Final Scope of Work/Deliverables for The Anadromous Fish Floor GIS contract

03/13/2020

The Forest Practices Board (Board) has accepted two Anadromous Fish Floor (AFF) proposals for comparison and analysis in order to help inform the appropriate metric for the permanent water typing system rule. The 'floor' concept is to establish those waters in which anadromous fish are presumed to be present in western Washington. The AFF is defined as measurable physical stream characteristics downstream from which anadromous fish habitat is presumed and where protocol surveying to identify fish habitat is generally not applied.

The primary objectives of the GIS spatial analysis include: (1) creating a synthetic stream network in selected western Washington watersheds in which the upper extent of the AFF can be located based on the relationship between known anadromous fish distributions and associated channel gradients, fish obstacles, fish barriers[1], and channel widths; (2) assessing the sensitivity of the results to the parameters used in the analyses; and (3) summarizing the results of the analyses to inform the Water Typing Rule Committee on AFF options.

The GIS spatial analysis is being overseen by the AFF Workgroup to help conduct the analysis. DNR will administer the contract.

The scope of work for the GIS spatial analysis contract is comprised of 7 tasks:

1. Build synthetic watersheds and synthetic hydrographic stream networks using NetMap. Add known and estimated fish distribution end points and currently known fish barrier locations provided by the AFF Project Team.
2. Work with the AFF Project Team to calibrate and assess the accuracy of the synthetic stream network's modeled channel attributes (e.g. gradient, width, natural fish barriers) using DNR-concurred Water Type Modification Forms and other available field data.
3. Participate in an AFF workshop to present the synthetic stream networks within the synthetic watersheds, and discuss how to perform a sensitivity analysis and final GIS analyses.
4. Conduct the sensitivity analysis on input parameters that will be used in the final GIS analysis to define stream reaches, channel gradients and natural fish barriers. Summarize findings in a short technical report.
5. Perform comparisons of potential AFF options provided by AFF Workgroup using synthetic hydrographic stream networks containing known anadromy and as necessary natural fish barriers and obstacles. Summarize results in a report containing maps and spreadsheets.
6. Prepare a written summary of methods used to create synthetic hydrographic stream networks and methods of analyses.
7. Participate in meetings, conference calls, give presentations.

Task Descriptions:

1. Build synthetic stream networks within selected watersheds.

Build synthetic hydrographic stream networks within the following watersheds containing high resolution lidar:

- Skookum Creek (near Shelton, WA);

[1] The landowner proposal includes obstacles as a part of its AFF definition for tributary streams, the westside tribal proposal includes barriers, which currently default to WDFW.

- Mill Creek (near Shelton, WA);
- Selected sub-basins in the Skagit and Samish watershed;
- Selected basins in the Olympic National Forest (data from Forest Service stream survey projects); and
- Stillman Creek, Kalama River, Jones Creek watersheds.

a. Build for the AFF Project Team: synthetic watersheds containing synthetic hydrographic stream networks using NetMap. This entails the following tasks:
   i. Assemble and mosaic lidar DEMs to cover the entire area encompassed by the study watersheds. If lidar data are not available for the entire watershed, merge with the highest-resolution DEMs available from the National Elevation Dataset.
   ii. Generate 2-D hydrography for larger channels using available multispectral imagery (e.g., NAIP) to map open water and use this to guide flow routing. This is required to produce smooth channel centerlines.
   iii. Create a hydrologically conditioned DEM in which all closed depressions are delineated and the most likely drainage paths for these depressions are identified.
   iv. Use the resulting flow-accumulation raster to identify flow diversion by road prisms; add digital culverts to enforce flow through roads.
   v. Iterate steps iii – iv until no substantial flow diversions remain.
   vi. Work with AFF Project team to verify synthetic channel locations against aerial photography and checks by field personal familiar with the watersheds. Correct channel locations as needed.

