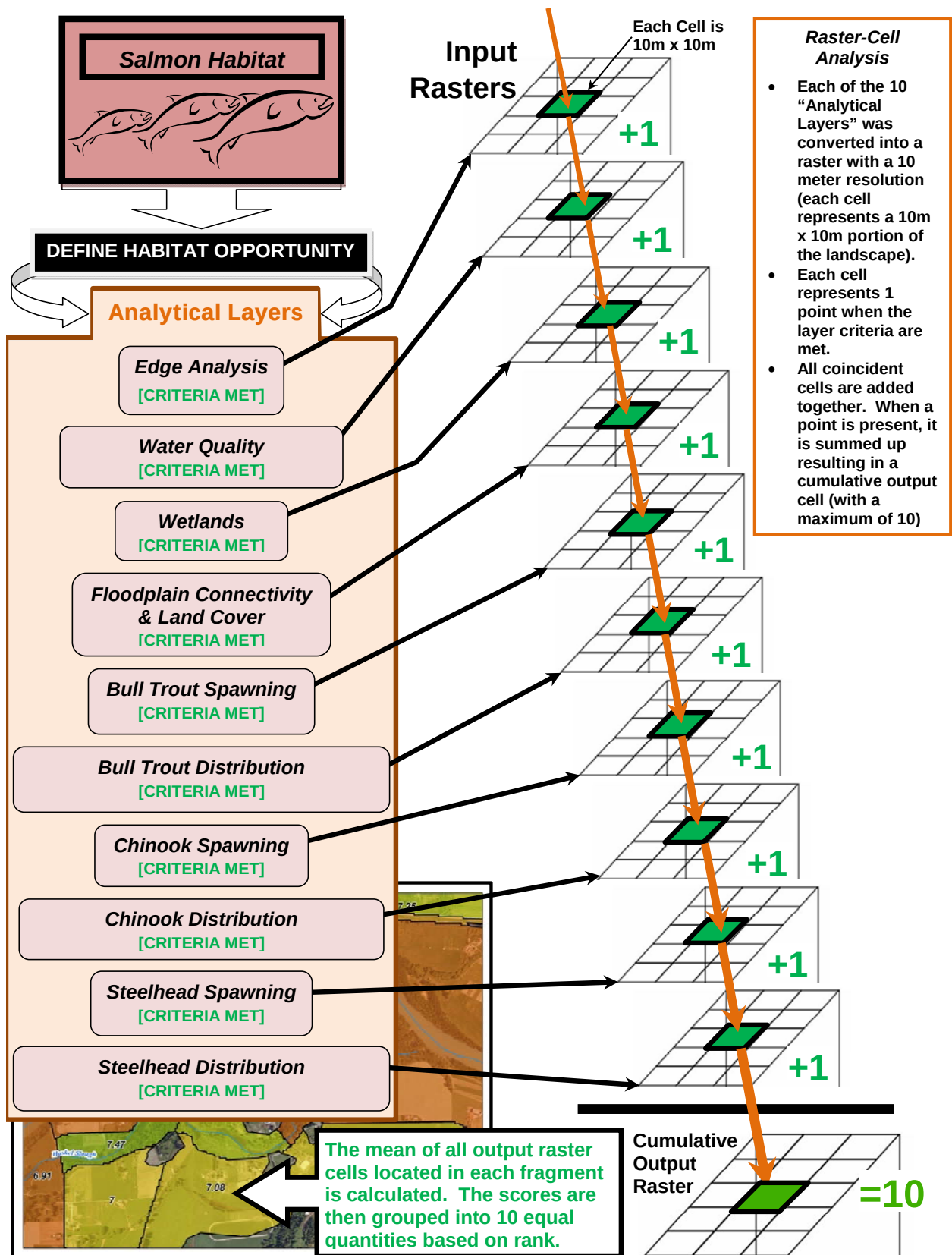


Figure 5. GIS Workflow for Salmon Habitat Scoring

Geospatial Analysis

The integration of the spatial criteria of the habitat restoration and flood risk management datasets was completed by building a selective prioritization system based on GIS analysis. All the layers in Figure 6 below were processed and incorporated into the GIS framework. Of the more than 44,000 fragments identified by the USGS floodplain analysis, 15,071 were larger than one acre and were scored using GIS integration. The principle process was to bring each dataset into a raster format with a 10-meter resolution (each cell represents a 10m x 10m portion of the fragment). An additive raster analysis was then applied to summarize the relative value for a given fragment in the floodplain. This was done separately for habitat restoration and flood risk management (Figures 7 and 8). The integration of the scoring was simply achieved by adding the two analyses together to provide a comprehensive multi-benefit opportunity score.

