Final Report
Third-Party Review of
Projects Involving Large Wood Emplacements

Parametrix
ENGINEERING . PLANNING . ENVIRONMENTAL SCIENCES

December 2015

Location: King County, Countywide (multiple locations)

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CONSULTANT SERVICES

This report was prepared by Parametrix (719 2nd Avenue, Suite 200, Seattle, WA) for King County Water and Land Resources Division.

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Acronyms and Abbreviations

Throughout this report, the following acronyms, abbreviations, and definitions were used:

BACI	Before-after-control-impact
BOD	Basis of Design
cfs	Cubic feet per second
CFM	Certified floodplain manager
COI	Conflict of Interest
CPUE	Catch per unit effort
Department	King County Department of Natural Resources and Parks
ELJ	Engineered log jam
ESA	Endangered Species Act
LF	Linear feet
LWD	Large Wood Design
Ordinance	King County Ordinance 16581 (June 2009)
Panel	Independent Expert Panel
PE	Professional engineer
Public Rule	Public Rule LUD 12-1
RM	River Mile
SEPA	State Environmental Policy Act
WDFW	Washington Department of Fish and Wildlife
WLRD	King County Water and Land Resources Division
WSE	Water surface elevation

DEFINITIONS

Geomorphology: The scientific study of the origin and evolution of topographic and bathymetric features created by physical or chemical processes operating at or near the earth's surface.

Large wood: The term "large wood" refers to downed trees, but does not include rooted, standing vegetation. (Large wood is also known as logs, large woody debris, coarse woody debris, snags, and large organic debris.)[1]

Large wood placement: The deliberate placement of large wood in rivers and streams by physically depositing pieces in or near the channel, or installing them in an engineered structure, for any purpose, including flood protection, bank stabilization, mitigation, and habitat improvement or restoration.[1]

Riparian Zone: The interface between land and a river or stream. Riparian zones are significant in ecology, environmental management, and civil engineering because of their role in soil conservation, their habitat biodiversity, and the influence they have on fauna and aquatic ecosystems.

Public safety: Unless otherwise noted, the term public safety is used in this document to reflect the safety of members of the public and water users of the rivers and streams in King County.[1]

River Mile: A measure of distance in miles along a river from its mouth. River mile numbers begin at zero and increase further upstream.

Rootwad: The root system of an upended tree. Rootwads that fall in wetlands or waterways such as streams and rivers are microhabitats for fish and aquatic invertebrates, which in turn provide food for fish, birds, and amphibians.

Thalweg: the portion of a stream or river with deepest water and greatest flow.[2]

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[1] Public Rule LUD 12-1, Appendix A (2010).

[2] WRIA 9 Habitat Limiting Factors and Reconnaissance Assessment for Salmon Habitat, http://www.govlink.org/watersheds/9/reports/recon.aspx.

EXECUTIVE SUMMARY

The King County Water and Land Resources Division (WLRD), part of King County Department of Natural Resources and Parks (Department), designs and implements a variety of instream projects for flood risk reduction, bank stabilization, and habitat enhancement. Some of these projects involve the placement of large wood as key design components. Such projects are subject to the requirements of King County Ordinance 16581 (Ordinance) and Public Rule LUD 12-1 (Public Rule). The Ordinance, adopted in 2009, requires the Department to consider public safety when installing large wood in rivers or streams located in King County. The Public Rule, adopted in 2010, defines the procedures for considering public safety and also requires a third-party review of a representative sample of constructed projects to evaluate their effectiveness relative to project specific goals and public safety. This report summarizes the findings and recommendations of the third-party review, per the requirements of the Public Rule.

Public Rule, Appendix A, Section V.4:

"The Department will provide for periodic independent monitoring and inspection of large wood emplacements by an appropriate third-party provider. This additional monitoring effort will be conducted every three years on a representative sampling of large wood emplacement projects. Reports of such inspections shall be provided to the Department and to all King County Council members."

Excerpt from Public Rule LUD 12-1, Establishing the Requirements for this Report

The purpose of the 2010 adopted Public Rule, as stated in Appendix A, Section I (Purpose), is threefold:

- To consider the public safety issues in the design of projects involving the placement of large wood in rivers and streams located in King County;
- To evaluate strategies for design of wood placements that will maximize project benefit and minimize risks to public safety; and
- To make available to the public the opportunity to provide input on proposed projects utilizing large wood.

The Rule also notes that the decision to recreate in rivers is ultimately the responsibility of the individual, and that enhancing awareness through public outreach and involvement is an important strategy for reducing the risk for recreational river users.

This report summarizes the findings of the third-party review required under the Public Rule Appendix A, Section V.4, and includes the:

- Assessment methodology,
- Processes for selecting the third-party provider and representative projects for review,
- Project work plan (including development of guiding questions and discipline specific evaluation criteria), and
- Findings and recommendations of the Independent Expert Panel (Panel) that conducted the third-party review.

The evaluation by the Panel recognizes that there is a balance between river management and recreational use along those rivers, and that rivers by their nature are dynamic with inherent safety concerns. Therefore, the Panel considered the role of public safety in the assessment of the design and implementation of these floodplain projects.

Selection of Independent Expert Panel

The Public Rule calls for the Department to "*provide for periodic independent monitoring and inspection of large wood emplacements by an appropriate third-party provider*." For this review, a panel of independent experts was selected to perform the duties of the third-party provider. It is the understanding of the Consultant Lead (Parametrix) that this third-party provider should possess appropriate technical knowledge, including information specific to rivers and associated habitat that may influence their level of knowledge and expertise related to the review. The Consultant Lead also understands that the third-party reviewer (i.e., the Panel) should:

- Be capable of providing unbiased opinions about the projects evaluated;
- Provide expertise in their respective fields (engineering, science, and safety);
- Be available and willing to participate in the review, within the requested timeframe; and
- Have no perceived, real or fiduciary conflicts of interest (COI), including prior or current involvement in the projects to be evaluated.

With these criteria, the Consultant Lead facilitated the Panel selection and considered more than 30 candidates from academia, government, and the private sector. Upon review of resumes and subsequent discussions with the Department's project managers to eliminate any potential COIs, the Panel was identified as:

- Mr. Mitch Price, licensed professional civil engineer
- Dr. Stephen Lancaster, geomorphologist
- Dr. Kelly Burnett, fisheries biologist
- Mr. Dan Hudson, river recreational safety specialist

The Consultant Lead believes the highest level of independence was achieved in the selection of this Panel, as no prior history of employment or contracted services with King County were identified with any of the Panel members or their associated firm or agency. This level of independence provided a clear separation between Panel members and Department staff directly involved in the planning, design, and implementation of the projects selected for review. This allowed Panel members to ask questions and independently evaluate whether the stated goals and objectives were met, while satisfying the requirements of the Public Rule.

To maintain boundaries between the independent expert panel and the Department's project teams, the Consultant Lead acted as the facilitator for meetings and site visits with the respective project managers, as well as providing access to documentation provided by Department, and summarizing the Panel's findings.

Selection of Representative Project Sites

It is the responsibility of the Department to identify "projects involving large wood to which the *Procedures for Considering Public Safety When Placing Large Wood in King County Rivers*, Appendix A" is applicable. The Department identified and provided the Consultant Lead fifteen (15) candidate large wood projects for evaluation. Primary and secondary criteria were developed; and because the safety of river users was of primary consideration, higher priority was given to projects that included moderate to high in-water recreational use. Secondary criteria were also considered with the goal of ensuring a diverse representative sampling of projects. Four (4) projects were selected for evaluation, covering range of project types (e.g., levee repair, floodplain restoration, levee setback), locations and river system in King County, construction dates, and project managers. The number of sites was based on factors including schedule, considering both the Panel's availability and the need to complete the evaluation during the summer recreational

use period; and the available budget estimated to synthesis the project information, coordinate and complete site visits, and document the observations and findings.

Upon review of the fifteen (15) candidate projects and after discussions with the Department to confirm the information provided regarding the primary and secondary criteria, the following four (4) projects were selected as the representative sample set:

1. **Belmondo Revetment Enhancement**, which consisted of reconstructing 370 linear feet (LF) of streambank revetment along the Cedar River with vegetated geogrids, two engineered log jams (ELJs) and 250 LF of roughness logs at a site with moderate in-river recreational use;
2. **Herzman Levee Repair**, which included approximately 300 LF of reconstructed river bank along the Cedar River with six pieces of large wood at a site with moderate use by floaters, boaters, and anglers;
3. **Reddington Levee Setback and Extension**, involving multiple emplaced wood structures in a reach of the Green River near a multi-use recreational center, with moderate levels of recreational use and an access point with a park and a sandy beach; and
4. **Upper Carlson Floodplain Restoration**, a project designed to reconnect the Snoqualmie River to floodplain habitat, including the construction of multiple ELJ structures at a site with a variety of recreational users and crafts.

PRIMARY CONSIDERATIONS:

- *Recreational use – volume and skill level of river users*
- *Number, size, and type of emplaced wood structures*

SECONDARY CONSIDERATIONS:

- *Number of wet seasons since construction (i.e. year constructed)*
- *Geographic diversity of rivers within King County*
- *Diversity among King County Project Managers*
- *Project type (setback levee, repair, revetment, water quality, floodplain protection, etc.)*

Criteria for Selecting Representative Projects for the Panel's Evaluation

Detailed documents for each of these four (4) projects were provided by the Department for synthesis into a project summary document for use by the Panel in the evaluation.

Panel Assessment Methodology

With the Panel and representative projects selected, the next step was to define the term, *public safety.* The Public Rule defines public safety as "*the safety of members of the public and water users of the rivers and streams in King County*." For this assessment, the Panel focused on "water users" who might be considered less skilled or experienced and the project elements that could impact those users. The Panel considered project design elements that could pose risks to them, such as the angle of large wood relative to stream flow, the incline of river banks (which can affect recreational users' ability to exit the river), and entrainment potential created by engineered structures or modifications to instream habitat features.

The assessment methodology included the development of:

- Project Work Plan, to define the scope of work and goals, to provide background information and discipline specific criteria for each Panel member, field check-lists, and overall schedule for the review;
- Field/site assessments (by Panel) to observe and document the constructed projects in order to support findings and recommendations; and
- Final documentation of findings and recommendations, field reports, and draft and final project summary report.

Project Work Plan

The Consultant Lead prepared a Work Plan for the Panel to use as a guide in their overall assessment of the sites. The Work Plan included summaries of the four (4) projects based on design and construction related documents provided by the four (4) respective project managers, and a summary of the projects' goals and objectives. The Work Plan was reviewed by the Department for accuracy prior to the Panel beginning their evaluation, and all documents provided were made available to the Panel, should additional detail or information be requested for their evaluation.

Guiding Questions

Through initial meetings with the Department and review of available documents, the Consultant Lead prepared a list of questions to be addressed by the Panel and to serve as guidance in their assessment of the projects. Two fundamental questions, related directly to the Public Rule, served as the basis for the overall evaluation:

1. Based on the available documentation and field observations, was public safety of primary consideration in the design and implementation of large wood placements in King County rivers, including flood risk reduction measures and river recreational safety? If so, in what ways?
2. Were the stated site-specific project goals and objectives achieved, while minimizing risk to public safety?

Through the development of these questions, it was determined that additional, more detailed and project specific questions would be beneficial to the Panel for their evaluation. Therefore, the Work Plan included a series of questions, which included:

- General (i.e., applicable to all projects), and
- Project specific, derived from the synthesized design and construction documents to support the response to site-specific goals and objectives.

The Panel was encouraged to use these questions for guidance in their evaluation, and to supplement as they found appropriate with any additional questions, observations, and findings that would support their conclusions and recommendations for each site reviewed. For reference, the approved Work Plan, including all of the guiding questions (fundamental, general, and project-specific), is included in **Appendix A**.

Public Rule, V.2:

"All projects must be designed to meet their important underlying goals and objectives. Within the context of those goals and objectives, public safety will be of primary consideration in selecting design alternatives."

Excerpt from Public Rule that was the Basis for the Two Fundamental Guiding Questions

Project Assessments by Independent Expert Panel

Upon review by the Panel of the synthesized project information and Work Plan, the Panel visited each of the four (4) sites, accompanied by the Consultant Lead and the Department's Project Managers for site access and orientation, and to answer questions from the Panel. At each location, the Panel considered each of the guiding questions, made observations regarding the constructed projects, and reviewed available project information in the field. Each Panel member provided a 'Field Report' following the site visits (**Appendix B**).

The Panel's conclusions were based on the synthesized project information, review of available documents, and their first-hand observations at each location. The Panel found that, in general, early stakeholder involvement had been incorporated through public meetings and soliciting input from safety specialists and other experts in respective fields.

Belmondo Revetment Enhancement Project

The Belmondo Revetment Enhancement Project (Belmondo) was designed to enhance the quality and quantity of aquatic habitat, promote lateral channel migration, maintain existing flood protection, and meet mitigation requirements for aquatic habitat impacts from an earlier log jam removal project. The Panel members visited the Belmondo site, reviewed project documents, and concluded that:

- The project was consistent with the Public Rule as well as site-specific goals and objectives;
- Risk to the public was minimized through the addition of low-water-level bumper logs, the angulation of the ELJs placed in such a way to deflect swimmers, and the inclusion of void-filling rocks to reduce entrapment possibilities; and
- Public safety was of primary consideration in the design and implementation of the project, as evident through recreational safety concerns addressed at both the 30% and 90% design stages.

The Panel observed additional benefits at the project site, including low-velocity aquatic habitat used by juvenile and adult salmon; bank stabilization (left bank); additional shade and cover, and streambank enhancement structures which featured two (2) ELJs, boulders, and large wood, that were trapping sediment and creating scour pools and fish refugia.

Belmondo Revetment Enhancement Project, Expert Panel Site Visit (August 2015)

Belmondo Revetment Enhancement Project Goals:

1. *Enhance the quality & quantity of aquatic habitat to be consistent with federal, state, and county standards for streambank stabilization projects*
2. *Meet Washington Department of Fish and Wildlife (WDFW) mitigation requirements for impacts on aquatic habitat associated with a log jam removal at Cedar Rapids in 2011 at RM 7.4.*

The Panel Evaluated These Site-Specific Project Goals and How the Balanced with Minimizing Risk to Public Safety

Herzman Levee Repair Project

The Herzman Levee Repair Project (Herzman) was completed in 2010 and consisted of repairing approximately 300 LF of flood-damaged levee on the right bank of the Cedar River at RM 6.6. The work included placing large rock near the low water line, replanting willows along the repaired levee, and adding large wood to mitigate for the loss of vegetation in the riparian zone and existing wood in the river channel. Bumpers consisting of rocks and logs were installed to deflect flows around the large wood. Panel members visited the site, reviewed available documentation, and concluded:

- The project was implemented consistent with the Public Rule as well as site-specific goals and objectives;

Herzman Levee Repair Project Expert Panel Site Visit (August 2015)

- Risk to the public was minimized by placing upstream bumper logs at angles to deflect recreational users away from the emplaced wood structures; and scaling back the amount of wood placements (originally to be the length of the project), reduced safety risks raised from stakeholders; and
- Public safety was of primary consideration through the use of large rock integrated into the wood structures to fill voids and reduce entrapment potential; and design elevation for the bumper logs were adjusted following input from public comment to increase protection for a range of summer recreational flows (150 to 500 cfs).

Herzman Levee Repair Project Goals:

1. *Balance permit-required mitigation for construction impact and recreational user safety*
2. *Have the levee function as originally designed; repairs required due to damage from floods to the face and toe of the upstream end of the levee; and conduct repairs during the Cedar River fish window*

The Panel Evaluated These Site-Specific Project Goals and How the Balanced with Minimizing Risk to Public Safety

An additional observed benefit of the project included a reduction in risk from slope instability with the side slopes (of the levee) flattened where possible. Opportunities for public input included two meetings (May 2010) hosted by the Department; and inclusion of signage placed upstream of the project site warning recreational users of hazards ahead.

Upper Carlson Floodplain Restoration Project Expert Panel Site Visit (August 2015)

Upper Carlson Floodplain Restoration

The Upper Carlson Floodplain Restoration Project (Upper Carlson), completed in 2014, removed 1,600 feet of levee and reconnected the Snoqualmie River to 50 acres of forested floodplain habitat that had been disconnected from the river for decades. The project also placed approximately 300 trees/logs in the adjacent right bank floodplain, constructed a set-back flood protection facility along approximately 1,000 feet of Neal Road, controlled invasive weeds on approximately 20 acres of the site, and planted native deciduous and conifer trees throughout the floodplain. The Panel reviewed the available documents, visited the site for field observations and concluded:

- The Upper Carlson Project was consistent with the Public Rule's stated purpose of maximizing benefits while minimizing the risk to the public;
- Public safety was of primary consideration in project design and implementation, as it incorporated features specifically directed at minimizing risks to recreational users and protecting public safety by maintaining flood protection in the project vicinity; and
- Project objectives were met, and the Panel recommended ongoing monitoring to determine if any adaptive management strategies are required.

Upper Carlson Floodplain Restoration Project Goals:

1. *Promote more natural rates & frequency of channel and floodplain processes to improve salmon spawning and rearing habitat with the primary focus on restoring mainstem edge and off-channel rearing habitat, specifically for ESA-listed juvenile Chinook salmon and steelhead trout*
2. *Maintain or improve current levels of flood hazard protection of private property and public infrastructure*
3. *Address potential impacts on recreational boater safety*
4. *Enhance and maintain the native riparian vegetation community*

The Panel Evaluated These Site-Specific Project Goals and How the Balanced with Minimizing Risk to Public Safety

It was also noted by the Panel that this project was an excellent example of floodplain restoration, and the project is "*to be commended for its goals of reconnecting the historical side channel and floodplain in an effort to improve habitat quality by providing for natural processes without increasing the relative flood risk*" (Mitch Price, Civil Engineer).

Reddington Levee Setback and Extension

The Reddington Levee was originally constructed in the early 1960's and the Setback and Extension Project (Reddington) was constructed in two phases. Phase 1 removed the existing levee and replaced it with a 4,800-foot-long setback levee. This work consisted of removing existing rock armor and levee fill materials; demolishing existing structures; constructing and relocating utilities; constructing a setback levee, access road, rock barbs, and ELJs; creating fish and rearing refuge habitat; and restoring the site with additional trees and shrubs. Phase 2 extended the levee north approximately 1,600 feet. The project provides flood protection to 321 residential parcels and 275 commercial parcels, valued at $680 million[3] (2009 assessed value).

Reddington Levee Setback and Extension Project Expert Panel Site Visit (August 2015)

Reddington Levee Setback and Extension Project Goals:

1. *Reduce risks from flood & channel migration hazards*
2. *Increase width of riparian corridor with a resulting increase in flow capacity & ecological benefits*
3. *Reduce vulnerability of levee to fluvial scour, mass wasting & channel migration*
4. *Reduce long-term costs of flood hazard management*
5. *Allow the river to meander, scour, & develop a more complex ecosystem, which includes formation of rearing habitat for juvenile salmon*
6. *Protect existing vegetation and restore a corridor of native vegetation to increase shoreline shading*

The Panel Evaluated These Site-Specific Project Goals and How the Balanced with Minimizing Risk to Public Safety

Upon assessment of the project and site visit/observations, the Panel concluded:

- The Reddington Project was consistent with the Public Rule's stated purpose of maximizing project benefits and minimizing risk to the public;
- Public safety was of primary consideration in project design and implementation, including replacement and extension of the levee at current design standards, and setting back the levee to reduce susceptibility to scour and increasing the flow containment capacity; and
- Public input was considered throughout the design phases, including the location, size, and anchoring of ELJs.