   The resulting synthetic hydrographic stream networks:
   vii. Must provide spatial resolution to a 1-2 meter DEM resolution that can accurately measure channel gradient and vertical drop structures and estimate channel width; and
   viii. Provide the attributes necessary to address the study objectives, including stream segment length (variable and fixed), elevation, drainage area, channel gradient (over any length scale greater than 2 meters), vertical drops, channel bankfull width and depth (regression based), floodplain width, tributary junctions, and the streamwise length between each reach and the basin outlet;

b. If needed, after AFF Project Team QA/QC, further adjust stream networks to represent known hydrography within watersheds.
c. Populate hydrographic stream networks with fish data, natural fish barriers and other features as identified by AFF Project Team.
   ix. Summarize fish distribution end points and stream attributes on maps and in table formats designed in conjunction with the AFF Project Team, including results from the three westside watersheds completed by Terrainworks (Stillman Creek, Kalama River, Jones Creek).

2. Work with AFF Project Team to increase understanding of the reliability of the characterization of the channel attributes derived from the synthetic stream networks.

Work with project to identify stream segments that have empirical data describing the channel attributes of interest (gradient, bankfull width, natural fish barriers) that can be used to calibrate model and assess its accuracy.

a. Work with AFF Project Team to set initial model parameters including:
   i. Reach length and gradient, including both variable length – based on channel width (e.g. 20x bankfull width) and slope-change consistency threshold (see Figure 1); and fixed length (e.g. 30 meters).

ii. Stream width(s) (measured in bfw);
iii. Permanent natural fish barrier criteria – height, width, gradient, length.

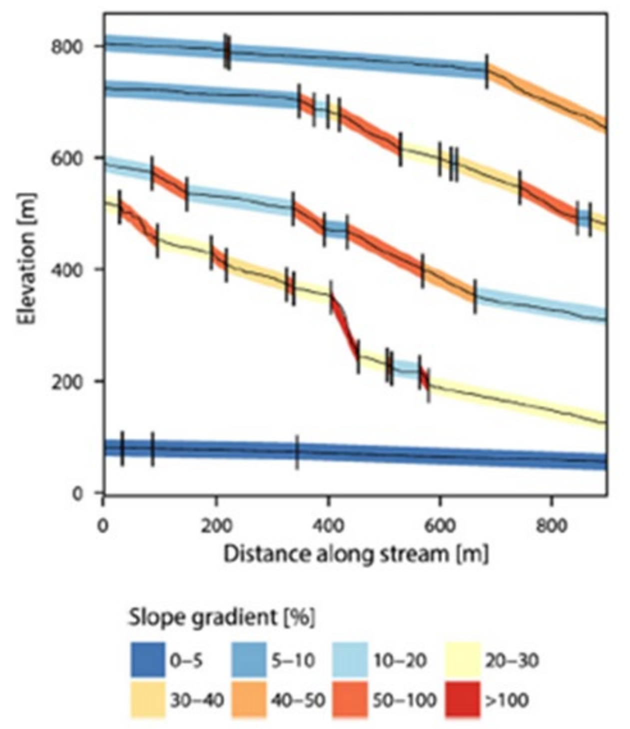

Fig 4. Example of stream segments derived from ALS data.

Figure 1. *An example of channel segmentation of varying length having homogeneous channel gradients (Tompalski et al. 2017). Appropriate gradient breaks will be defined during consultation with project collaborators.*

b. Compute the additional attributes outlined above (1.a.iii) for each variable and fixed reach segment;
c. Create maps of the selected watersheds with the following locations plotted:
   i. Documented end of anadromous and other fish species habitat (fish habitat data provided by the AFF Project Team in step 1.c);
   ii. Barriers – including both field-identified permanent natural fish barriers from fish distribution data, GIS datasets, and modeled barriers based on fish barrier criteria provided by Project Team, including barriers that meet the Washington Department of Fish and Wildlife definition of permanent natural barriers [2];

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[2] **The current WDFW natural fish barrier definition used in the Tribal AFF proposal**

Natural barriers, that would exclude most adult salmonids, are defined as:

- a waterfall > 3.7 vertical meters in height,
- a stream reach having a sustained gradient exceeding 20% for 160 or more meters (continuous), or,
- a channel having a sustained gradient >16% for a distance of 160 meters and having a width <0.6 meters in Western Washington or <0.9 meters in Eastern Washington as measured at the scour line