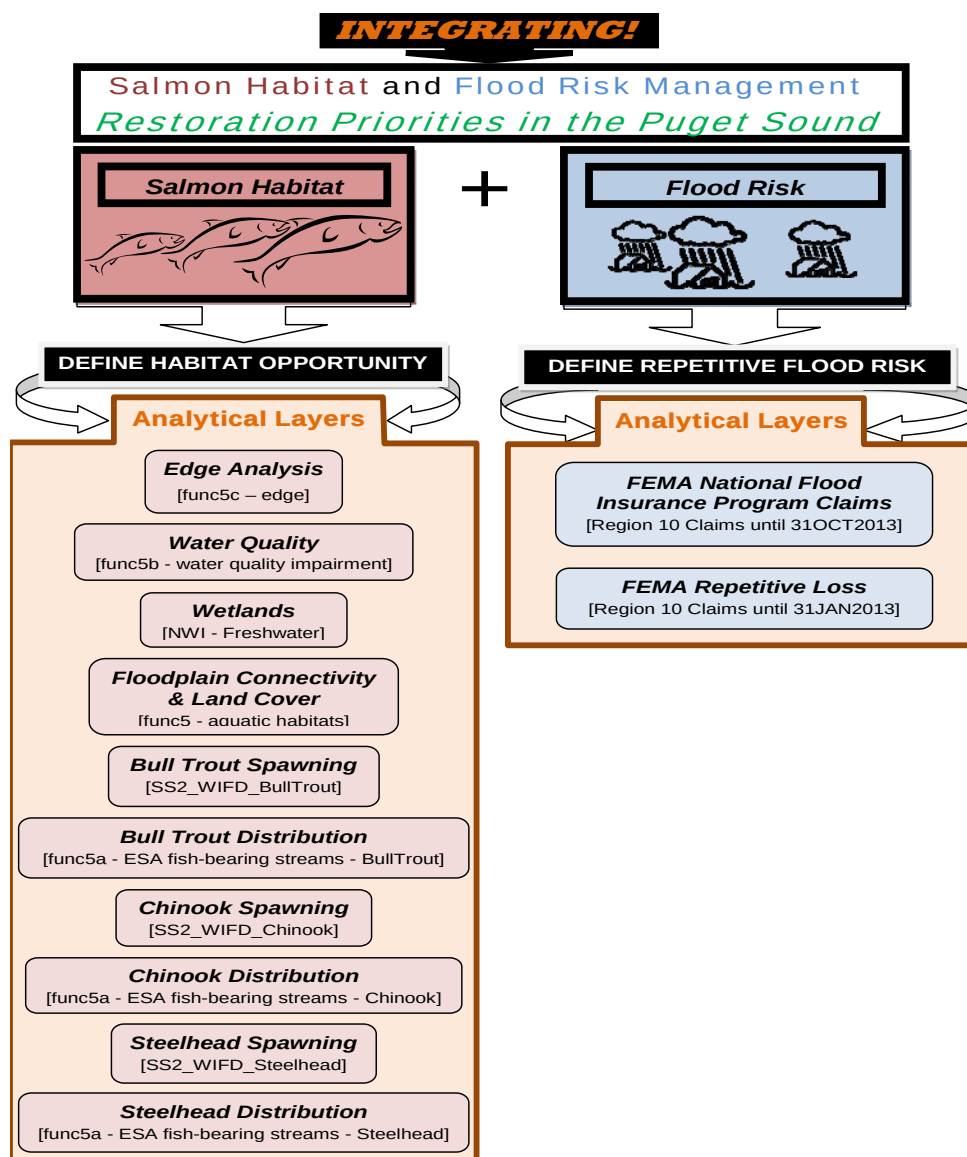


Figure 6. GIS integration of salmon habitat and flood risk layers