Dr. Lancaster specifically commented on being impressed by the "*ambitious scope and diligent execution of the project*." In particular, he noted the monitoring so far has been thorough and data-rich and he found no particular issues regarding public safety. It was also noted by Panel members that the project appears to be on track with the stated short- and long-term monitoring goals.

[3] King County briefing to Homeowners' Association at River Mobile Estates, May 9, 2012.

Conclusions and Recommendations

This Panel evaluation and summary report was prepared in response to the Public Rule. Through detailed evaluation, field observations, and review of the synthesized information for the four (4) selected representative projects, the Panel responded to the two fundamental questions, with an affirmative:

1. Yes, public safety was of primary consideration in the design and implementation of large wood of large wood placements in the rivers and streams evaluated in King County; and
2. Yes, site-specific project goals and objectives were achieved, while minimizing risk to public safety.

It should be noted that this report represents recommendations and findings of the Panel as a whole, and not the opinion of the Consultant Lead or any employee of the Department. For brevity, the verbal and written assessments of the panel members were summarized for this report by the Consultant Lead. Confirmation was obtained by each expert panel member that their findings were accurately presented, as summarized in this report. To preserve the integrity of each panel member's findings, their full, unedited reports have been included as an Appendix to this report (**Appendix C**).

Recommendations

The Panel and the Consultant Lead offer the following recommendations for future, similar independent expert panel reviews of emplaced wood projects on rivers in King County associated with the Public Rule:

1. Collection of pre-construction baseline data (habitat surveys, fish monitoring, water quality data, etc.) as relevant to project-specific goals to aid in a quantifiable evaluation for any site specific goals and objectives;
2. Extending the review period to observe sites under a range of river conditions (e.g., one wet and one dry season) to document variable elements such as bumper logs intended to rise/lower with water levels, creation of aquatic habitat pools, and recruitment of natural logs; and
3. Selection of older (constructed) projects to evaluate the longer-range objectives relative to habitat restoration and geomorphology conditions of the site.
4. Modification of the process/approach to the third party review to include the synthesis of information to be performed by the Department's Project Managers, with a review and response by the Panel prior to the site visits, which could be facilitated by a third party (i.e., Consultant Lead) to maintain the desired level of independence.

Outside the Panel review process itself, the Consultant Lead offers the suggestion of engaging a public outreach specialist to evaluate both the effectiveness and cost-benefit of the public outreach process. It may be possible that:

1. Those interested in engaging are already participating, or
2. There are others interested, but it is unknown why they are not participating.

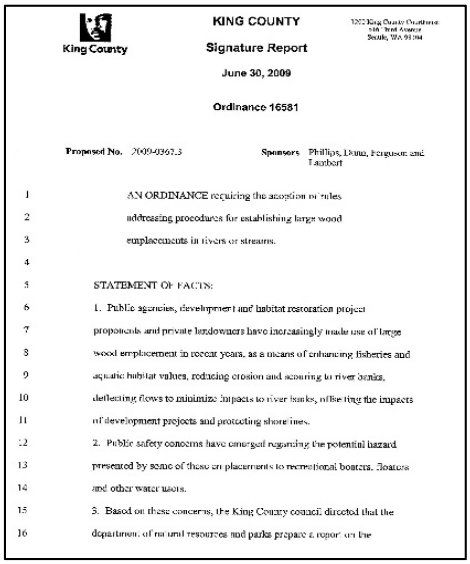
A survey of residents in the vicinity of future project locations may provide additional information on the level of interest and involvement desired by those residents.

Overall, the Panel found the projects to be impressive in the balancing of public safety with other stated project goals and objectives and the intent of the Public Rule achieved for this evaluation.

1. INTRODUCTION AND BACKGROUND

The King County Water and Land Resources Division (WLRD), which is part of King County Department of Natural Resources and Parks (Department), designs and implements a variety of instream projects for flood-risk reduction, bank stabilization, and habitat enhancement. Some of these projects involve the placement of large wood as key design components. Such projects are subject to the requirements of King County Ordinance 16581 (Ordinance) and Public Rule LUD 12-1 (Public Rule). The Public Rule established procedures for considering public safety with respect to recreational use when placing large wood in rivers and streams within King County.

Parametrix was hired as the Consultant Lead to select a representative sampling of large wood emplacement projects and to assemble an independent expert panel (Panel) that would provide third-party review of those projects. And to summarize the findings and recommendations of the Panel.



King County

KING COUNTY

Signature Report

June 30, 2009

Ordinance 16581

Proposed No. 2009-0367.3 Sponsors Phillips, Dunn, Ferguson and Lambert

AN ORDINANCE requiring the adoption of rules addressing procedures for establishing large wood emplacements in rivers or streams.

STATEMENT OF FACTS:

1. Public agencies, development and habitat restoration project proponents and private landowners have increasingly made use of large wood emplacement in recent years, as a means of enhancing fisheries and aquatic habitat values, reducing erosion and scouring to river banks, deflecting flows to minimize impacts to river banks, offsetting the impacts of development projects and protecting shorelines.

2. Public safety concerns have emerged regarding the potential hazard presented by some of these en placements to recreational boaters, floaters and other water users.

3. Based on these concerns, the King County council directed that the department of natural resources and parks prepare a report on the

King County Ordinance 16581 (June 2009)

1.1 Overview and Purpose of the Public Rule

The Public Rule requires the consideration of public safety features in the design of projects involving the placement of large wood and to evaluate strategies that would maximize project benefits while minimizing risk to the public, allow for public input, and require a third-party evaluation of constructed projects. Key elements of the rule, relevant to this review, include Sections I and V from Appendix A of the Public Rule:

Public Rule, Appendix A, Section I (Purpose)

The purpose of the Public Rule is threefold:

1. To consider public safety issues in the design of projects involving the placement of large wood in rivers and streams located within King County
2. To evaluate strategies to maximize project benefit and minimize risks to public safety
3. To provide opportunity for the public to provide input on proposed projects utilizing large wood

Public Rule, Appendix A, Section V.4 Monitoring Project Outcome

Section V.4 of the Public Rule requires *"the Department to provide for periodic independent monitoring and inspection of large wood emplacements by an appropriate third-party provider…… every three years on a representative sampling of large wood emplacement projects. Reports of such inspections shall be provided to the Department and to all King County Council members."*

The work completed under this contract (number: P00116P12) is in response to that requirement of the Public Rule. Specific items from the Ordinance and Public Rule Appendix A, considered for each site as part of this evaluation, as applicable, included:

1. Did the project include a conceptual design? If yes, did the conceptual design address:
    a. Proposed location, size, shape, and anchoring of wood?
    b. Whether it was proposed to include wood recruitment, and if so, how?
    c. Whether the emplaced wood is intended to remain fixed or moveable?
    d. How the emplacement is to function to meet project goals?

2. Did the conceptual design include a description of how public safety considerations were incorporated into the project's design?
3. Was timely notice provided by the Department to recreational users, environmental interests, the neighboring community, and others indicating interest, about the proposed project and how comments could be made on the conceptual design?
4. Was public safety of primary consideration in the design and implementation of the large wood placements?
5. Were the other stated site-specific project goals and objectives achieved, while minimizing risks to public safety?

These five (5) items were the basis of two (2) fundamental questions developed for the evaluation of the projects, as discussed in detail in Section 2 of this report.

The primary driver for this work was to evaluate the effectiveness of each representative project relative to its project-specific goals, with special emphasis on whether the project considered public safety, specifically the safety of in- or on-river recreationalists like swimmers, tubers, rafters, and kayakers. The importance of considering public safety in large wood emplacement projects are indicated in the following two excerpts from the Public Rule.

Public Rule Reference	
Appendix A, Section V.1	The Department will ensure that, in implementing the rules, the procedures and design options affording the greatest safety for river users shall be of primary consideration in design concerns involving a balancing of important public purposes as the county addresses safety issues in large wood emplacements and other instream designs.
Appendix A, Section V.2	The Department's project design teams rely on sound engineering and design practices in the development of all Department projects and consider a wide range of public safety issues, including recreational safety, as well as potential flooding and erosion effects on infrastructure, neighborhoods, critical facilities, and other land uses. The responsibility for design decisions rests with the County's multi-disciplinary design teams and licensed professional engineers. All projects must be designed to meet their important underlying goals and objectives. Within the context of those goals and objectives, public safety will be of primary consideration in selecting design alternatives.

In the case of this independent review, the scope of monitoring included reviewing the final design, as-built drawings, any adaptive management efforts or reports as provided by the Department, and field observations of that current state of each project. This review did not consider any ongoing monitoring or studies of each site.

1.2 Selection of Independent Review Panel

The Panel selection process began with the review of over 30 potential candidates and a meeting with representatives from the Department to consider their qualifications. Based on feedback and discussions with the Department, the Consultant Lead made the final selection of the Independent Expert Panel (Panel) with the greatest degree of independence (i.e. free of perceived, or apparent fiscal COIs) from prior work with King County. The selected Panel brought experience from academia, design engineering, and both the government and private sectors. The following summarizes the selection criteria and a short biography for each selected panel member.

Category	Criteria	Selected Panel Member
Licensed Professional Engineer	Experience in river hydraulics and designing and overseeing the construction of river engineering projects involving engineered log structures, flood hazard assessment, and the protection of Endangered Species Act (ESA)-listed salmonids, and with experience in post construction inspection.	**Mr. Mitch Price, PE, CFM** of the River Design Group specializes in river mechanics, and computational hydraulics with a focus on design optimization for hydraulic performance, ecosystem response and risk resilience. His experience includes flood hazard assessment and mitigation, hydrologic forecasting, bridge scour and river instability countermeasures, channel and floodplain restoration, dam removal and fish passages.
Geomorphologist	PhD, or equivalent experience, in geomorphology, geology, or related field and demonstrated experience applying a process-based approach to the analysis of the relationships between landscape evolution, fluvial geomorphology, large wood accumulation, sediment transport, and channel migration	**Dr. Stephen Lancaster** is a graduate of MIT and Harvard, and is currently an Associate Professor of Applied Geomorphology at Oregon State University (OSU). Dr. Lancaster brings a strong understanding of the geomorphology in the Pacific Northwest, and his resume includes numerous publications and presentations directly applicable to the King County emplaced large wood projects.
Fisheries Biologist	Expertise analyzing the effectiveness of placed wood projects to aquatic habitat and other restoration goals and expertise monitoring and inspecting projects within the context of ESA-listed salmonids	**Dr. Kelly Burnett**, US Forest Service (retired), brings experience in how salmon and trout use stream habitats; and how these habitats are distributed across a landscape, advancing knowledge of interactions among in-channel conditions, watershed processes, and land management.
River Recreational Safety Specialist	Demonstrated experience providing river guide services and safety training and experience analyzing instream hazards related to both natural wood accumulations and engineered large wood projects	**Mr. Dan Hudson**, Rescue 3 International Trainer, brings 25 years of search and rescue experience to the expert panel, as well as 11 years of experience as a Lead Swiftwater Rescue Trainer (independent instructor). He is skilled at evaluating riverine systems from a public safety perspective and brings knowledge of Pacific Northwest rivers.

1.3 Selection of Representative Project Sites

Since the adoption of the Public Rule in 2010, the Department has completed fifteen (15) projects on rivers in King County (**Figure 1**) involving the placement of large wood to which the Public Rule applies, and has a website dedicated to large wood projects http://www.kingcounty.gov/environment/watersheds/general-information/large-wood/project-list.aspx. **Table 1** lists those fifteen (15) completed projects, as identified and provided by the Department. The representative sites were selected based on design and construction methods that included the placement of large wood at or near flood protection facilities, and that were located on reaches with potential river recreational use. In addition to those criteria, the Consultant Lead also considered the following to achieve a diverse and representative sample:

- Age of Project: Construction completion date, to evaluate a site under recently constructed conditions, versus a site exposed to multiple wet seasons to observe factors that might impact site stabilization, migration of natural wood, ecological benefits, etc.;
- Geographic Diversity: The river system within King County, to consider different conditions (geomorphologic, riparian corridor, fish habitat, recreational use, etc.) that could differ between river systems and project sites that would be variability to the evaluations; and
- Management Approach: Diversity among the Department's project managers, to evaluate any differences in how project goals and objectives were approached and implemented to balance project benefits with public safety.

Since the Public Rule requires the safety of river users to be of primary consideration, higher priority was given to selecting projects that included the placement of large wood in areas with moderate to high in-water recreational use.

Table 1: Completed King County Emplaced Wood Projects since Adoption of Public Rule (2010)

No.	Project Name, Location	Project Type	In-River Recreational Use	Emplaced Wood	Project Manager	Construction Completed	River System
1	Upper Carlson Floodplain Restoration, Snoqualmie River, River Mile (RM) 33	Levee Setback	Wide variety of recreational users and crafts with more intensive use during summer	Several engineered log structures within the right bank	Dan Eastman	Summer 2014	Snoqualmie River
2	Long Marsh Creek, Long Marsh Creek at May Creek confluence	Sediment Removal	No use by floaters, boaters, or anglers.	Sediment removal from channel	Wes Kameda	Summer 2014	May Creek
3	May Creek Drainage, May Creek at 148th Ave SE	Sediment Removal	No use by floaters, boaters, or anglers.	Sediment removal from channel	Wes Kameda	Summer 2014	May Creek
4	Fenster 2B Revetment Setback, Green River, RM 31.8	Revetment Setback	Recreational tubers, floaters and anglers	Three buried wood structures; no wood placed in the channel/river	Laird O'Rollins	Summer 2014	Green River
5	Reddington Levee Setback and Extension, Green River, RM 28.2 - 29.5, Left Bank	Levee Setback	Floaters, boaters and anglers	Multiple emplaced wood structures and rock barbs	Erik Peters	Fall 2013	Green River
6	Belmondo Revetment Enhancement, Cedar River, RM 10.5	Bank Protection	Moderate use by floaters, boaters, anglers	Two ELJs and two boulder clusters	Mason Bowles	Summer 2013	Cedar River

No.	Project Name, Location	Project Type	In-River Recreational Use	Emplaced Wood	Project Manager	Construction Completed	River System
7	Mason Thorson Extension Levee Repair, Middle Fork Snoqualmie River, RM 1.5, Left Bank	Levee Repair	Moderate summer recreational use by kayakers	2-6 pieces of large wood[4] anchored via earth surcharge and rock ballast.	Mark Ruebel	September 2011	Middle Fork Snoqualmie River
8	McElhoe Pearson Restoration Snoqualmie River, RM 23.1 - 23.3	Levee Setback	Moderate use by floaters, boaters, and anglers	9 pieces of LW; ~ dozen small trees placed in floodplain	Fauna Nopp	Summer 2012	Snoqualmie River
9	Belmondo Bank, Cedar River, RM 9.5 - 10	Bank Protection	Moderate use by floaters, boaters, and anglers	Bank roughening; (ELJ) structure	Mason Bowles	August 2012	Cedar River
10	Cedar Rapids Repair, Cedar River, RM 7.3 - 7.8	Levee Repair	Moderate use by floaters, boaters, and anglers	Setback levee, manage natural large wood recruited to site during flood	John Engel	August - September 2011	Cedar River
11	Rainbow Bend Levee Removal & Floodplain Reconnection, Cedar River, RM 11.2-11.5	Levee Removal	~250-500 floaters	Includes addition of floodplain roughness	Jon Hansen	2013	Cedar River
12	Singer Judd Creek Pond Enhancement, Judd Creek	Habitat Enhancement	None	40 to 60 logs, 10 to 12 inches in diameter and 20 to 25 ft long	Cody Toal	September 2011	Judd Creek
13	Tate Creek Drainage Improvements, Tate Creek -North Fork Rd SE	Sediment Removal	Low or no use by floaters, boaters, or anglers	Sediment Removal from Channel	Shannon Kelly	Completed 2011	Tate Creek
14	Herzman Levee Repair, Cedar River, RM 6.6, Right Bank	Bank Protection	Moderate use by floaters, boaters, and anglers	6 pieces of large wood	Wes Kameda	Summer 2010	Cedar River
15	Cedar River Trail, Site 2B, Cedar River, RM 6.5, Left Bank	Bank Protection	Moderate use by floaters, boaters, and anglers	6 pieces of large wood	Kate Akyuz	Summer 2010	Cedar River

The Consultant Lead considered each of the fifteen (15) projects and, based on the desire for maximum diversity in the representative sample within the constraints imposed by the schedule and budget for this review, as well as the logistics of conducting site visits, selected the following four (4) sites:

[4] Following 30 percent design reviews, the use of large wood was removed from consideration for the Mason Thorson Extension Levee Repair project.

No. 1: Upper Carlson Floodplain Restoration Project: The project is located on the Snoqualmie River at RM 33 and includes a setback levee with large wood installed as multiple engineered log structures. This reach of the Snoqualmie River supports a wide variety of recreational users, particularly people using a diversity of crafts (tubes, canoes, drift boats and rafts). Construction was completed in the summer 2014.

Rock Bar Observed Along Right Bank, Upper Carlson Floodplain Restoration Project (August, 2015)

No. 5: Reddington Levee Setback and Extension: Located on the Green River at RM 28.2, this two-phased project includes multiple emplaced wood structures, as well as a levee setback and extension. This reach of the river, located near a multi-use recreational center, has a moderate level of recreational use and includes an access point with a park and a sandy beach. Construction was completed in the fall of 2013.

No. 6: Belmondo Revetment Enhancement Project: This project is located on the Cedar River at RM 10.5 and included 370 LF of reconstructed streambank revetment with vegetated geogrids, two ELJs, and 250 LF of roughness logs in a reach with moderate seasonal use by in-river recreational users. Construction was completed in the fall of 2013.

Large Wood Observed at Belmondo Revetment Enhancement Project (August, 2015)

No. 14: Herzman Levee Repair: This project, completed in 2010, is located on the Cedar River and includes approximately 300 LF of reconstructed river bank with six pieces of large wood, and has moderate use by floaters, boaters, and anglers.