While it is recognized that different species have various jumping and swimming abilities, for example, bull trout are often found above 30% gradient (Cannings and Ptolemy 1998) and cutthroat trout have been found in gradients up to 33% (Jauquet 2002), for purposes of this manual, the 20% gradient threshold has been accepted as the upper limit for most adult salmonids.

iii. Natural fish obstacles – both field-identified and modeled obstacles;
iv. Downstream-most reaches that exceed 5%, 7%, 10%, 12% and 16% on each stream that contains an end of fish habitat distribution point and/or an end of anadromous habitat point;
v. Landowner AFF points for each stream with an end of fish distribution/fish habitat point and/or an end of anadromous habitat point.

3. Participate in Workshop to present synthetic stream networks within synthetic watersheds.
AFF Project Team will schedule a workshop for the AFF Workgroup, Water Typing System Board Committee and interested stakeholders to describe the synthetic stream networks and analysis methodologies to evaluate options for an AFF.

a. Prepare a presentation to describe how synthetic watershed and synthetic hydrographic stream networks have been built and the accuracy of the stream characterization analyses;

The meeting agenda will include:

b. Finalizing the sensitivity analysis;
c. Discussing final GIS analysis.

4. Help design and conduct sensitivity analysis on GIS model accuracy

- Address the following questions through a sensitivity analysis:
  - How do different minimum reach lengths affect estimates of channel gradient?
  - How does application of variable versus fixed reach lengths affect the distributions of estimated channel gradients and stream length between modeled AFF alternatives and known anadromy?
  - How do different definitions of barriers change the distributions of stream gradients and channel lengths observed in the GIS analyses?
  - How do different threshold values for the minimum change in gradient that trigger a reach break affect distribution of channel gradients?
- Summarize findings of sensitivity analysis in a short technical report

5. Select final stream parameters, perform GIS analysis
Work with the AFF Project Team to select final stream model parameters (reach definition, barrier definition). Perform comparisons of the AFF options provided by AFF Workgroup to the synthetic hydrographic stream networks containing known anadromy and natural fish barriers.

a. Build and populate database/spreadsheet that includes at a minimum the following information:
   i. For each end of fish and end of fish habitat point (for both anadromy and other fish)
      A. Reach description, both upstream and downstream of point, (based on field data, if available, and modeled info) – gradient, bankfull width and depth, step height (if present), floodplain (if present), channel confinement;
      B. Steepest downstream reach gradient;
      C. Steepest upstream reach gradient (to next barrier);
      D. Distance to nearest barrier, both upstream and downstream;
      E. Distance, positive or negative, to downstream-most reach in stream that exceeds 5%, 7%, and 10% gradient;
      F. Distance, positive or negative, to landowner end of AFF points;
      G. Distance, positive or negative, between AFF point and concurred F/N Break.

c. Help develop field protocols for model validation

i. Design field sampling protocols to assess model accuracy (with Project Team)
    - Channel gradient
    - Stream width
    - Barrier identification

ii. Assist in providing guidance, as necessary, to field data collection work done by Project Team

iii. Help summarize with Project Team potential error in model estimates based on QA/QC findings

6. Participate in meetings, conference calls, give presentations

- Meet with Project Team one time
- Participate in an AFF workshop
- Participate in weekly conference calls with full AFF Workgroup
- Give one presentation on the sensitivity final analysis results
- Participate in presentation of the final GIS analysis

7. Write up methods and help draft final reports

- Summarize GIS methods in final report
    - Help summarize with Project Team the GIS analysis and findings in final report

Citations

Cavalli, M., Tarolli, P., Marchi, L., and Fontana, G. D., 2008, The effectiveness of airborne LiDAR data in the recognition of channel-bed morphology: Catena, v. 73, p. 249-260.

Tompalski, P., Coops, N. C., White, J. C., Wulder, M. A., and Yuill, A., 2017, Characterizing streams and riparian areas with airborne laser scanning data: Remote Sensing of Environment, v. 192, p. 73-86.