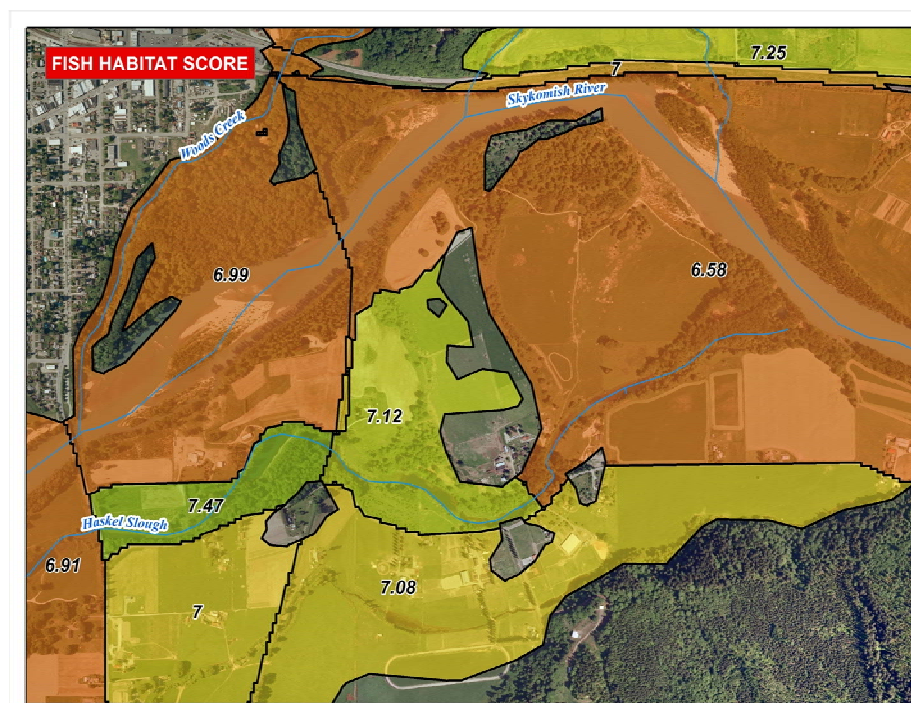
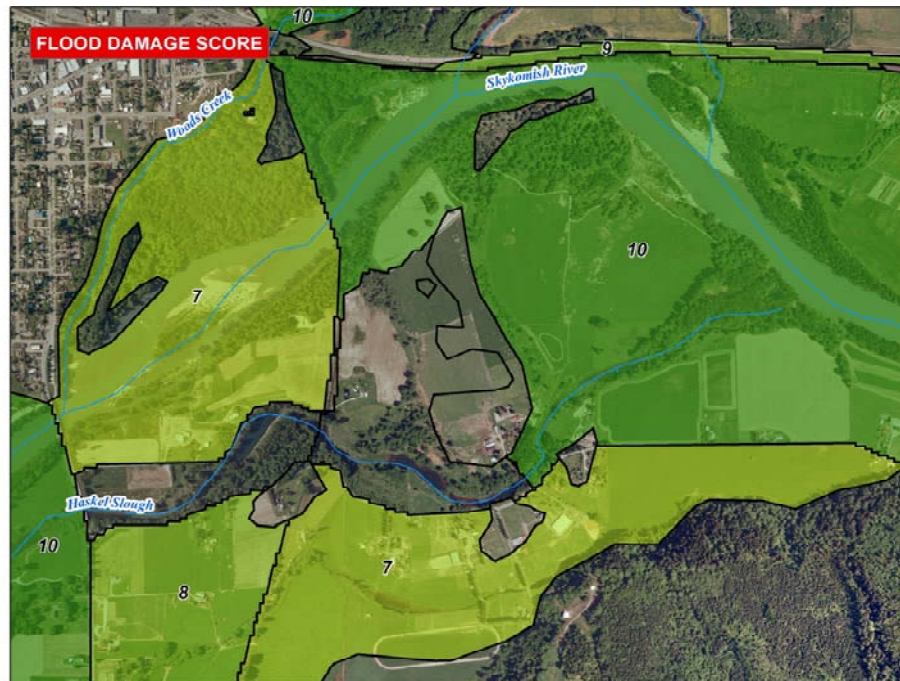