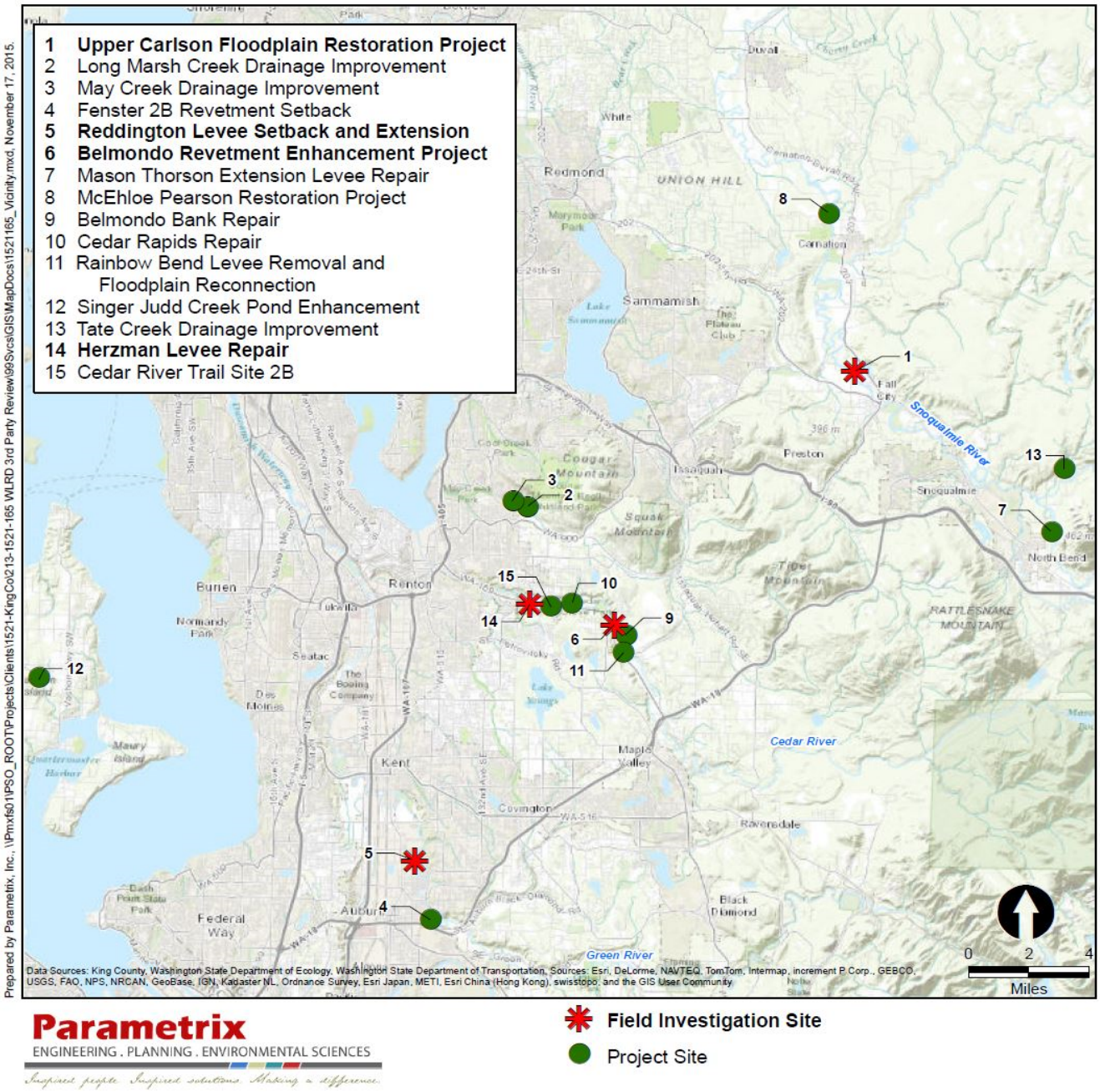


Figure 1. Locations of King County Completed Emplaced Wood Projects (Since March 2010)

2. ASSESSMENT METHODOLOGY

This section describes the assessment methods used to evaluate overall project effectiveness with respect to project-specific goals and the Public Rule, and includes:

1. Kickoff meetings to receive overviews of the four (4) projects
2. Synthesizing available project information (provided by the County, or publically available)
3. Development of a Work Plan
4. Field investigations of each project
5. Documentation of all observations and findings based on both the project synthesis and field observations

Four (4) projects were selected for evaluation, covering range of project types (e.g., levee repair, floodplain restoration, levee setback), locations and river system in King County, construction dates, and project managers. The number of sites was based on factors including schedule, considering both the Panel's availability and the need to complete the evaluation during the summer recreational use period; and the available budget estimated to synthesis the project information, coordinate and complete site visits, and documentation of observations and findings.

2.1 Project Kickoff and Orientation

The Consultant Lead coordinated and facilitated two, 2-hour meetings with the Department to discuss background information, review King County large wood policies, and prepare for the site visits. The meetings were hosted by the Consultant lead, attended in person by County staff and virtually by the expert panel (due to their remote locations, most of whom were located outside the State of Washington). The Department's Project Managers presented key details of their projects, including goals and objectives, and were available to answer questions from the Panel. The first meeting was held on July 28, 2015, and covered the following topics:

- Overall project background, goals, and objectives
- Discussion of the Public Rule
- Expectations of the expert panel members
- Project Overview: Upper Carlson Floodplain Restoration Project
- Project Overview: Herzman Levee Repair Project
- Project Overview: Reddington Levee Setback and Extension

The second meeting was held on July 30, 2015, and covered the following topics:

- Background on the Public Rule and Ordinance
- Project Overview: Belmondo Revetment Enhancement Project
- Project Specific Questions from the Expert Panel and Consultant Lead
- Review of Schedule and Key Milestones

During these meetings, the goals and objectives for each of the four (4) projects were confirmed with the respective Project Managers, and the guiding questions began to be developed.

2.2 Document Summary and Review

The Consultant Lead prepared a summary (project overview/synthesis) for each of the four projects to assist the Panel with understanding each project, its respective goals and objectives, and any other pertinent information (including public meetings and outreach efforts, modifications

made and documented as part of the final designs, and adaptive management efforts). To support this effort, general and project-specific documents were provided by the County, including:

- Ordinance 16581 (June 30, 2009)
- Public Rule LUD-12-1 (March 31, 2010), and Appendix A to the Public Rule
- Procedures for Managing Naturally Occurring Large Wood in King County Rivers
- Synthesis of 2013 River Recreational Studies (2014)
- Large Wood Annual Meeting agendas, sign-in-sheets, and project information
- Large Wood Stakeholder Committee Report (2009).

For the selected project sites, the respective project managers provided the following information (where available and/or applicable):

- Site Management Plans
- Baseline documentation
- Basis of Design reports
- Final design drawings
- As-built drawings and closeout documentation
- Inspection and monitoring reports, including wood investigation reports
- Public records from the design process, public meetings, permit applications, and the State Environmental Policy Act (SEPA) process
- Available information regarding adaptive management, press releases, or other efforts to disseminate information or advise the public of associated risks

The Consultant Lead reviewed and summarized this information, and both the summary documents and access to all the County provided documents were made available to the Panel in advance of the project field visits. The Consultant Lead cataloged the documents for ease of reference by the Panel, and included the catalog index with the Work Plan.

2.3 Development of Project Work Plan

The Department reviewed and approved a Work Plan (**Appendix B**) prepared by the Consultant Lead, for use by the Panel during the field visits. This Work Plan included:

- Project-specific goals and objectives
- Guiding questions to assist the Panel in their assessment of the Projects
- Discipline-specific criteria
- Field investigation activities
- Final documentation process
- Project schedule
- Catalog of reference documents

The goals and objectives provided for each project were identified from project documents and confirmed with the respective project managers. Guiding questions were developed for the projects based on the project goals and the Public Rule. The Work Plan also provided discipline-specific criteria for each panel member to use as a guide in evaluating each site according to the member's area of expertise, both through the field investigation and review of available documents.

Discipline Specific Criteria for Geomorphology

- Condition of embankment (such as visible erosion, riprap, concrete, rebar, boulders), river substrate/bottom
- Seasonal flow rates, depths, and shifting channel conditions

- Flood hazard risk reduction, including erosion measures
- Adaptive management actions, respective to project effectiveness to meet stated goals

Discipline Specific Criteria for Civil Engineering

- Flood risk reduction and mitigation measures, relative to design and constructed project
- Condition of revetments and levees (before and after construction and improvements)
- Existing infrastructure (bridges, levees, and revetments)
- Naturally occurring large wood, and large wood placed during construction of each project
- Stability of ELJs
- Adaptive management actions, respective to project effectiveness to meet stated goals

Discipline Specific Criteria for Fisheries Biology

- Substrate, water temperature, turbidity, depth, flow, current (if able to measure in the field)
- Identification and condition of side channels, mainstem edge, and other additional habitat refugia
- List of endangered species (according to ESA) relative to each project location
- Adaptive management actions respective to creating, preserving, or restoring habitat created by the project

Discipline Specific Criteria for River Recreational Safety

- Direction and approach of main current flow
- Varying hydraulic conditions at project (low flow versus high flow)
- Visual observation of river bottom in the direct vicinity of the project site (rock versus sandy) and likelihood to act as 'strainer' that trap shoelaces or clothes
- Identification of possible helical flow (usually closer to shore or near levees) that may impact smaller children
- Overall project effectiveness, relative to public safety and stated project-specific goals
- Identifying those design features that can impact boater safety
- Adaptive management actions respective to river safety and project effectiveness
- Efforts to disseminate public safety information or otherwise advise the public of associated risks (through websites, warnings posted at sites, and information kiosks)
- Boater difficulty classification

2.4 Development of Guiding Questions

To assist the Panel with their evaluation of each project relative to the intent of the Public Rule, a series of guiding questions was developed by the Consultant Lead and reviewed by the Department as part of the Work Plan. These questions were presented in three categories:

- Fundamental Questions: the basis for this evaluation and related directly back to the Public Rule;
- General: guiding questions that could be applied to all four (4) projects; and
- Project-Specific: questions to aid the Panel in their evaluation to determine if project specific goals and objectives were achieved.

The Panel evaluated each of the four projects from their respective technical backgrounds (engineering, science, and river recreation safety), and addressed these questions, either through an evaluation of available documents provided through the Consultant Lead, or through direct field verification and observations. It is important to note that the independent review of each project was based on project designs, as-built plans, adaptive management efforts, and the

current state of the project identified through field investigation—***and did not*** include any ongoing project-related efforts, monitoring, or mitigation measures for each site.

Fundamental Guiding Questions

The two fundamental questions, applicable to all four of the Projects, and related directly back to the Public Rule, were:

1. Based on the available documentation and field observation - was public safety of primary consideration in the design and implementation of large wood placements in King County rivers, including flood risk reduction measures and river recreational safety? If so, in what ways?
2. Were the stated site-specific project goals and objectives achieved, while minimizing risk to public safety?

General (Guiding) Questions

To assist the Panel in responding to the Fundamental Questions, additional 'guiding questions' were developed to explore each of the projects deeper:

1. What design elements (signage, ELJs, boulders, barbs, etc.) can be identified that were implemented with public safety as a primary consideration?
2. In the Panel member's opinion, are there any noticeable changes (positive or negative) to the river immediately upstream or downstream as a possible/likely result of the project that impacts either the stated project goals or public safety?
3. Can the Panel identify any unintended safety hazards (i.e., "underwater strainers," entrapment of natural wood, etc.) that have developed as a result of the implemented projects?
4. Were adaptive management techniques applied at the site (such as reducing the number of unknowns, and better understanding to improve decision making), learning about management outcomes, and incorporating what was learned into ongoing management?
5. What additional data (or data gaps) would be beneficial for King County to collect during ongoing monitoring measures (or as baseline data prior to construction) to evaluate the effectiveness at each project site relative to meeting project goals and objectives? Is there a range of conditions recommended for data to be collected?
6. Has there been any loss or apparent degradation of features designed as public safety measures (i.e., emplaced wood, ELJs, bumper logs, barbs, geogrids for bank stabilization, signage, etc.) after the site has experienced a high flow or flood?

Site-specific (Guiding) Questions

Project-specific questions were developed for the Panel to assist in responding to the second fundamental question, which applied to the project-specific goals and objectives. These were provided to the Panel in the Work Plan (Tables 2 through 5, **Appendix B**), along with a cross reference (where available) to the resources provided by the Department. The Panel supplemented the guiding questions with their own observations, documentation, and findings.

2.5 Project Site Visits and Observations

Expert Panel Field Visit to the Upper Carlson Floodplain Restoration Project Site (August, 2015)

Upon review of the Work Plan and synthesized project information, the Panel made site visits to each project to record field observations and verify the project goals and objectives, relative to the Public Rule. It also provided an opportunity for the Panel to collect any additional information necessary to address the guiding questions. Pre-field investigation activities included verifying site access and project-specific elements (i.e. location of ELJs, beginning/end point of levee extension, etc.); as well as daily 'rally points' for Panel members.

The field work occurred from August 24 through August 26, 2015, with a pre-field meeting on the morning of August 24 for the Panel to review the field notebooks, overall project goals, guiding questions, and site visit schedules and procedures. This meeting was followed by the site visit to the Upper Carlson Floodplain Restoration Project. August 25 included site visits to the Herzman Levee Repair Project and Belmondo Revetment Enhancement Project. August 26 included the site visit to the Reddington Levee Setback and Extension Project, which included a final on-site debrief with all Panel members and the Consultant Lead.

At each site, the respective project manager provided a site orientation, recap of the key project goals and objectives, and served as a resource for the Panel for any questions. To maintain the independent nature of the evaluation, the Project Manager's role was to serve as a resource for any new questions, to identify the project-specific features and facts, but not to provide opinion or recommendations to any of the 'guiding questions.' The Consultant Lead was present at all times to ensure these boundaries were maintained during the site visits.

During each site visit, the Panel documented observations relative to public safety, ecological benefits, or flood protection measures, such as:

- Location of Large Wood in the river (right bank, left bank, center, other)
- Large wood projecting into the river
- Large wood angle – relative to flow direction
- Velocity of river at the project location(s) as low, medium, or high relative to boater safety
- Site distance (boaters' perspective) approaching large wood from upstream
- Adaptive management measures applied
- Access points to the river near project location(s)
- Habitat restoration measures

The Consultant Lead was responsible for organizing advance field work activities, facilitating site orientation with the Department's Project Managers, photo documenting the site visits, debriefing the panel members after each site visit, facilitating follow-up questions, and providing a field report (**Appendix B**).

3. FINDINGS: BELMONDO REVETMENT ENHANCEMENT PROJECT

The Belmondo Revetment Enhancement Project is located at RM 10.5 on the left bank of the Cedar River, near State Route 169 (**Figure 2**). The focus of the Panel's review was the project completed in 2013 (note: there were other recent projects completed at this site in 2010 and 2012). The 2013 project consisted of reconstructing 370 LF of river bank with vegetated geogrids and four (4) streambank enhancement structures. The structures included two large ELJs and 250 LF of roughness log structures. The instream structures incorporated boulders, large wood, and rock ballasting to trap sediment and create scour pools and fish refugia. Toe rock placed during emergency repairs in 2009 was left in place.

Left Bank, Downstream View of the Belmondo Project Site (August 2015 Site Visit)

3.1 Project Performance Relative to the Public Rule

Based on their reviews of project information and observations made during the August 25, 2015 site visit, the Panel concluded that the Belmondo project, as designed and implemented, is consistent the Public Rule's stated purpose of maximizing project benefits and minimizing public risk. Panel members determined that public safety was of primary consideration in the design and implementation of the Belmondo project, and that the project's goals and objectives were met. The Basis of Design (BOD) report for the project documented the public safety considerations of the design, and provided information about the location, dimensions, and anchoring of emplaced wood.

The Panel noted that the Department provided multiple opportunities to inform the public of the project, and to receive their input. Comments solicited through various events were considered on the preliminary (30%) design drawings. Additionally, a project website was maintained and updated throughout the project design and implementation process. Other opportunities for public input included the SEPA comment period and a presentation at the first annual "I Love the Cedar River" meeting (November 2011). Additional input was collected during an on-site review of the 60% design with representatives of the King County Sheriff's Office Marine Rescue and Dive Unit and Wave Trek Rescue Consultants. The following are examples of design revisions made in response to public safety concerns identified during the public input process:

Public Outreach Efforts for the Belmondo Project:

- Public review and comment on the 30% design
- WDFW and tribal review and comment on the 60% design
- Public review and comment on the 90% design
- Revisions to the 100% design in response to WDFW and tribal objections

Belmondo Team Outreach Efforts to Multiple Stakeholders for Input on Public Safety

- Reorganization of the streambank enhancement structures
- Modifications to the ELJ size and organization to present an angled face to boaters
- ELJs redesigned to eliminate void spaces
- Size and spacing of the boulders modified to reduce entrapment risk

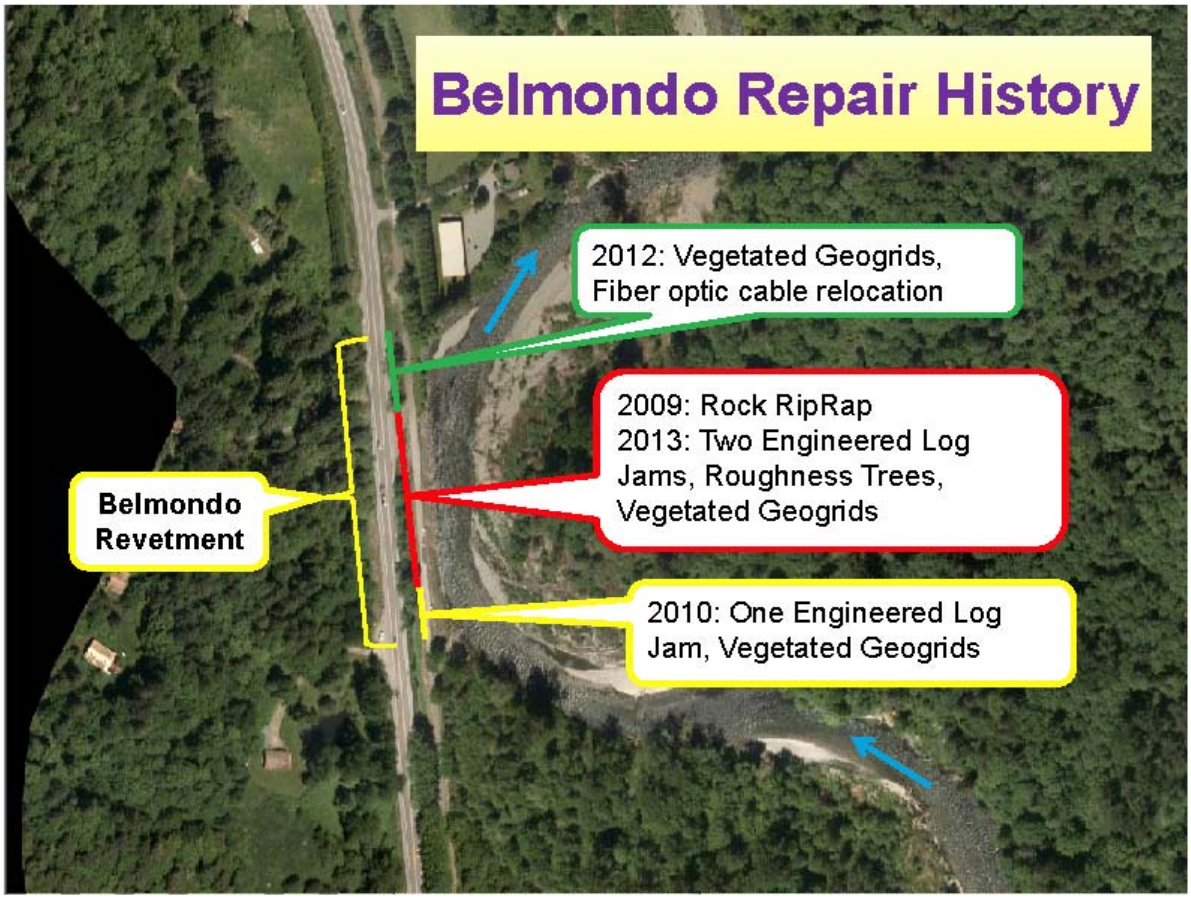


Figure 2. Overview and Repair History of the Belmondo Project
(*Graphic provided by King County*)

3.2 Public Safety Considerations

The Panel members with areas of expertise that overlap substantially with public safety concerns (i.e., river recreational safety, civil engineering, and geomorphology) concluded that public safety was of primary consideration in the design and implementation of the Belmondo project. The project design incorporated features specifically directed at minimizing risks to recreational users of the river and include a process for public outreach that allowed for changes in the project to address the public's concerns about the safety of river users.

Following are key points from the reports prepared by the Panel members, identifying the ways in which public safety was taken into consideration during the design and implementation of the Belmondo project.

River Recreational Safety Specialist: Dan Hudson

Mr. Hudson noted that the Belmondo project included measures that demonstrated public safety was of primary consideration in the design and implementation of the project; including flood risk reduction measures as well as river recreational safety, including:

- A review by a water rescue and safety expert whose comments and evaluations resulted in the addition of low-water-level bumper logs, as well as the angulation of the ELJs to deflect swimmers from potential entrapment; and
- Inclusion of void filling rocks to further eliminate entrapment possibilities.

Warning Sign Observed Upstream of the Belmondo Project Site (Photo by Dan Hudson)

During the site visit, Mr. Hudson observed warning signs upstream for the project site for recreational floaters (presumably posted during the construction phase). He believes it was to warn of hazards ahead and advised users to move to river right, and encouraging users to avoid the potential associated logjam hazards at the project site. Mr. Hudson noted that although warning signage was still present, there were no apparent permanent mounting systems. The sign was placed on a leaning metal bracket commonly utilized for temporary road signs. The temporary nature of the signage would require site monitoring by local authorities to ensure the sign remained in place during high recreational user periods.

Additional notes from Mr. Hudson included:

- Laminar flow of the river channel around the right-hand turn of the Cedar River, moving to river left as designed above the Belmondo reach. The laminar flow migration to the left side of the available channel is a normal effect present in moving water in a right hand turn. Once the laminar flow encountered the upstream ELJ of the project, the current was forced away from the project and returned towards the right side of the channel and the available floodplain.
- There have been no reported rescues, searches, or recoveries as a result of a call for service in the Belmondo reach since the project was completed in 2013.
- Mr. Hudson also noted that King County provided several public input opportunities during the design phase, facilitating the protection and enhancing the safety of the recreational community.

While acknowledging that public safety was of primary consideration in the project design, Mr. Hudson expressed concern that potential risks had not been wholly eliminated, and that rivers by their nature are dynamic and include inherent risks. He specifically noted:

- Two rootwads extended into the main (laminar) flow of the channel on the upstream side of the ELJ that could result in a risk to recreational users if the rootwads were not visible; but that the depth below the surface during the site visit was negligible (i.e. low risk); and
- The remains of a safety cable fence on top of the upstream ELJ (river right) had been vandalized, as the cable was disconnected from an anchor at one end and one of the galvanized steel posts was broken off of the top of the ELJ.

Underwater Rootwads Extending into the Laminar Flow at the Belmondo Project Site (Photo by Dan Hudson)

Civil Engineer: Mitch Price, PE, CFM

Mr. Price noted the following relative to public safety considerations of the Belmondo project:

- Floodplain ELJ structures initially considered upstream of the project were not included in the project design, based on their potential to promote split flows that could create unmitigated floater hazard risks;
- Safety features incorporated into the conceptual design included limiting protrusions on wood structure faces, placing deflector logs, reducing structure porosity, and minimizing exposed fasteners; and
- Design of the roughness log complexes included buried concrete with 5/8" Grade 70 chain anchoring to insure they would remain immobile for the 100 year flood flow and that over the long term, as the wood complexes decompose, chain anchors are safer than steel cable in that they will sink to the channel bottom and not pose any risk of entanglement.

Additionally, Mr. Price noted that there were several public safety-oriented changes made to the project in response to public review/comments, which included:

- The rock and ELJ structures were adjusted to be no more than one-third the channel width and angled 45 degrees downstream with additional horizontal bumper logs on the upstream face and around the rootwads, so that boaters would be redirected away from the structure and new log recruitment would be minimized;
- Infilling of void space with large rock to reduce entrapment and straining risk;
- Orienting rootwads downstream to reduce entrapment risk for approaching floaters; and
- Providing sufficient clear passage between the project and the right bank with slackwater over the pointbar in the upper and lower meander segments.

Geomorphologist: Dr. Stephen Lancaster

With regard to the project considering public safety within the design (while maximizing project benefits), Dr. Lancaster noted that public safety was the primary, if not the only, reason for including bumper logs and internal rock ballast in the project design. He had the following additional notes relative to geomorphology and public safety:

- The area adjacent to the revetment downstream of the first barb is shallow slackwater. Any floaters that may find themselves in this area would not be threatened by swift currents past rough rootwads; more likely, they would simply come to rest on a gravel bar.
- Erosion of the right bank following project construction has created a smooth gravel bank adjacent to the fastest flow—a change that promotes public safety. That is, the first barb, which presents a relatively smooth log bumper to the current and any floaters riding that current, diverts the flow toward the right bank, which is also smooth, perhaps as a result of recent bank erosion, and away from roughness elements on the downstream side of the barb and through the rest of the revetment.

Dr. Lancaster also noted clear signage was installed upstream of the project site to warn floaters about the structures and identify portage take-outs so that floaters have the option to avoid interaction with the log structures altogether.

Various Project Photos from August 2015 Site Visit

Fisheries Biologist: Dr. Kelly Burnett

With respect to public safety, Dr. Burnett simply noted that the project design was modified in response to public comment to reduce risks to recreational users. She cited from the memorandum "*Belmondo Revetment Enhancement – Safety Review and Design Modifications*," dated April 11, 2012 contained in the Belmondo Revetment Enhancement Project BOD Report (July 23, 2014), that the project changed substantially from the 30% design due to concerns for public safety.

She noted that the original design consisted primarily of four (4) instream structures - two (2) boulder clusters and two (2) ELJs. She noted that modifications included reorganizing these four structures, starting upstream with an ELJ rather than a boulder cluster, and altering the structures themselves to present an angled face to boaters and to reduce entrapment risk. She believes that these alterations retained the essential features of the 30% design and thus did not appear to have negatively affected the capacity to achieve desired objectives that called for large wood to enhance various fish habitat functions. Dr. Burnett noted that chief among these functions was creating low-velocity zones, providing cover from predators, increasing interactions with the right-bank floodplain, and forming deep, complex pools.

3.3 Site-specific Project Goals and Objectives

As confirmed with the Department, the Belmondo project had two (2) overall goals and four (4) site-specific objectives (**Table 2**).

Table 2: Belmondo Project Goals and Objectives

Project Goals	Project-specific Objectives
1. Enhance the quantity and quality of aquatic habitat to be consistent with federal, state, and county standards for streambank stabilization projects by promoting lateral channel migration and maintaining existing flood protection 2. Meet WDFW mitigation requirements for impacts on aquatic habitat associated with a log jam removal at Cedar Rapids in 2011 at RM 7.4	1. Construct 370 LF of enhanced bank stabilization and compensate for log jam removal at Cedar Rapids 2. Replace 2009 emergency riprap repair above the ordinary high water level with vegetated geogrids to support the establishment of riparian shade and cover 3. Construct two (2) ELJs to deflect high flows and shear away from the left bank, scour pools, and promote lateral channel migration and connectivity with the right-bank floodplain 4. Construct two (2) complexes of roughness logs to reduce local velocity and shear, promote sediment deposition, and provide fish refuge

The Panel determined that the stated goals and objectives were met, including bank stabilization along the left bank of the Cedar River, vegetated geogrids providing shade and cover, and the construction of two ELJs and two (2) complexes of roughness logs. Additional findings included:

- Promoting lateral channel migration from the emplaced wood
- The observation of low-velocity aquatic habitat and both juvenile and adult salmonids using those habitats; which the Panel believes could indicate progress toward meeting the goal of enhancing the quantity and quality of aquatic habitat

While the Panel found that the Belmondo project goals were met, the degree to which the establishment of shade/cover and creation of scour pools were achieved varied at the site or were difficult to document due to the low flow conditions observed during the site visit (**Table 3**).

Table 3: Performance of the Belmondo Project Relative to Anticipated Responses to Project Objectives

Anticipated Response to Objective	Project Performance
Support the establishment of riparian shade and cover	Vegetation establishment is progressing slowly, with a much better survival rate in watered areas that are using drip-tape. Drought conditions are resulting in plant mortality in some un-watered areas.
Deflect high flows and shear away from the left bank, scour pools, and promote lateral channel migration and connectivity with the right-bank floodplain	The ELJ structures appear to have deflected recent flows away from the left bank to promote flows to the right-bank. However, while the upstream structure is maintaining a scour pool, the downstream structure did not appear to be and it was unknown if this was a result of flow rates observed during the site visit.
Reduce local velocity and shear, promote sediment deposition, and provide fish refuge	Velocity and shear appear to be reduced, and sediment deposition appears to be occurring in the local vicinity of the roughness log complexes. The logs appear to provide good interstitial space, which would be expected to provide aquatic refugia once the logs are submerged.

Following are key points from the individual Panel members, specific to the project achieving the stated goals and objectives.

Fisheries Biologist: Dr. Kelly Burnett

Dr. Burnett noted that in general, the riparian plantings have established and are growing, with the drip irrigation areas appearing more robust than other areas; but that the Cedar River is too wide at the project location for the newly planted riparian vegetation to effectively shade the channel. Additional notes regarding the habitat included:

Juvenile salmonids Observed in Low-Velocity Refuge Habitat at the Belmondo Project Site (August, 2015)

- Areas of low-velocity habitats were increased by the project and juvenile salmonids were observed using these habitats;
- Due to the low water levels during the August 2015 site visit, the complexes of roughness logs were not interacting with the wetted channel;
- Although a key objective of the Belmondo project was to "promote lateral channel migration and connectivity with the right-bank flood plain," the channel has not yet reconnected to its floodplain; and if the connection can be re-established, this should facilitate development of low-velocity habitats that benefit salmonids; and
- Large wood was observed on the mid-channel bar, apparently newly recruited from upstream.

Lastly, Dr. Burnett noted that according to the *Belmondo Revetment Enhancement Fish and Aquatic Habitat Monitoring Report* (April 2015 draft), it was unclear whether the riprap along the Herzman Levee is the current control site for monitoring the effectiveness of the Belmondo project. If so, and if the Herzman Levee Setback and Floodplain Reconnection Project proceeds as scheduled in 2018, then she believes it will be necessary to identify another control site for the Belmondo project.

Geomorphologist: Dr. Stephen Lancaster

Dr. Lancaster has noted that the revetment has apparently caused the formation of diverse aquatic habitats, at least in terms of flow velocities and water depths; and that scour on the upstream side of the upstream barb has created a deep pool with exposed bedrock at the bottom. At higher flows, the downstream sides of both barbs create slack water. Additional observations include:

- The barbs appear to be promoting lateral channel migration away from the revetment. The upstream barb deflects the current (which would otherwise tend to hug the left bank through this bend in the river) toward the right bank. At least at low flow, he observed that the thalweg is against the gravel bar on the right bank. The effect at high flows was apparent to him from the pattern of deposition since construction (downstream of the first barb, the area adjacent to the revetment is largely depositional), and he noted that gravel bars have grown, and that there is evidence of fine sediment deposition in the backwaters on the downstream sides of the barbs.
- No unintended safety hazards are apparent. He noted that it would be possible for someone on an inner tube to go under the first bumper log, and if that happened, the floater would find themselves in a relatively still part of the pool, sheltered from the current by bumper logs. However, he believes such a scenario is unlikely.

Civil Engineer: Mitch Price, PE, CFM

Mr. Price noted that the April 2015 monitoring report documents progress toward the project's biological goals, but that there is not yet documented analysis for or monitoring of the anticipated geomorphic response.

Mr. Price also noted that collection of geomorphic monitoring data is recommended to evaluate project adjustment and channel migration, flow patterns and floodplain connectivity, and log recruitment. Mr. Price recommended it include repeat bathymetric cross sections and a longitudinal profile and possibly surficial sediment gradations over multiple water years (as deemed appropriate based on observed site changes).

River Recreational Safety Specialist: Dan Hudson

Mr. Hudson noted that he believes the stated site-specific project goals and objectives were achieved at Belmondo, and were successful in their intent to minimize the risk to public safety.

4. FINDINGS: HERZMAN LEVEE REPAIR PROJECT

The Herzman Levee Repair Project was completed in 2010. The project consisted of repairing approximately 300 LF of existing, flood-damaged levee on the right bank of the Cedar River at approximately RM 6.6 (**Figure 3**). Repairs included placing very large rock near the low water line. The project design also included replanting the repaired area with willow and placing large wood to mitigate for the loss of vegetation in the riparian zone and existing wood in the river channel. Bumpers consisting of rocks and logs were also installed to deflect flows around the large wood. The intent of the repairs was to restore the levee to a state comparable to its original condition; and it was noted by the Department that the repair project did not include any modifications that intended to change the character, scope, or size of the original design.

Recreational Floaters Observed During Project Construction, July 2010
(Photo provided by King County)

4.1 Project Performance Relative to the Public Rule

Based on their reviews of project information and observations made during the August 2015 field review, Panel members concluded that the Herzman project, as designed and implemented, is consistent the Public Rule's stated purpose of maximizing project benefits and minimizing public risk. Panel members determined that public safety was of primary consideration in the design and implementation of the project, and that the project's goals and objectives were met. The goal of balancing habitat conservation and recreational user safety was met by meeting with the public and placing bumper logs upstream of the new rootwads.

The project charter called attention to the importance of coordination and public input on the large wood elements in the project design. The project manager encouraged early coordination with user groups and outside experts in recreation, boater safety, and fire and rescue, regarding the inclusion of large wood in the project design. It was noted that the project was not designed to recruit or trap additional woody debris or material that may be floating in the river.

The Herzman project team provided opportunities for public input. King County hosted two meetings on May 26, 2010, to present information on the Herzman Levee Repair and other projects involving placement of large wood in rivers and streams (these meetings were distinct from the "I Love the Cedar River" meetings, which are typically held during the month of November).

Figure 3. Aerial Images of the Herzman Project Site, Before and After Project Completion
(*Graphic provided by King County*)

4.2 Public Safety Considerations

The Panel found that public safety was of primary consideration during all phases of the project, with the following examples:

- The wood structures were designed to minimize hazards to passing floaters;
- Upstream bumper logs were designed to deflect recreational users away from the emplaced wood structures; and
- Inclusion of large rock in the wood structures to reduce the possibility of entrapment.

Following are key points from the reports prepared by the Panel members, identifying the ways in which public safety was taken into consideration during the design and implementation of the Herzman project.

River Recreational Safety Specialist: Dan Hudson

Mr. Hudson found that public outreach and involvement occurred and that public safety was a primary consideration of the design, as evident through:

- Community meetings publicized and conducted, and recommendations implemented;
- Large wood was placed only at the tail end of the project site, and bumper logs were placed so as to deflect unwary recreational users away from the rootwads;

- Voids immediately adjacent to the bumper logs and ELJs were filled with large rock, reducing foot and body entrapment possibilities within the project zone for general recreational users; and
- Signage was placed upstream of the project site, warning recreational users of the hazards ahead.

Mr. Hudson noted that although the laminar flow of the Cedar River pushes directly up along the river levee at the project site, the bumper logs appear to be very capable of pushing recreational users away from the ELJs. During the August 2015 field visit (when flows were substantially below typical summer levels), the project ELJs were not in contact with the active channel. The rock toe of the levee, located upstream, effectively redirected the laminar flow of the current away from the ELJs.

Mr. Hudson verified that regional response agencies (Maple Valley Fire and Life Safety and the King County Sheriff's Office Marine Services Unit) reported no calls for rescue within the reach of the Herzman Project during or after project construction. Additionally, agency representatives have a key to the Cavanaugh Pond Gate for quick site access in case of an emergency response to the project reach.

Civil Engineer: Mitch Price, PE, CFM

Mr. Price made the following observations relative to public safety:

- To reduce stability risk, the side slopes of the levee repair were flattened where possible;
- Large wood pieces were scaled back, re-located, and re-oriented to address public safety concerns;
- Large wood was placed only at the downstream end of the construction limits, and the two (2) rootwad pieces were angled towards the channel bed (with two-thirds of the length anchored in the levee for stability) and downstream of four bare bumper logs; and
- The design elevations for the bumper logs were adjusted following public comment to increase protection for a range of summer recreational flows (150 to 500 cfs).

Geomorphologist: Dr. Stephen Lancaster

Dr. Lancaster made the following observations, relative to the Herzman project's public safety:

- Permitting requirements originally called for incorporation of wood along the length of the project, but safety issues raised by stakeholders led to scaling back on wood placements, and wood was incorporated only at the downstream end;
- Each structure incorporates a smooth log protruding from the bank on the upstream side and, on the downstream side, another protruding log but with attached rootwad;
- The smooth, upstream log protrudes farther, so close encounters between floaters and rootwads are unlikely; and
- Rocks, small relative to those facing the levee, are placed in piles on the upstream sides of large wood pieces near water level to prevent floaters from being drawn under the wood.

Various Project Photos from August 2015 Site Visit

Fisheries Biologist: Dr. Kelly Burnett

Dr. Burnett noted that the design of the Herzman Levee Repair Project appears to have been modified in response to public safety concerns as reflected in documents provided to the review panel. She noted that the limited project scope and modest habitat objectives suggest that these objectives were unlikely to have been compromised by project design changes to enhance public safety.

4.3 Site-specific Project Goals and Objectives

The Herzman project was designed to meet two (2) overall goals, with three (3) specific objectives (**Table 4**).

Table 4: Herzman Project Goals and Objectives

Project Goals	Project-specific Objectives
1. Balance permit-required mitigation for construction impact and recreational user safety 2. Have the levee function as originally designed; repairs required due to damage from floods to the face and toe of the upstream end of the levee; conduct repairs during the Cedar River fish window	1. Repair 260 LF of levee along the face and toe of the upstream end 2. Replant the willows on the levee 3. Place large wood at the downstream end of the repair to mitigate for the existing canopy of willow and the wood in the water that was lost during the repair of the levee face

The Panel determined that the goals and objectives were achieved (Table 4), as the levee was repaired as intended, willows were replanted, and large wood was placed at the downstream end of the repair site. It was noted that it was not possible to determine the extent to which the emplaced wood mitigated for the loss of instream wood present before the project because detailed information about the lost wood was not available.

The goals of the project were to balance permit-required mitigation for construction impacts and recreational user safety, have the levee function as originally designed, and to conduct repairs during the Cedar River fish window. The Panel found that these goals were achieved.

Following are key points from the reports prepared by the Panel members, identifying specific ways in which the goals and objectives were achieved.