Figure 7. A reach of the Skykomish River. In the top image, each fragment is grouped into 10 equal bins based on its flood risk ranking against one another (10 being the highest for flood risk reduction opportunities). In the bottom image, the same fragments are assigned a 1-10 score based on habitat restoration criteria.

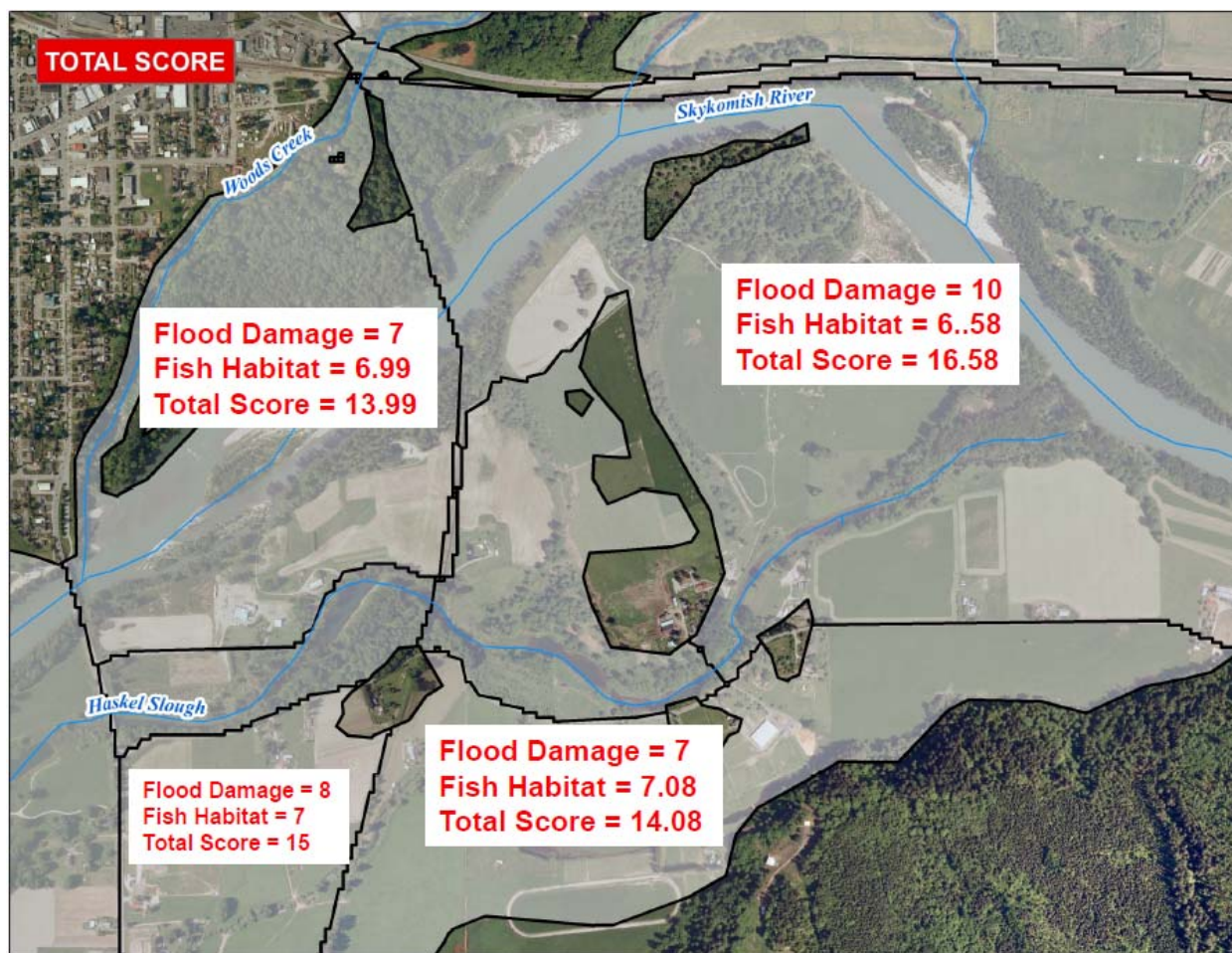


Figure 8. A reach on the Skykomish River. Combining flood risk and habitat restoration scores into a comprehensive opportunities score.

Puget Sound Basin Results

The highest-scoring fragment totaled 17.61. Note the flood risk scores were based on grouping an equal number of fragments into 10 bins, so out of the approximately 15,000 fragments greater than 1 acre, about 1500 of them scored a 10, another 1500 a 9, and so on. The top ranked fragment at 17.61 scored a 10 in flood risk and a 7.61 in habitat restoration, which is the highest habitat restoration score. The 171-acre parcel has had 16 FEMA claims totaling approximately \$250,000. A 514-acre fragment had the highest flood damage, with 137 FEMA claims totaling \$3.7M.

The PDT checked outputs for not only the top scoring fragments but also for the largest fragments by acreage. The acreage is important because there may be relatively simple floodplain projects or policy changes which can lead to significant risk reduction and habitat improvement. For instance, several 5,000+ acre fragments ranked in the top 20. Land use decisions, zoning policy, and other non-structural measures may be very attractive for maintain/improving these larger areas depending on further investigations. A region-wide view of fragment scoring can be seen in Figure 9.