Fisheries Biologist: Dr. Kelly Burnett

Dr. Burnett observed that the willow plantings have been effective in re-establishing a canopy as well as shade and cover along the embankment. However, she noted that data on riparian vegetation prior to construction were not available as a quantitative basis for comparison. The willow plantings appear healthy and appear to have grown substantially since 2010. These will likely contribute to the creation of low-velocity habitat during relatively high stream flows but will unlikely ever be tall enough to shade much of the channel. No tree species were planted on the upper bank that might eventually provide channel shading. The following are additional

Robust Willow Growth Observed Along the Right Bank of the Herzman Levee Repair Project (August, 2015)

observations and findings from Dr. Burnett from the August 2015 site visit:

- Large pools downstream of the rootwads (except at the furthest downstream piece of wood) may provide fish habitat. During the August 2015 field review, rootwads of the placed logs were in contact with the wetted channel but contributing only marginally to habitat complexity. More of the large wood and bumper logs will likely be in the wetted channel at higher stream flows, increasing the potential to contribute cover and low-velocity habitats.
- No fish were seen in the site during the field review. However, if the Herzman Levee is the control for the Belmondo project, as indicated in the draft *Belmondo Revetment Enhancement Fish and Aquatic Habitat Monitoring Report* (April 2015), then salmonids were documented at the Herzman site during the spring of 2014. Juvenile coho salmon and juvenile Chinook salmon were found in riprap, bar, side channel, and backwater habitats.

Geomorphologist: Dr. Stephen Lancaster

The following are observations made by Dr. Lancaster during the August 2015 site visit:

- The rock armoring the face of the repaired levee was larger than in the original levee, and the larger rock should allow the levee to function as the original levee was intended;
- The willow plantings are healthy and robust; and
- The wood remains in place and provides some shelter and shade next to the right bank, where the flow is otherwise swift.

Face of the levee at the Herzman Levee Repair Project, Right Bank of Cedar River (August 2015)

Dr. Lancaster noted that levee failures can occur when a levee is over-topped by rising flow, and that plunging flow would attack the unarmored back side of the levee. It is also possible for over-topping to follow as a consequence of mass failure, or slumping, which becomes more likely as water from the river permeates the levee, and rising pore pressures in the levee matrix reduce its effective strength. Dr. Lancaster suggested collecting data about how pore pressures in the levee matrix respond at river stages.

Civil Engineer: Mitch Price, PE, CFM

Mr. Price noted that the Herzman Levee as repaired in 2010 exceeds the function as originally designed in 1976, and includes increased rock size gradation for the revetment toe and face. Further, he noted that the repaired levee provides additional flood protection, in that the top elevation of 131 feet provides freeboard relative to the 100-year base flood elevation of approximately 127.5 feet. Additional observations made by Mr. Price during the August 2015 site visit included:

- Mitigation for loss of the existing willow canopy seems well on-track, based on the high survival rate and density of the willow plantings; and
- The root balls on the emplaced wood seemed too small to provide any notable habitat benefit and that the creation of increased roughness and localized velocity reduction, while possible, could not be ascertained from the provided documentation or observed directly due to very low flows.

Mr. Price recommended collecting monitoring data during representative flow conditions to allow a more thorough assessment of the interaction between the emplaced wood and the river; and that on future projects, a more suitable comparison for pre/post project mitigation could detail the habitat conditions and aquatic suitability and not solely the wood count.

River Recreational Safety Specialist: Dan Hudson

Mr. Hudson noted that the project appears to be functioning well and was completed as designed, and that there were no apparent discrepancies between the project design and the completed and functioning repaired levee.

Signage at Entrance to the Cavanaugh Pond Natural Area (Note: River Hazard Warning Sign, Upper Left of Photos)

5. FINDINGS: REDDINGTON LEVEE SETBACK AND EXTENSION PROJECT

The Reddington Levee was originally constructed in the early 1960s, and in 2013 the Reddington Levee Setback and Extension Project construction was completed. The project provides flood protection to 321 residential parcels and 275 commercial parcels, valued at $680 million (2009 assessed value). The site is located in the City of Auburn (City), and includes multiple stakeholders including the City, King County Flood Control District, Muckleshoot Indian Tribe and property owners. The project consists of setback levee construction, existing levee removal, utility construction and relocation, engineered erosion protection, and fish habitat protection measures (**Figure 4**).

Reddington Levee Setback and Extension Project Site (Photo Provided by King County)

The Reddington Project was constructed in two phases. Phase 1, which removed the existing levee and replaced it with a 4,800-foot-long setback levee, was completed in 2013. The work consisted of removing existing rock armor and levee fill materials; demolishing existing structures; constructing and relocating utilities; constructing a setback levee and access road, rock barbs, and engineered log jams; creating fish and rearing refuge habitat; and restoring the site with native trees and shrubs. Phase 2 of the project, which extended the levee north approximately 1,600 feet, was completed in 2014.

5.1 Project Performance Relative to the Public Rule

The Panel concluded that public safety was of primary consideration in project design and implementation, the purpose of the Public Rule was met, and the project-specific goals were also achieved. The project included a conceptual design, which considered the location, size, and anchoring of the ELJs and that the ELJs were designed to remain in place (i.e., they are not moveable).

Construction Photo of Rock Barb and Large Wood within Alcoves - Later Covered/Buried (Photo Provided by King County)

Consideration of public safety played a significant role in at least two design decisions. To address concerns for the safety of boaters and other recreational users of the river, stand-alone ELJs were not included in the final project design. Stand-alone structures are often used for habitat creation and energy dispersion and are designed to have the river engage the ELJ over a wide range of angles and potentially flow on either side of the structure. It was noted by the Panel that the project design team determined there was insufficient room for a full-width active channel between any potential ELJ locations and the setback levee. Flow directed between an ELJ and the levee would be confined and have higher erosion potential, necessitating continuous rock revetment along the levee face and raising concerns for recreational safety.

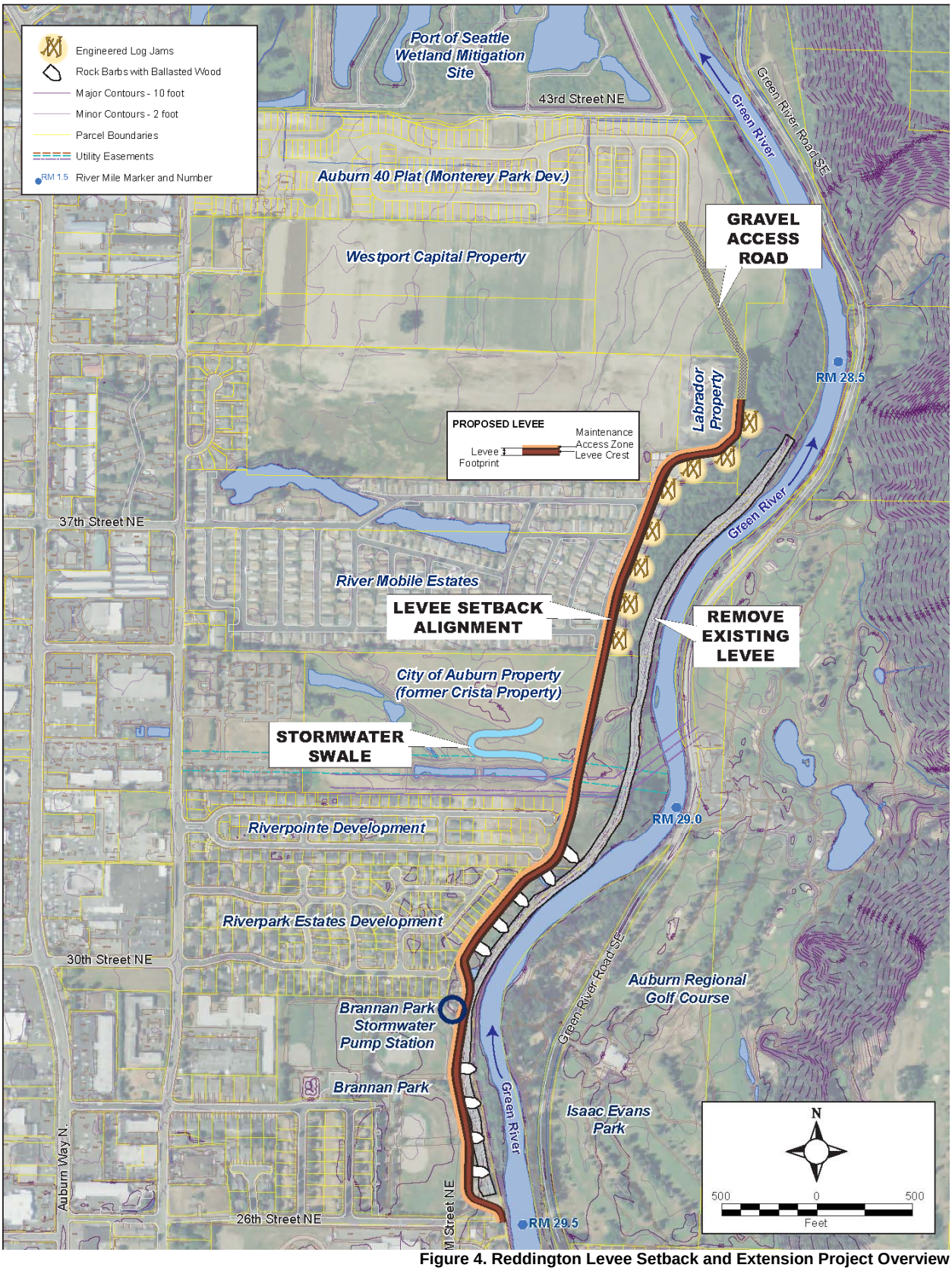


Figure 4. Reddington Levee Setback and Extension Project Overview
(*Graphic provided by King County*)

Second, large wood was not incorporated into the design of the rock barbs (but was instead placed in the downstream lee of the barbs), so as to eliminate the risks that might result from the creation of voids in the barb structures. Rock barbs were selected for the upstream reach and independently ballasted wood clusters were placed behind rock barbs in the hydraulic shadow. The inclusion of rock barbs deflected the main current as well as recreational users away from the eddy or pool areas behind the barbs where the ELJs are located.

Public Outreach Efforts for the Reddington Project

- Two community meetings (May 2012), Homeowner's Association for the River Mobile Estates and a Project Open House
- Public review and comment on 30% and 60% designs
- Project website maintained throughout the project

Reddington Team Outreach to Community Groups for Input on Public Safety

The public was included in outreach efforts during the design. Potential recreational users, environmental interests, neighboring communities, and project stakeholders were invited to comment. Two community meetings were held on May 9 and 12, 2012, with the first meeting specifically provided to the Homeowners Association for the River Mobile Estates. A second community meeting was held as an open house to provide information to the public and to make them aware of what to expect during the project construction. In addition to the public meetings, a project website was created and maintained throughout the project.

The Panel found that public safety, both boater safety and floodplain protection, was incorporated as part of the primary design objectives. Examples included the evaluation of various modes of failure for ELJs to ensure that the ELJ structures (whether bank-attached or independently ballasted) were designed to be stable and could not move in such a way as to increase boater risk. These analyses evaluated ballast requirements to offset buoyancy, sliding risk, fasteners, and connection sizing.

5.2 Public Safety Considerations

It was the findings of the Panel that the public was consulted, alternatives evaluated, and safety considered a primary design element of the final constructed project. The following are key notes from the Panel member's individual reports.

Geomorphologist: Dr. Stephen Lancaster

Dr. Lancaster noted that the major driver behind the Reddington project is to increase public safety by replacing an old levee that did not meet current standards with a new one that exceeds those standards. As built, he noted that the new levee had a larger design flood than the old levee, at 14,900 cfs vs. 12,000 cfs.

Overall, Dr. Lancaster was impressed by the ambitious scope and diligent execution of the project. In particular, the monitoring so far has been thorough and data-rich and he found no particular issues regarding public safety.

Fishery Biologist: Dr. Kelly Burnett

Based on the available documentation, Dr. Burnett noted that boater safety was a prominent concern in the design, and included a feasibility assessment of alternatives to protect the levee and improve fish habitat. She noted that the BOD Report (2013) discussed this assessment and reasons why certain alternatives were rejected. Decisions regarding the extent and type of erosion protection for each of the six levee segments followed a three step evaluation process and were based on channel migration hazard zone maps for a 20- to 50-year period. Segments were assigned to one of three approach categories:

- No Levee Scour Protection (Segments 4 and 6),

- Protect Levee Face (Segments 2 and 5), and
- Riparian Buffer (Segments 1 and 3)

She noted that descriptions for the latter two approaches presented trade-offs between boater safety and habitat, particularly when the use of large wood was proposed. For the Riparian Buffer approach, structures were installed that consisted of rock barbs and independently ballasted loose wood pieces placed on the downstream side of each barb. Design of these structures appears to have balanced levee protection and habitat benefits. She provided the following example: placing wood in the lee of the barbs alleviated boater safety concerns, but the ballasted wood should launch into the scour hole that will eventually develop off the downstream tip of the barb, providing cover and habitat benefits.

Civil Engineer: Mitch Price, PE, CFM

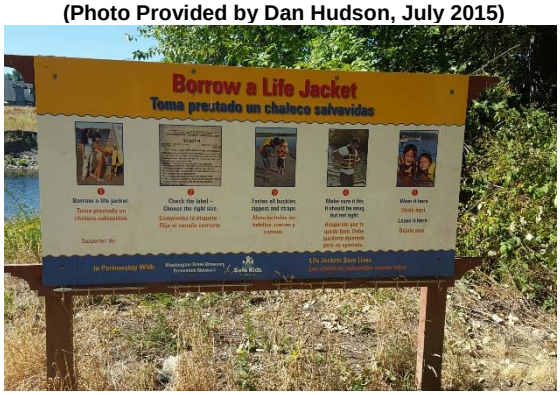
With regard to public safety, Mr. Price found that in the downstream reach, the eight (8) bank-attached ELJs were designed to remain intact and settle/rotate into the bed as localized scour hole develops. He noted that these structures are located well behind a diverse riparian corridor with large trees and are not expected to create any direct boater hazard. Mr. Price believes that as new trees are recruited at the left-bank margin, they would not be expected to affect recreational boater safety as long as they point downstream and do not occupy more than 15% of the active channel width.

River Recreational Safety Specialist: Dan Hudson

Mr. Hudson noted that there were several rafting/tubing groups as well as unaided swimmers/waders of river right at the local Golf Course Park beach during an initial site visit (July 2015). He observed approximately 25 in-river recreational users (swimmers) near the park on the beach opposite of the project. The laminar flow of the river in this area is in the center of the channel, which would push the park waders and swimmers from the park away from the project rock barbs on river left. The tubers were not utilizing paddles, however they had no issues negotiating past the exposed rock barbs.

Mr. Hudson found no concerns with the Reddington Project relative to public safety, and photo documented signage near the project relative to public safety (i.e. use of life jackets).

Recreational Users Accessing River from the Beach Across from the Project Site (Photo Provided by Dan Hudson, July 2015)



Public Safety Signage Observed Near the Reddington Project Site (Photo provided by Dan Hudson, July 2015)

5.3 Site-specific Project Goals and Objectives

The Reddington Project had six (6) goals and four (4) objectives (**Table 5**); and the Panel found that these goals and objectives were achieved, and the following includes additional notes from the specific Panel members.

Table 5: Reddington Project Goals and Objectives

Project Goals	Project-specific Objectives
1. Reduce risks from flood and channel migration hazards for King County residents in the vicinity of the Reddington Levee along the Green River 2. Increase the width of the riparian corridor along the Green River in the vicinity of the Reddington Levee, with a resulting increase in flow capacity & ecological benefits 3. Reduce the vulnerability of the levee to fluvial scour, mass wasting, and channel migration 4. Reduce the long-term costs of flood hazard management 5. Allow the river to meander, scour, and develop a more complex ecosystem, which includes formation of rearing habitat for juvenile salmon 6. Protect existing vegetation and restore a corridor of native vegetation to increase shoreline and channel shading, support the riparian food web, and improve fish and wildlife habitat adjacent to and within the river channel	1. Replace levees that do not meet modern structural design standards and have a history of seepage problems 2. Set the levees back to reduce their susceptibility to scour and allow more natural channel movement within the project area 3. Increase the flow containment capacity of the levee system beyond 12,000 cubic feet per second (cfs) to 14,900 cfs plus 3 feet of freeboard 4. Extend the levee system where no levee currently exists along roughly one-third mile of the river bank from just north of the River Mobile Estates to 43rd St. NE

Geomorphologist: Dr. Stephen Lancaster

Dr. Lancaster found that the project goals and objectives had, for the most part, been met without significant risk to public safety. He noted that the value used as the basis for the objective pertaining to flow containment capacity of the levee system was not based on the most recent estimate of the 500-yr recurrence interval flood; that most recent estimate is 18,800 cfs. Whereas the old levee would have constricted the flow at bankfull and higher discharges, so that the levee would have been subjected to attack by the main current, the setback of the levee should generally make it less prone to damage by swift currents. In addition to the distance from the channel, buried barbs will likely prevent lateral channel migration from threatening the levee.

Additionally, Dr. Lancaster noted that according to the monitoring report, the results of the project are generally good, and where there are outstanding issues, plans for addressing those issues have been implemented. The increase in “edge habitat” is particularly large, due mainly to the reconnected side channel, and juvenile salmonid counts are impressive. Problems such as invasive flora (canary grass and blackberry) and fauna (bullfrog) have been noted and measures to remedy the problems put into place.

Reddington Setback Levee and Extension Edge Habitat Observed (August 2015 Site Visit)

Fishery Biologist: Dr. Kelly Burnett

Upon review of available documents including the "Reddington Levee Setback Monitoring Report – Year 1" (December 1, 2014) and site visit (August 2015), Dr. Burnett's findings and observations included:

- The area of low-velocity habitat appears to have increased;
- Juvenile salmon (Chinook, coho, chum, and pink) and trout (cutthroat and rainbow) have been observed at the Reddington site; and
- Juvenile Chinook salmon were found in the outlet of the side channel in two of the three sampling periods during April and May 2014.

Dr. Burnett believes, however, that the project was implemented too recently (2013) to allow reliable interpretation of site-level monitoring data regarding the formation of rearing habitat for juvenile salmon. Dr. Burnett noted that, based on catch per unit effort (CPUE) data, use by juvenile Chinook salmon was greater at the Reddington site than at either the control or reference sites, but that this pattern did not hold true for other juvenile salmonids. She observed that the CPUE approach seems appropriate given constraints posed by the Green River as well as the limitations and biases acknowledged in the monitoring report.

Civil Engineer: Mitch Price, PE, CFM

Mr. Price found that the objectives for the Reddington Project were generally accomplished while minimizing risk to public safety, and he noted that the project appears on track with both short term and long term goals. Specifically, he noted the Reddington Project had been designed and constructed to reduce the flood and channel migration hazards for the nearby residents, to contain the USACE revised 500 year flood. He also noted that erosion, scour, and migration risks were comprehensively evaluated and addressed by implementing a system of rock barbs, rock revetments, and ELJs.

Mr. Price's observations included that the floodplain reconnection had begun, including the process of natural erosion for near-bank terraces; and that the beginning of ecological benefits were also observed. He noted that while flows were extremely low during the field visit, additional positive observations included:

- Localized zones of reduced velocity and corresponding juvenile salmonid refugia (between barbs 6-9, upstream of Brannan Park);
- Eight large buried ELJ structures (not yet active) expected to provide flow deflection, reduction in near bank velocity, and a future positive ecological response;
- Expected reduction in vulnerability of the levee from the fluvial scour, mass wasting, and channel migration (expectation based on project as construction);

Large Emplaced Wood Noted at the Reddington Project Site as Not Yet Active with the Main Channel (August 2015)

- Risk reduction investment of 2.5 percent of average parcel value, based on conveying the 500-year annual exceedance event and providing additional protection to nearly 600 parcels with an assessed value of $680 million;
- Both rock and wood structures were installed to provide flow steering, increase near bank roughness, and provide for the development of improved aquatic habitat while mitigating for levee erosion risk; and
- Revegetation cover of willow with active recruitment is occurring on the lower terrace surface around the barbs and on the lower inset floodplain; the higher elevation band, however, was noticeably drier with observable vegetation mortality (possible need for a more aggressive watering effort to improve vegetation survival).

Vegetation Noted Along the Higher Elevation Band at the Reddington Project Site Noted as Generally Adapting/Surviving (August 2015)

Post implementation performance monitoring of the Reddington project is detailed in the 2013 habitat monitoring plan and addendum with a ten year schedule. Monitoring of ecological performance is tied to general indicators such as: side channel connectivity and wetland development, placed/recruited wood stability, vegetative cover, and low velocity salmonid edge habitat. Categorized monitoring tasks identify performance standards, monitoring methods, and adaptive management strategies for select habitat indicators. No long term physical channel monitoring such as repeat bathymetric cross sections and longitudinal profile were identified in the provided documents and may be intermittently warranted within the 10 year timeframe to insure the channel adjustment and corresponding flood conveyance capacity is performing as intended.

River Recreational Safety Specialist: Dan Hudson

Mr. Hudson noted that this project's long range potential impact for river migration is impressive. Although most of the project is buried and will not come into play or be exposed by river migration until there are several significant river flows, he feels that the project's design will achieve the goals and objectives as stated.

Mr. Hudson contacted regional emergency response organizations for data on this site. Valley Regional Fire Authority Battalion Chief Perry Bogaard advised that there had been zero fire agency calls or rescues as a result of, or associated with, the project since its completion in 2014. His impression of the project was consistent with Mr. Hudson; the project was effective in protecting the recreational user and should cause no negative impacts in the foreseeable future.

Various Project Photos from August 2015 Site Visit

6. FINDINGS: UPPER CARLSON FLOODPLAIN RESTORATION PROJECT

The Upper Carlson Floodplain Restoration Project (Upper Carlson), completed in 2014, removed 1,600 feet of levee and reconnected the Snoqualmie River to 50 acres of forested floodplain habitat that had been disconnected from the river for decades. The project also placed approximately 300 trees/logs in the adjacent right bank floodplain, constructed a set-back flood protection facility along approximately 1,000 feet of Neal Road, controlled invasive weeds on approximately 20 acres of the site, and planted native deciduous and conifer trees throughout the floodplain (**Figure 5**).

Aerial View of Upper Carlson Floodplain Restoration Project (Photo Provided by King County)

6.1 Project Performance Relative to Public Rule Requirements

Based on their reviews of project information and observations made during the August 2015 field review, Panel members concluded that the Upper Carlson project, as designed and implemented, is consistent with the Public Rule's stated purpose of maximizing project benefits and minimizing public risk. Panel members determined that public safety was of primary consideration in the design and implementation of the Upper Carlson project, and that the project's goals and objectives were met. The Basis of Design report for the project documents the incorporation of public safety considerations into the project design, and provides information about the location, dimensions, and anchoring of emplaced wood.

Public Outreach Efforts for the Upper Carlson Project:

- Solicited expert opinion on 30% design
- Solicited public input via LWD meetings and public meeting
- Provided comment period on 30% plans and LWD checklist
- Three Work-Group meetings

Upper Carlson Team Outreach to Stakeholders and Work-Groups for Input on Public Safety

Considerable outreach to the recreational community occurred during the planning phase (30% and 60% design stages) of this project. Public involvement and input was received through regional organizations and agencies, including the Fall City Fire Department, the River Safety Council, Wave Trek (which provided design consultation), and the King County Sheriff's Office Marine Services Unit. The review process included identifying potential risks, collecting and evaluating data to understand causes and conditions of specific risks, public coordination with the recreation community, and incorporation of measures to reduce short-term risks. The design team acknowledged that wood-related hazards are more likely to be the product of the inherently unpredictable natural processes of post-implementation channel migration and wood recruitment, rather than any specific project design components. Design components to address safety included:

- Removal of 250 high-risk trees from the rapid channel migration zone
- No instream wood placement and no permanent ELJ structures in the upstream reach
- Overbank felled trees oriented based on natural reference conditions
- Felled trees placed coincident with a wider predicted low flow channel.

Design modifications were made between 30% and 60% design because of boater safety concerns. Additional modifications were made to the 60% design for the floodplain area behind the existing Upper Carlson Levee. These included:

- Removal of buried logs from the project design
- Retention of more mature floodplain trees
- Reduction in the number of logs and log clusters placed in the floodplain
- Staggering of logs in log clusters, to moderate the recruitment rate

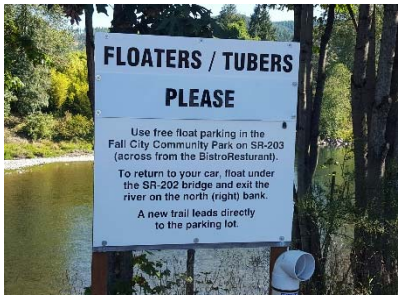
For the setback revetment area near Neal Road, the design safety considerations included:

- Locating permanent ELJ structures near the downstream end of the site to reduce potential boater interaction
- Constructing the flow-deflector ELJ-1 nearest the main channel downstream at an offset location that will promote wood recruitment upstream and where it will take several years to interact with the main channel at low flows
- Modifying the more porous piling based ELJ-1 structure with a denser ballasted structure lower in the water column

ELJ structures were anchored to driven wood piles ballasted with native spoils to withstand buoyant flood forces; additionally, racking logs and slash material was attached with steel cabling to minimize flow piping and straining potential.

6.2 Public Safety Considerations

The Panel members with areas of expertise that overlap substantially with public safety concerns (i.e., river recreational safety, civil engineering, and geomorphology) concluded that public safety was of primary consideration in the design and implementation of the Upper Carlson project. The project design incorporated features specifically directed at minimizing risks to recreational users of the river. The project was also designed to protect public safety by maintaining flood protection in the project vicinity.



Examples of Public Safety Signage Near the Upper Carlson Project Site (Provided by Dan Hudson)

The following are key points from the reports prepared by the Panel members, identifying the ways in which public safety was taken into consideration during the design and implementation of Upper Carlson.

River Recreational Safety Specialist: Dan Hudson

In review of the 2013 '*King County Recreational River Survey*' on the Snoqualmie River, Mr. Hudson believes that the predominant recreational users in this reach were underrepresented. In his opinion, this reach of the river would be more likely used by recreational anglers than any other type of user. His professional opinion is that the average large-river angler is better prepared to navigate in and around moving water and is more capable of handling the associated hazards, compared to the typical rafter/tube user.

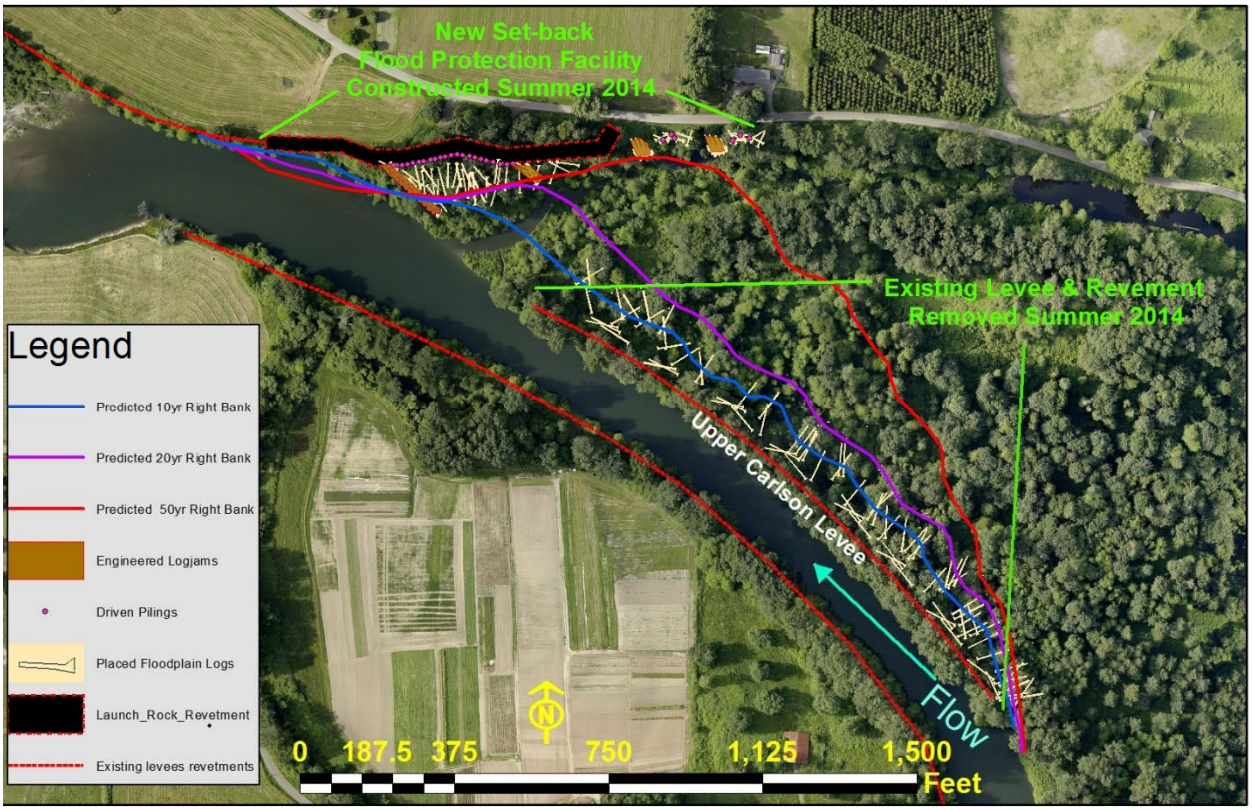


Figure 5. Upper Carlson Floodplain Restoration Project Overview
(*Figure provided by King County*)

Mr. Hudson noted that the area upstream from this project is a tuber/rafter high use reach of the Snoqualmie River, but these users generally exit out river right, upstream from the project zone. Signage (placed by third parties) has been placed on the river identifying the exit for these types of users and in his opinion it appears to have been effective.

Additionally, Mr. Hudson noted that the County had posted safety signs at several locations in the immediate vicinity of the project site. The Department provided further clarification/information that four (4) project kiosks are accessible to the public with additional safety information relative to general river recreational use and project specific information on the Upper Carlson Project (see example provided by King County).

Example Upper Carlson Project Kiosk
(Provided by King County)

Civil Engineer: Mitch Price, PE, CFM

Mr. Price noted that because the Upper Carlson project will create a more dynamic and natural environment, he did not believe it was possible to mitigate all risks through the design itself. Instead, he noted that King County developed a site management plan with mitigation measures to minimize recreational boater risk to inevitable natural hazards expected to occur. Mr. Price

also noted that the February 2014 Site Management Plan identified a series of progressive steps that will allow a flexible, effective response when making decisions about wood hazard management. The steps included:

- Monitoring, educational outreach, and signage
- Signage and portage improvements
- Small-scale wood manipulation
- Temporary river restrictions or closure
- Large-scale modification of accumulated woody debris to allow safe passage during recreational flows.

Mr. Price observed that wood removal, especially if it requires heavy equipment, is not an effective long-term risk management strategy. Such removal or modification would be limited to select situations where other, less intrusive options cannot effectively abate the hazard.

Geomorphologist: Dr. Stephen Lancaster

Dr. Lancaster noted that managers and planners considered public safety in every decision, and they found that the project poses a small and manageable risk to public safety. With regard to Upper Carlson, specific examples of how the risk to public safety were managed included:

- The use of recreational use surveys to provide information on the rates and skill levels along this reach of the river
- Seeking, receiving, and substantially addressing public input – including County personnel making public presentations, writing detailed responses to questions and concerns, and modifying plans to address some potential hazards

Dr. Lancaster noted additional immediate effects from the Upper Carlson Project that he believes may further reduce risks to the public, including:

- Bank erosion occurring as a direct result of the project has widened the channel, so that flows will be slower; and
- A new gravel point bar formed at the upstream end, making the channel shallower (pre-project river was narrow, deep, and swift, the restored river is wider, shallower, and slower) and the new bar provides a potential beaching point for floaters.

New Gravel Point Bar Noted at the Upper Carlson Project Site; Upstream View of River (August 2015)

Fisheries Biologist: Dr. Kelly Burnett

Dr. Burnett noted two elements for the Upper Carlson project regarding habitat that pertained to public safety:

- 300 felled trees placed in the floodplain were distributed beyond the "rapid channel adjustment zone" for a more "natural release rate of logs," which is consistent with ecological and public safety concerns.
- Two major adaptive management actions and the progressive strategy for adaptive management, are intended to address public safety issues while mitigating risks with the least invasive solutions (as detailed in the *Upper Carlson Floodplain Restoration Project Site Management Plan*, King County 2015a).

Dr. Burnett noted that the '*Instream Project Checklist'* at the 60% design phase clearly and succinctly documents specific changes to the project from the 30% design phase and is a useful

model for future projects; and that habitat objectives were not expected to be substantively compromised by many of the design changes (e.g., shortening and reducing the porosity of the downstream ELJ or changing the orientation of placed large cottonwood logs) between the two phases due to concerns for public safety. However, she did believe that some of the changes may reduce the likelihood that desired large wood functions are fully achieved over the longer term. She felt that it was unclear whether trees placed in the floodplain beyond the "rapid channel adjustment zone" for a more "natural release rate of logs" will be available to function during the life of the project. Although log decomposition was acknowledged in the 60% Instream Project Checklist (Appendix L)(King County 2014), the assumption that felled trees will maintain enough structural integrity for delivery via bank migration and for fulfilling stated floodplain and channel functions is presented without discussing the implications of decomposition over 50 years.

Dr. Burnet noted that decomposition rates will vary by log moisture content, size, and species (Harmon et al. 1986). Logs decay faster when on land than submerged in water, or when they are of smaller diameters, or of deciduous species (rather than conifer). Thus, she noted that relatively fast decay rates are reasonably expected for most project placed logs because log clusters were assembled on the floodplain primarily from small diameter (≤ 17" dbh) deciduous species (e.g., black cottonwood [*Populus balsamifera*] and red alder [*Alnus rubra*]). She believes that if the placed logs rapidly lose structural integrity, then fewer logs will effectively function as intended to "increase surface roughness on the floodplain and improve the quality of mainstem edge habitat along the banks as the river migrates … and recruits them into the river, thereby reducing flow velocities and moderating channel migration rates." If decay rates are slower for buried than surface logs, then the decision not to bury the large cottonwood logs may reduce long-term functionality of placed wood. Contributions to these functions may also be limited by the decision to distribute rather than cluster floodplain logs given that log jams are more stable and more likely to trap wood transported from upstream than smaller log aggregations or single logs. Dr. Burnet observed the use of many of the felled trees in the setback revetment at Neal Road left fewer and smaller trees to be placed adjacent to the levee removal area than called for in the 30% design.

6.3 Site-specific Project Goals and Objectives

The project was designed to meet four overall goals, with four project-specific objectives (**Table 6**).

Table 6: Upper Carlson Project Goals and Objectives

Project Goals	Project-specific Objectives
1. Promote more natural rates and frequency of channel and floodplain processes (such as channel migration, overbank flooding, and wood recruitment) to improve salmon spawning and rearing habitat with the primary focus on restoring mainstem edge and off-channel rearing habitat, specifically for ESA-listed juvenile Chinook salmon and steelhead trout 2. Maintain or improve current levels of flood hazard protection of private property and public infrastructure 3. Address potential impacts on recreational boater safety 4. Enhance and maintain the native riparian vegetation community	1. Remove approximately 1,600 feet of existing levee and allow the river to expand, migrate, and reconnect with former channels within this reach 2. Construct approximately 1,200 feet of set-back revetment to protect Neal Road and the adjacent Carlson property 3. Incorporate input from the local recreational boating community into the Design Plans and the Site Management Plan and implement this plan to manage risk to recreational boaters at the site and in the reach 4. Re-vegetate areas disturbed during construction and areas where invasive plants have been treated with herbicide; continue to manage invasive plants and promote native communities

The Panel determined that the project objectives were demonstrably met, but ongoing monitoring is essential to determine if proposed adaptive management strategies are required. Following are key points from the reports prepared by the Panel, identifying the ways in which the project met the specific goals and objectives.