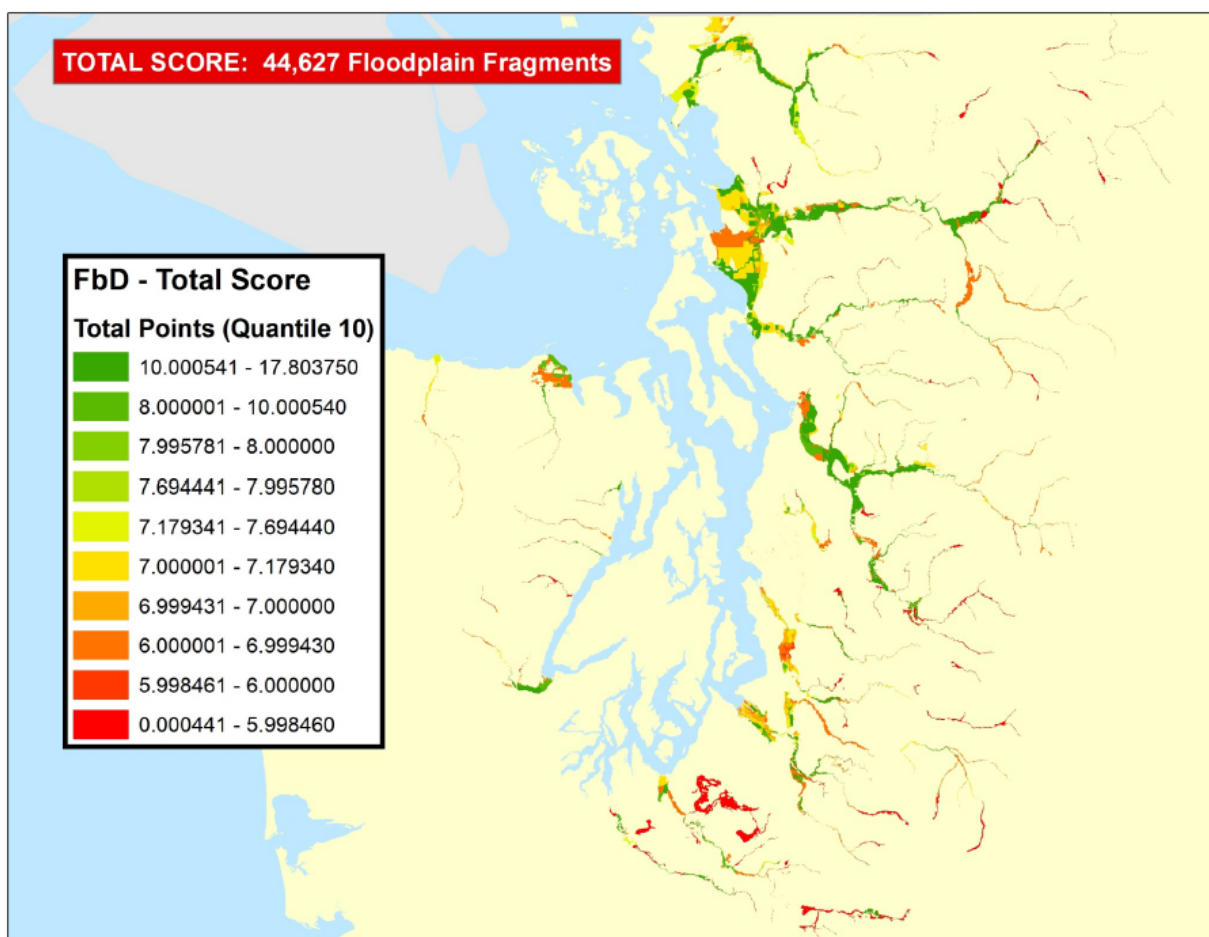


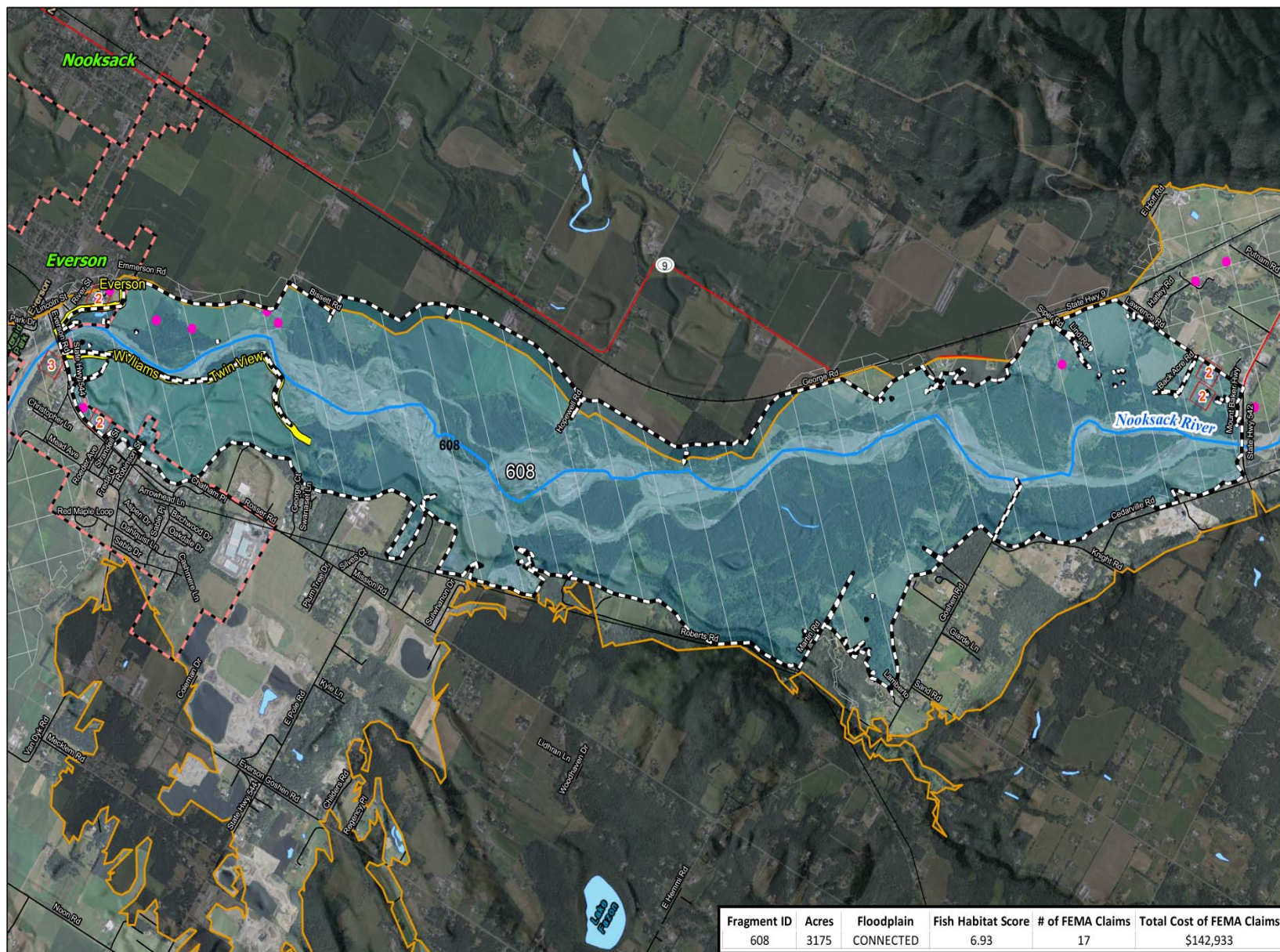
Figure 9. Color-coded view of all Puget Sound floodplain fragments analyzed, scored, and ranked for highest multi-benefit opportunities. Notice most the higher-scoring green fragments are closer to the coast. More populated areas will often have higher flood risk and cause greater habitat impairment. Additionally, density of endangered salmonid species is typically greater in the lower reaches of basins.

Location maps with more detail were developed for the top 20 ranked fragments. A 3,000-acre connected fragment in the Nooksack Basin can be seen in Figure 10. Several FEMA single and repetitive loss claims have been made within this boundary. There are also levees on both banks at the downstream end. This