Fisheries Biologist: Dr. Kelly Burnett

Per Dr. Burnett's field review, the Upper Carlson Project appears to have been implemented as designed. Project components most directly advancing project goals of ecological/habitat benefits are:

- 1,600 feet of levee and revetment removal that reconnect the main channel to approximately 50 acres of forested floodplain
- Approximately 300 logs placed in the right bank floodplain
- 20 acres of floodplain treated for invasive weeds
- Several thousand native deciduous and conifer trees planted on the floodplain to help restore sediment and hydrologic processes and increase future salmonid habitat complexity

Despite observed geomorphic changes that imply a trajectory toward achieving goals, the Upper Carlson was implemented too recently for a reliable field review of site-level effectiveness in producing desired ecological/habitat benefits. Geomorphic measurements supplied by King County for channel widening and bank migration, as well as field observations from August 2015, indicate that since project implementation:

- Approximately 1.5 acres of new mainstem aquatic habit have developed
- The trees recruited from upstream are starting to increase the amount and complexity of low-velocity rearing habitat along the right bank
- Expanding left-bank gravel bar includes well-sorted gravels of appropriate size for salmonid spawning
- Invasive plants are scarce in treated areas
- The black cottonwood, willow, and red alder plantings have established, grown, and likely functioned to slow flood flows and trap debris; and
- Numerous conifer plantings generally appear healthy during the first of three scheduled years for maintenance

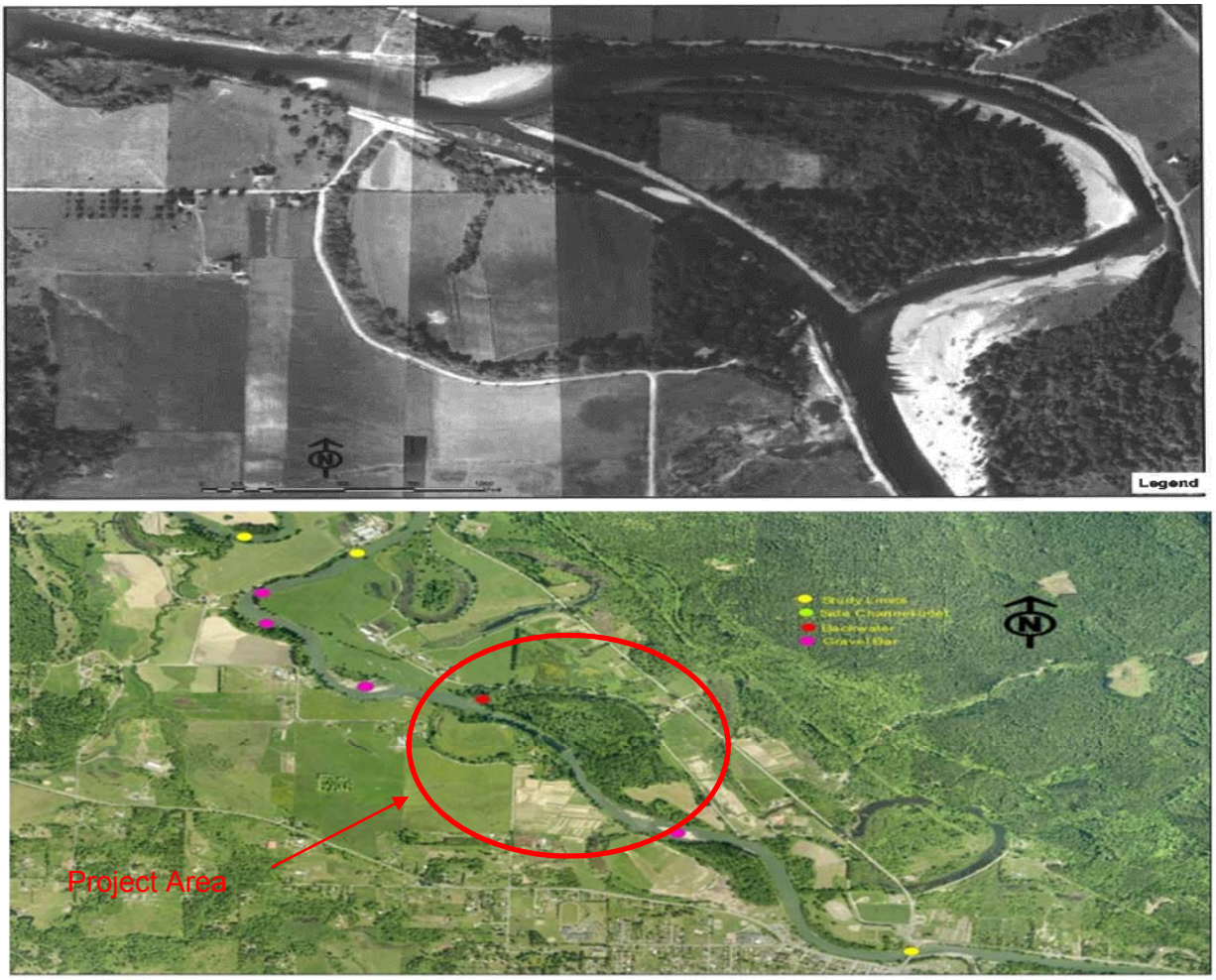
Riparian Plantings Observed at the Upper Carlson Project Site (August 2015)

Dr. Burnett noted that one concern about project effectiveness arises from the assumption that the 300 trees placed in the floodplain will be available to function during the life of the project due to a loss of structural integrity of those trees over time.

Geomorphologist: Dr. Stephen Lancaster

Dr. Lancaster noted that the flood experienced in the first year caused substantial bank erosion, but not yet to the point of much wood input to the channel. Due to the relatively narrow pre-project channel, the nearly uniform bank erosion through the project reach, and the typically shorter wavelengths of meanders in adjacent reaches, he inferred that the recent bank erosion represents channel enlargement rather than channel migration, but also notes the new point bar at the upstream end of the reach suggests that channel migration will follow.

Dr. Lancaster also believes that the left-bank levee, levees on adjacent reaches, and the set-back levee at the downstream end of the reach (the catcher's mitt), will likely inhibit the development



Upper Carlson Project Reach, Historic (1936) and Pre-Project (2009) Conditions (Photos Provided by King County)

of large-amplitude bends at the Upper Carlson site. Small meander bends migrate downstream; as the bends lengthen, the locus of larger bank shear stress remains "tied" to the upstream cross-over, i.e., the point of zero curvature between one bend and the next, and the transverse component of migration increases. The abandoned meander bend next to Neal Road had to originally migrate to its present position from upstream. That downstream sense of migration is evident in the 1936 aerial photograph from the wide un-vegetated area indicative of downstream migration of the upstream bend. At that time, Dr. Lancaster noted that it appears that migration was already inhibited on the right by efforts to protect Neal Road and on the left by a levee.

From the old photos, Dr. Lancaster inferred that the old channel migrated into its current position, but its shape was influenced by protection of Neal Road from erosion. Relative to some other bends on the Snoqualmie, the old bend at the Upper Carlson site is relatively low-amplitude. Still, he felt that if the old bend had not been artificially cut off, it would have eventually been cut off without getting any bigger, as the upstream limb of the bend simply caught up with the downstream limb, which was pinned against the road. With the recent removal of the Upper Carlson levee and the formation of a bar on the left bank at the upstream end, meander bends will “spawn” and grow within the project reach; bends will not initiate upstream and migrate into the project reach because the banks upstream are artificially stabilized. Dr. Lancaster has provided additional information on this observation in his final report (see **Appendix C**, page 26 of Dr. Lancaster’s report).

Dr. Lancaster noted that with respect to the goal of maintaining or improving current flood hazard protection levels, this may require adaptive management measures to realize. Additional notes included (see **Appendix C**, page 27-28 for additional details). He also noted:

- Hydraulic modeling predicted small changes in water surface elevation (WSE), but he did not believe it could account for the channel enlargement that has already taken place (when the bottleneck is enlarged, the flood WSE decreases). As the narrowest part of that bottleneck was moved downstream by removal of the levee, he believes that the WSEs that backed up behind that bottleneck have also moved downstream.
- A bottleneck appears to have formed by the lower Carlson revetment and the downstream end of the Aldair levee; which he would expect to see accelerated flows and steepened water levels during flooding (at, and immediately downstream of, the bottleneck).

Dr. Lancaster noted that while this condition likely existed prior to construction, he believes that the removal of the upstream bottleneck will likely increase patterns of scour and deposition downstream of the Aldair levee; and that adaptive management funds may be appropriate to apply a slight setback and extension of the Aldair levee to mitigate for these concerns.

With respect to addressing potential impacts on recreational boater safety, Dr. Lancaster reiterated his observation that managers and planners considered public safety in every decision, and they found that the project poses a small and manageable risk to public safety. He also noted that continued monitoring and inspection by the sheriff, as planned, will allow adaptive management to mitigate any risks posted by large wood entering the channel as it meanders.

Concerning the goal of enhancing and maintaining the native riparian vegetation community, Dr. Lancaster noted that:

- Ongoing monitoring has recorded that knotweed infestation is ongoing, however eradicating invasive species is not a stated goal.
- The barren bank should be monitored so that native riparian species are able to colonize the bank as it evolves.

Civil Engineer: Mitch Price, PE, CFM

Mr. Price noted that the Upper Carlson project is to be commended for its goals of reconnecting the historical side channel and floodplain in an effort to improve habitat quality by providing for natural processes without increasing the relative flood risk. Further, he noted that the Upper Carlson project has a well-documented adaptive management strategy to mitigate for future uncertainty. The following are his findings relative to the project-specific goals:

- The first goal to promote more natural rates and frequency of channel and floodplain processes has begun following the removal of the revetment levee.
- The second goal to maintain (or improve) current flood hazard protection levels appears likely based on project design estimates but should be actively monitored with air-photos, stage recorders and synoptic water surface surveys during future flood events to insure the project is performing as anticipated.
- The third goal to address potential impacts on recreational boater safety has been considered throughout the design and construction process but will require frequent monitoring to insure the site management plan can effectively mitigate for variable future hazards.

- The fourth goal to enhance and maintain the native riparian vegetation community is consistent with connecting the right overbank floodplain and historical side channel.

Upper Carlson Project Riparian Zone, Engineered Large Wood Structures Observed Off Of the Right Bank (August 2015)

Additionally, Mr. Price noted that post implementation monitoring of the Upper Carlson is noted in the basis of design report as being necessary to evaluate project performance. From a safety perspective related to wood risk, the monitoring approach is comprehensively detailed in the February 2014 site management plan and relies upon a standardized visual inspection form.

In order to document physical reach scale adjustments as the right bank continues to erode into the floodplain, Mr. Price recommends the County repeat bathymetric cross sections and a longitudinal profile through the project reach and extend at least ten bankfull widths upstream and downstream of the implemented project as well as the next meander downstream of the Aldair levee. Additional survey of the side channel and right overbank may also be warranted depending upon the observed degree of physical adjustment.

River Recreational Safety Specialist: Dan Hudson

Mr. Hudson noted that this project was designed to encourage river migration and create large wood containment and recruitment in and about the channel, and that this has the potential to be inherently dangerous to recreational users (as rivers are dynamic and by their nature pose inherent dangers). However, he noted:

- In-river signage was placed during the construction phase warning potential recreational users of the project activity;
- Current signage and kiosks, continues to advise unwary recreational users of the exit location, which prevents rafters from wandering further downstream past the normal take out location;
- Local residents are 'ecstatic' about the impact of the signage noting that traffic congestion and parking problems had been reduced; and
- The reach downstream of the SR 202 bridge is not favored by most recreational users as most floaters and tubers exit the river before they enter the Upper Carlson project area;
- Most kayakers stay above Big Eddy, 3 miles upstream; and
- Most people who enter the project area do so inadvertently.

Mr. Hudson noted that in his opinion, this project was a good use of funds to proactively remove a known hazard (double row of pilings that extended across the river downstream of the project), which was deemed the most substantial hazard to boaters in the area by a Fall City workgroup in 2015.

Additionally, Mr. Hudson noted:

- The project, by design, is going to place a significant amount of large wood into the river channel; and
- River migration to river right would encourage gravel deposits on river left and, by design, provide for a safe passage for the recreational users in the project reach.

7. CONCLUSIONS AND RECOMMENDATIONS

It was the pleasure of the Panel to provide this evaluation of a representative sampling of emplaced large wood projects for King County in response to the Public Rule; and of the Consultant Lead to facilitate and summarize their findings. The conclusions and recommendations presented in this summary report are those of the Panel. To preserve the integrity of each panel member's work, their full, unedited reports have been included as **Appendix C**.

This third-party evaluation was conducted in response to the Public Rule, which established procedures for considering public safety with respect to recreational use when placing large wood in rivers in King County. The assembled Panel performed an independent review of a representative sampling of constructed emplaced large wood projects to evaluate their effectiveness relative to the project-specific goals and public safety, including river recreationalists (tubers, rafters, and kayakers). Through their independent and detailed evaluations of site-specific questions, observations, and review of the synthesized projects, the Panel responded to the two fundamental questions:

1. Was public safety of primary consideration in the design and implementation of large wood placements in King County rivers, including flood risk reduction measures and river recreational safety?
2. Were the stated site-specific project goals and objectives achieved, while minimizing risk to public safety?

The Panel concluded that all four projects were consistent with the purpose of the Public Rule (Sections 2.1 to 2.3 and Appendix A, Sections Ia to Ic) by meeting project-specific goals and objectives, while considering input from the public (via public meetings and comments on the design packages). The Panel found that the Department's Project Managers were responsive to public and industry experts' input, relative to incorporating river recreational safety and flood risk reduction features into each constructed project.

7.1 Consideration of Public Input and Project Effectiveness

The Panel was asked whether they observed any changes made to the projects based on the public input regarding safety, and if those changes impacted the effectiveness of each project. Mr. Hudson felt that safety considerations prompted relatively minor modifications to each of the project designs, and that these modifications did not reduce the effectiveness of the projects in achieving their stated goals and objectives. He also believes that the potential liability of not making the changes (even if relatively minor modification) would have been significant at each of the project sites.

Dr. Lancaster had separate opinions for each of the four (4) sites. For the Belmondo Project, he noted that the design revisions made for safety reasons did not negatively affect effectiveness as determined by sturdiness and habitat enhancement. For the Reddington project, he did not find any safety concerns that significantly affected the effectiveness of the project. However, for the Upper Carlson site, Dr. Lancaster believes that if not for safety concerns there would likely be more wood in the channel today, which could have enhanced habitat. Safety considerations dictated that buried wood was predominantly placed at higher elevations, so there may potentially be less enhancement of habitat at lower stages. He also noted that for the Herzman Project, the originally planned log structures would likely have provided additional habitat enhancements that are lacking as a result of safety concerns.

Mr. Price noted that the projects other than Upper Carlson appeared to include LWD for habitat enhancement not as a primary project goal but as a secondary benefit where feasible. He noted that depending on the specific project design, adjusting certain design features to meet public safety requirements (e.g., reducing the amount of wood or minimizing void space with rock fill) can be expected to reduce the habitat benefit potential of the emplaced wood. Other design adjustments, such as changing the LWD orientation or increasing the available width for safe boater passage, did not necessarily decrease habitat effectiveness.

Mr. Price also observed that design decisions focused on maintaining or increasing the emplaced wood habitat while still meeting public safety requirements are to be commended. Examples of such decisions include the additional wood placed in the hydraulic shadow of the flow steering structures on the Belmondo project, the buried ELJ structures on the Reddington and Upper Carlson projects intended to interact with the river over a long term time frame, and bumper logs that provide for some public safety while allowing for increased ELJ void space, and pool development.

Dr. Burnett noted that for the sites evaluated, there appeared to be a balance in habitat restoration with input from the public. She provided an example where this was well document on the Upper Carlson Project through the use of "Instream Project Checklist at the 60% design phase." Dr. Burnett noted that this checklist clearly and succinctly documented specific changes to the project from public input. She noted that many of the design changes (e.g., shortening and reducing the porosity of the downstream ELJ or changing the orientation of placed large cottonwood logs) between the two phases due to concerns for public safety, did not substantively compromise the surrounding habitat.

7.2 Additional Recommendations for Future Projects

The experience of the project team inspired recommendations (see below) for similar future independent review projects of emplaced wood on King County rivers, some relative to the project approach (for the reviewers) and others more administrative in nature.

7.2.1 Selection of Third-Party Independent Review Panel

Panel members expressed the belief that third-party, independent reviewers could remain independent in their evaluation even with prior experience with King County, and that there may be benefits to having knowledge of the rivers and project protocols. One related recommendation would be to consider an independent panel to be qualified experts, and exclude only firms/individuals who directly contributed (e.g., as designers, contractors, or construction managers) to the projects being reviewed. This would provide a range of possible benefits and limitations relative to the independent nature of the panel. **Table 7** summarizes potential benefits of alternative approaches, with Option 1 providing the greatest degree of independent review and least knowledge of the projects and King County and Option 3 providing the greatest site specific knowledge, but least level of independence. Option 3 would not be recommended, and was provided to demonstrate a range of options.

Table 7: Options for Future Third Party Panels

Third-Party Panel Member Options	Benefits	Limitations
1. No prior direct working experience with King County	Minimal potential for prospective panel members to have professional relationships with County staff that would interfere with their ability to perform an impartial review	Limits the number of qualified experts available and willing to serve as reviewers; limits the potential that reviewers will be familiar with regional or site-specific issues and concerns
2. No involvement in design or implementation of specific projects under review, but prior experience with King County	Increased pool of experts, including those with local experience and familiarity with project sites and pertinent issues local to the project(s)	Potential for perceived conflict of interest, based on individual or firms' prior working relationship with King County
3. Direct working knowledge of and/or experience with the projects being evaluated	Firsthand knowledge of the project, issues, and process directly associated with the project	Likely conflict of Interest, based on involvement with the specific project and inability to be independent in the review

The panel members expressed no concern over the use of local experts with prior knowledge and/or experience with King County, and believed there might be benefit to the County (e.g., knowledge of specific fish species, riparian habitat, geomorphologic conditions, recreational use levels, etc.). This is, of course, just a recommendation for consideration; it is ultimately the decision of the Department to determine the level of independence desired, balancing the benefits and possible limitations of each option.

As an additional reference, information from the National Academies' *Policy on Committee Composition and Balance and Conflicts of Interest for Committees Used in the Development of Reports* (http://www.nationalacademies.org/coi/bi-coi_form-0.pdf) includes several principles pertinent to the provision of independent third-party review. That policy document defines the term "conflict of interest" as applying only to current interests and suggests that conflicts of interest not arise from past interests that have expired, no longer exist, and cannot reasonably affect current behavior. The National Academies policy document also states that the term "conflict of interest" does not apply to possible interests that may arise in the future but do not currently exist, because such future interests are inherently speculative and uncertain.

7.2.2 Selection of Representative Projects

The Panel suggested the consideration of 'older' constructed projects (where available) to provide opportunity to observe longer-range project goals and ability to provide definitive (and where available, quantifiable) evidence of project performance relative to public safety and stated goals. An example of where this would be beneficial from the Reddington project came from Mr. Price:

"*Reddington setback levee design aimed to provide containment and conveyance of the 500-year annual exceedance event while mitigating for erosion using a design approach that balanced risk with cost in project sub-segments. Based on the geomorphic, hydraulic, and design information provided, the project as constructed would be expected to reduce the vulnerability of the levee from fluvial scour, mass wasting, and channel migration. However, considering the relatively short timeframe that has elapsed since project completion, it is too early to identify any definitive evidence that demonstrate this.*"

7.2.3 Public Outreach, Involvement, and Input

Suggestions for encouraging and enhancing public involvement in the design process for future emplaced wood projects include engaging the services of a public relations expert, to evaluate the overall effectiveness of outreach efforts to determine if current approaches are reaching interested parties who wish to be more engaged or involved in the overall process but have a limitation (knowledge of the project, meetings time/date/location, other). A second recommendation would be conduct a survey of residence near future project sites to determine desired level of involvement. Without additional empirical data or survey information it unknown if all interested parties are present at public outreach events, or if in fact the Department is currently reaching those interested in participating in the public input process.

7.2.4 Review Relative to Flow Events and/or Construction Dates

As part of project recommendations, the panel members were asked to consider and provide recommendations on how many years (or high flow events) they would advise to trigger consideration for the third party review. Input on overall schedule was also requested, and the feedback/recommendation was to extend the time for upfront review of the synthesized project related documents, time to conduct two site visits (if found needed or desired by the Panel) to observe the projects under a range of flow conditions, and/or to allow for follow up field visits to verify information.

Mr. Hudson's opinion was that third-party reviews be considered after one or two significant high-water events. While, Dr. Burnett believes that it depends on the time frame for the specific habitat objectives of the project. Dr. Lancaster recommends that reviews be triggered by events causing significant changes to projects or adjacent areas as part of adaptive management, for example:

- Bank erosion within project reaches or adjacent reaches
- Changes resulting from gradual decay, or even growth, of organic elements

Mr. Price felt it was difficult (in general) to assign a fixed number of years (or high flow events) to trigger consideration for third party review as he felt it depended on the project goals and objectives and the anticipated timeframe for those to be observable or tested. He noted that it is fairly common for river engineering projects to be designed with a projected short term geomorphic or habitat response as well as a large flood event response (or performance standard). He recommended that as a guideline, a reasonable timeline for third party review might be approximately 5 years post implementation, except when annual monitoring has documented project performance diverging from design predictions or a large flood event or public safety concern has triggered an adaptive management response action. He also suggested that regular monitoring of project performance using both qualitative (e.g., photos, checklists, etc.) and quantitative (e.g., repeat bathymetric cross sections, longitudinal profile of river thalweg, site specific stage time series) tools provides important supporting information to facilitate the less frequent third party review.