fragment scored highly for habitat restoration opportunity due to presence and spawning of endangered species, among other criteria.

The availability of funding for floodplain projects, even those offering multiple benefits, is a constraint and will be for the foreseeable future. In basins where local jurisdictions have to make tough choices of how to best use diminishing floodplain dollars, it is the hope of this study team that the analysis, ranking, and mapping done here can be another tool to support decision makers as they prioritize floodplain improvement demands. Additionally, the study team intends to move this methodology forward by geographically matching up high-scoring areas to various funding programs and authorities available through USACE and Silver Jackets partners. While local governments may appreciate scaling down the analysis to single river basins and comparing fragments on a reach scale, the real value will be attaching those reach scale prioritized areas to possible funding streams leading to actual implementation.



Nooksack River Basin Opportunities

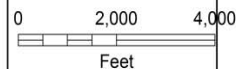


Fragment ID: 608

Floodplain Fragment Rank

- 1
- 2
- 3
- 4
- 5

Connected Floodplain
Disconnected Floodplain
FEMA Claims
FEMA Repetitive Loss
Habitat Work Schedule
Rivers
Lakes
Levees
Roads
Railroads
City Boundary
Study Extent



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Fragment ID	Acres	Floodplain	Fish Habitat Score	# of FEMA Claims	Total Cost of FEMA Claims
608	3175	CONNECTED	6.93	17	\$142,933

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