7.2.5 Process/Approach for Third Party reviews

Regarding the process for the third-party review, it was recommended by the Panel that the Department consider an alternative, iterative approach to the evaluation, and participation by King County Project Managers to summarize the available information. The suggested approach included the following five (5) steps:

Step 1: King County project managers summarize their projects in the form of report with cross referenced available documents and source data. For these reports, they gather all of the available data, provide a full bibliography, and make all sources available in one place. This would reduce the possibility of a missing information or documentation, misinterpreting complex and large projects with extensive design decisions with multiple stakeholder involvement, since they (the Project Managers) are the most knowledgeable of their projects.

Step 2: Third-party, independent reviewers would then provide detailed written reviews of the reports, where those reviews might, for example, request consideration of additional data (if available). The reviewers could evaluate the managers' own evaluations of whether project goals and objectives had been met. Reviewers would expect some basis in data for any conclusions made by the managers.

Step 3: King County managers would then revise their reports and prepare a response to comments from the third-party reviewers.

Step 4: After receiving the revisions and responses, the third-party, independent reviewers would then conduct site visits, which function in part as a "ground-truthing" or verification of the managers' reports.

Step 5: Reviewers would then write their final reviews of the projects, as they would then be prepared to make observations, recommendations and/or judgments regarding project performance relative to stated project goals. For example:

- Did the managers address and evaluate all goals and objectives according to facts and data to the satisfaction of the reviewers?
- Do the reviewers agree with the managers' conclusions?
- Did the projects meet their goals and objectives? If it's too soon to say, are the appropriate monitoring data being collected to allow proper evaluation at some later date?

7.3 Recommended Additional Baseline Data for Future Projects

Upon completing the evaluation of the four projects, the Panel members were asked if there were any recommendations they might have for future third-party evaluations that would assist with the assessment process. In general, the feedback included that collection of data (e.g., fish monitoring, water quality, habitat surveys) before commencing construction would provide a baseline for comparisons to post-construction conditions, as well as allow a more quantifiable assessment of each project relative to its goals and objectives. Similarly, incorporating pre-project geomorphological data into hydraulic models would allow a closer look at potential public safety risks. Specific recommendations include:

- Conducting cost-benefit analyses to identify potential flood effects on property and infrastructure downstream, and to identify what would be affected if the project wasn't completed;
- Data on ecological factors (e.g., re-establishment of riparian vegetation, size and condition of instream wood) pre-project construction;
- For non-emergency projects with a long planning horizon, a before-after-control-impact (BACI) design for evaluating fish response, as statistical methods for analyzing data collected with a BACI design are well established and easily applied;
- Incorporating modeling (similar to that at Upper Carlson) into the design process to identify areas more and less likely to experience scour or deposition, and an understanding of the potentially different roles of instream wood and better predictions of which logs or

structures would promote scour *versus* which would lead to deposition, which would likely be subjected to swift currents and steep shear stress gradients *versus* providing shelter in slackwater, and which would or would not present potential hazards to the public;

- Data regarding grain size would be particularly valuable to collect on projects where bank erosion is a major design feature, to allow assessments of the effective reduction in bedload transport rate;
- For projects with goals and/or objectives that emphasize the promotion of lateral channel migration and floodplain connectivity, monitoring rates of channel migration as well as development and fish use of low-velocity habitats in the floodplain will aid in evaluating project effectiveness;
- Ensure existing conditions (e.g., hydraulic and geomorphic) are well documented and the expected response for the proposed design quantitatively demonstrates a beneficial improvement based on project actions; examples include comparison of:
    - Cross sectional rating curves or longitudinal profiles, comparison of exceedance duration curves for floodplain inundation, near bank stress, residual pool depth, ELJ degree of submergence, etc.
    - (for public safety) existing and proposed maps of the velocity field (magnitude and direction) at wood emplacements for representative flows as well as identifying specific threshold flows for which public safety is a concern

Dr. Lancaster noted that the amount of study applied to the Upper Carlson project was truly impressive, including the use of 2-D hydraulic modeling. In summary, all of the Panel members preferred to quantitatively demonstrate how the proposed project is expected to perform versus qualitatively noting general expected response.

8. REFERENCES

In addition to the project-related documents provided by the Department (see Appendix C of Appendix A [Work Plan for Third Party Review of Projects Involved Large Emplaced Wood]), the following documents or sources were used as references for this report:

1. King County Code Chapter 2.98
2. King County Ordinance No. 16581 (2009)
3. King County Code Title 21A
4. King County Comprehensive Plan Policies
5. King County Council Adopted Salmon Recovery Plans for Water Resources Inventory Areas 7, 8, and 9 (2005 and 2006)
6. King County Flood Hazard Management Plan Policies G-3, G-9, G-10, PROJ-6, RCM-1, RCM-2 (2006)
7. King County 2013 River Recreational Study
8. International Boater Difficulty Rating System for Whitewater Boating: (Accessed August 2, 2015) http://www.americanwhitewater.org/content/Wiki/safety:start?#class_i_rapids
9. Large Wood Stakeholder Committee Final Report and Recommendations (2009)

Appendix A

Work Plan for Third Party Review of Projects Involving Large Emplaced Wood

Work Plan for
Third-Party Review of
Projects Involving Large Wood Emplacements

Department of Water and Land Resources Division

August 2015

Location: King County, Countywide (multiple locations)
Contract Number: P00116P12

Acknowledgements

Thank you to the project managers of King County Water and Land Resources Division for their time and support in providing background information and access to each of the project sites, and to the Expert Panel members for the independent evaluation and assessment of each.

CONSULTANT SERVICES

This report was prepared by Parametrix, 719 2nd Avenue, Suite 200, Seattle, WA, 98104.

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Appendix A Ordinance 16581 and Public Rule LUD 12-1 PR
Appendix B Expert Panel Members' Resumes
Appendix C Catalog of King County Project Related Documents

Acronyms and Abbreviations

cfs	Cubic feet per second
ELJ	Engineered log jam
ESA	Endangered Species Act
EP	Expert panel
PFD	Personal flotation devices
PPE	Personal protective equipment
RM	River Mile
SEPA	State Environmental Policy Act
WDFW	Washington Department of Fish and Wildlife
WLRD	King County Water and Land Resources Division

Definitions

Large wood: The term "large wood" refers to downed trees, but does not include rooted, standing vegetation. (Large wood is also known as logs, large woody debris, coarse woody debris, snags, and large organic debris.)*

Large wood placement: The deliberate placement of large wood in rivers and streams by physically depositing pieces in or near the channel, or installing them in an engineered structure, for any purpose, including flood protection, bank stabilization, mitigation, and habitat improvement or restoration.*

Public safety: Unless otherwise noted, the term public safety is used in this document to reflect the safety of members of the public and water users of the rivers and streams in King County*

*per www.kingcounty.gov

Introduction and Background

The King County Water and Land Resources Division (WLRD) designs and implements a variety of instream projects for habitat enhancement, bank stabilization, and flood-risk reduction. Most of these projects involve the placement of large wood as part of their key design components. These projects are subject to post-construction monitoring, inspections, and adaptive management conducted by King County and third-parties to observe the constructed projects relative to their original stated goals and objectives. This work will be conducted in accordance with Ordinance 16581 (2009), and Public Rule LUD-12-1 PR (2010) (**Appendix A**). The primary focus is to evaluate the effectiveness of each project relative to the project-specific goals, with special emphasis on whether the project adequately considered public safety of unskilled river recreationalists (especially tubers, rafters, and kayakers).

Public Rule LUD-12-1 PR established safety procedures regarding recreational use when placing large wood in King County rivers, and lays out the procedures for the independent evaluation of emplaced wood projects as follows:

> *"The Department will provide for periodic independent monitoring and inspection of large wood emplacements by an* ***appropriate third-party provider****. This additional monitoring effort will be conducted every three years on a representative sampling of large wood emplacement projects. Reports of such inspections shall be provided to the Department and to all King County Council members."*

At the time of this work plan and since the public rule was adopted, 15 wood emplacements projects in King County riverine systems have been completed. Parametrix was hired to serve in the capacity of Consultant Lead to assemble an independent Expert Panel (EP) that will serve in the capacity of ***third-party provider***. The independent panel is comprised of a licensed civil engineer, geomorphologist, fisheries biologist, and a river recreational safety specialist (see resumes, **Appendix B**).

Of the 15 completed projects since the public rule was adopted, four were selected to serve as representative sample locations (see **Figure 1**). The four sites were selected based on design and construction methods that included the placement of large wood, flood protection facilities, and were located on reaches of the river with potential river recreational use. In addition to those criteria, the Consultant Lead chose to add additional diversity factors, so the sites could be evaluated from other perspectives, including:

- Number of wet seasons since the projects were constructed, to evaluate more recently completed projects relative to others sites that may have been in place for multiple wet seasons to observe any factors that might impact site stabilization, migration of natural wood, etc., and how those factors might impact stated project goals
- Geographic proximity in King County so different rivers could be considered (geomorphologic conditions, fish habitat, recreational use, etc.)
- Diversity among the King County Project Managers to evaluate any differences in how project goals and objectives were approached and implemented

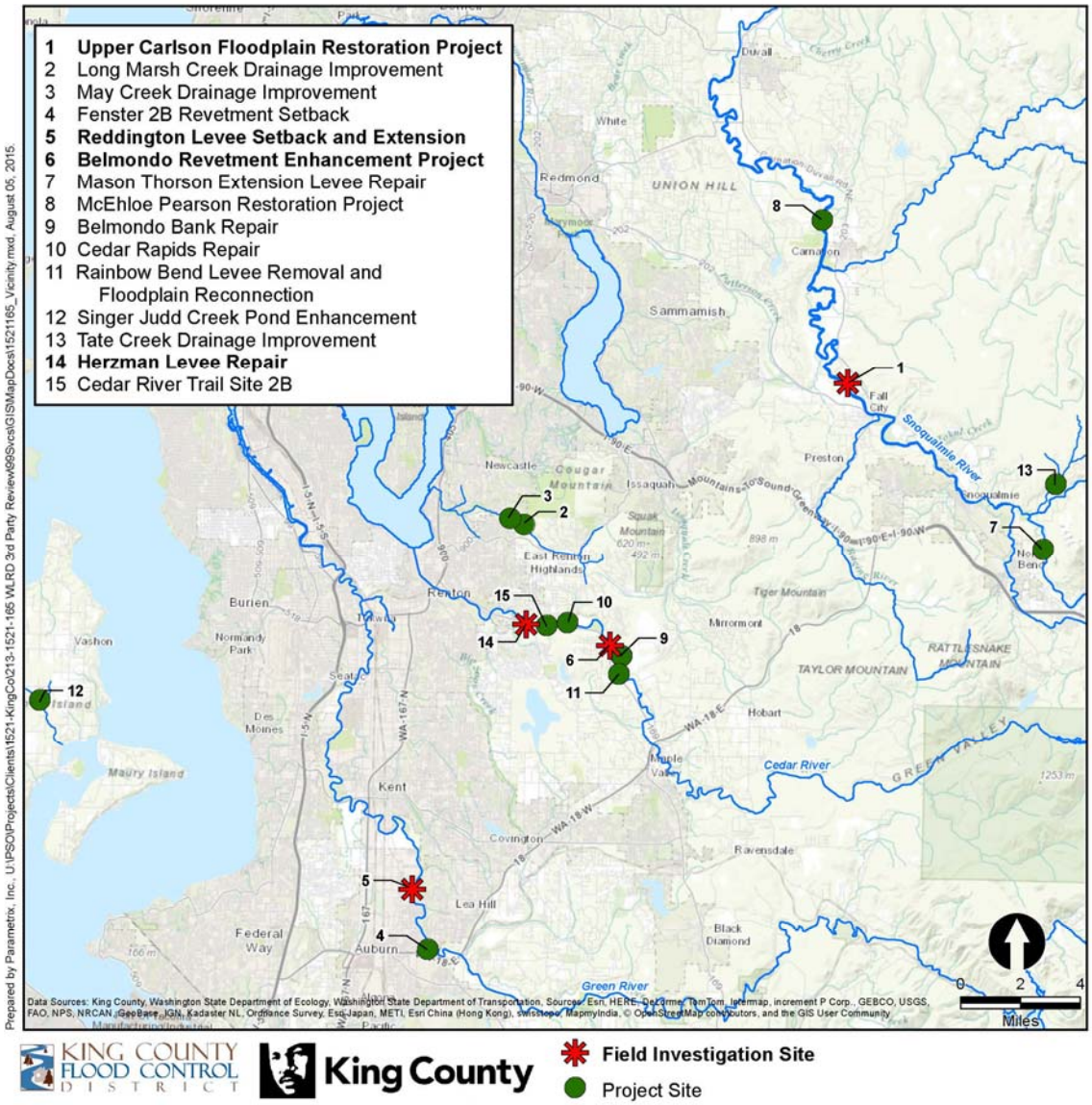


Figure 1. Locations of King County Emplaced Wood Projects Completed after March 2010

This Work Plan has been developed to provide guidance and direction on the goals of this specific work order and has **three** components:

1. Summarize each project to clearly state its goals and objectives (i.e., ascertain/determine what the project said it would do)

2. Review with the EP members the summarized information and goals, and visit each location to determine if:
    a. Public safety was considered in accordance with the Public Rule and Ordinance
    b. Stated project goals were accomplished with respect to the design objectives while minimizing risks to public safety

3. Document and report the findings of the EP members for each project

The independent evaluation by this panel acknowledges the dynamic nature of rivers, and that river recreation is not a risk-free activity regardless of the impacts (positive or negative) of engineered projects. With either engineered improvements to the river or leaving naturally occurring large wood and structures, a certain degree of risk remains to the boaters and floaters. The risk is influenced by the skill of the boater or floater, river conditions on day of use, and use of personal protective equipment (PPE) or personal flotation devices (PFD), such as life vests. To evaluate and observe each project site with potential recreational use, the field investigations for this work will occur in August 2015 to coincide with potential river recreation activity.

1.0 Emplaced Wood Projects' Goals and Objectives

With respect to the four (4) selected projects and their respective stated project goals and objectives, the EP members will be reminded that Appendix A of Public Rule LUD-12-1 PR (2010) states:

> *"….. projects must be designed to meet their important underlying goals and objectives. Within the context of those goals and objectives, public safety will be of primary consideration in selecting design alternatives."*

The EP is to evaluate each of the projects with primary consideration of public safety, but consider all of the stated goals and objectives of each project. The Consultant Lead has summarized (from project related documents) each project's goals and objectives to support the EP's determination whether each project accomplished its stated goals (see **Table 1).** These goals and objectives were confirmed with the King County Project Managers for accuracy and are the basis of the EP's evaluation, in addition to the fundamental questions to be answered.

Table 1. Representative Emplaced Wood Projects' Goals and Objectives

Project	Goals	Specific Objectives
Belmondo Revetment Enhancement, Cedar River, River Mile (RM) 9.5 to 10.8, Left Bank	1. Enhance the quantity and quality of aquatic habitat to be consistent with federal, state, and county standards for streambank stabilization projects by promoting lateral channel migration and maintaining existing flood protection 2. Meet Washington Department of Fish and Wildlife (WDFW) mitigation requirements for impacts on aquatic habitat associated with a log jam removal at Cedar Rapids in 2011 at RM 7.4	1. Construct 370 linear feet of enhanced bank stabilization and compensate for log jam removal at Cedar Rapids 2. Replace 2009 emergency riprap repair above the ordinary high water level with vegetated geogrids to support the establishment of riparian shade and cover 3. Construct two engineered log jams (ELJs) to deflect high flows and shear away from the left bank, scour pools, and promote lateral channel migration and connectivity with the right-bank floodplain 4. Construct two complexes of roughness logs to reduce local velocity and shear, promote sediment deposition, and provide fish refuge
Herzman Levee Repair, Cedar River, RM 6.6, Right Bank	1. Balance permit-required mitigation for construction impacts and recreational user safety 2. Have the levee function as originally designed; repairs are required due to flood damage to the face and toe of the upstream end of the levee; conduct repairs during the Cedar River fish window	1. Repair 260 linear feet of levee along the face and toe of the upstream end 2. Replant the willows on the levee 3. Place large wood at the downstream end of the repair to mitigate for the existing canopy of willow and the wood in the water that was lost during the repair of the levee face

Table 1: Representative Emplaced Wood Projects' Goals and Objectives (Continued)

Project	Goals	Specific Objectives
Reddington Levee Setback and Extension, Green River, RM 28.2 to 29.5, Left Bank	1. Reduce risks from flood and channel migration hazards for King County residents in the vicinity of the Reddington Levee along the Green River 2. Increase the width of the riparian corridor along the Green River in the vicinity of the Reddington Levee, with a resulting increase in flow capacity and ecological benefits 3. Reduce the vulnerability of the levee to fluvial scour, mass wasting, and channel migration 4. Reduce the long-term costs of flood hazard management 5. Allow the river to meander, scour, and develop a more complex ecosystem, which includes formation of rearing habitat for juvenile salmon 6. Protect existing vegetation and restore a corridor of native vegetation to increase shoreline and channel shading, support the riparian food web, and improve fish and wildlife habitat adjacent to and within the river channel	1. Replace levees that do not meet modern structural design standards and have a history of seepage problems 2. Set the levees back to reduce their susceptibility to scour and allow more natural channel movement within the project area 3. Increase the flow containment capacity of the levee system beyond 12,000 cubic feet per second (cfs) to 14,900 cfs plus 3 feet of freeboard 4. Extend the levee system where no levee currently exists along roughly one-third mile of the river bank from just north of the River Mobile Estates to 43rd St. NE
Upper Carlson Floodplain Restoration, Snoqualmie River, RM 33, Right Bank	1. Promote more natural rates and frequency of channel and floodplain processes (such as channel migration, overbank flooding, and wood recruitment) to improve salmon spawning and rearing habitat with the primary focus on restoring mainstem edge and off-channel rearing habitat, specifically for ESA-listed juvenile Chinook salmon and steelhead trout 2. Maintain or improve current levels of flood hazard protection of private property and public infrastructure 3. Address potential impacts on recreational boater safety 4. Enhance and maintain the native riparian vegetation community	1. Remove approximately 1,600 feet of existing levee and allow the river to expand, migrate, and reconnect with former channels within this reach 2. Construct approximately 1,200 feet of set-back revetment to protect Neal Road and the adjacent Carlson property 3. Incorporate input from the local recreational boating community into the Design Plans and the Site Management Plan and implement this plan to manage risk to recreational boaters at the site and in the reach 4. Re-vegetate areas disturbed during construction and areas where invasive plants have been treated with herbicide; continue to manage invasive plants and promote native communities

2.0 Background Information and Guiding Questions (Task 2)

As part of the project work plan, the Consultant Lead will prepare summaries (project overviews) of each of the four projects, to assist the EP members with understanding each project, their respective goals and objectives, and any other pertinent information (including modifications made and documented as part of the final designs). As part of this task, the Consultant Lead will coordinate with King County Project Managers to obtain project-related documents, presentations, and other readily accessible information pertaining to each of the projects. Sources include websites, public notices, stakeholder information, recreational assessments conducted for large wood projects, and any relevant studies of boater safety and river navigability conducted on comparable rivers. The following documents and information sources were provided by King County Project Managers:

- Ordinance 16581 (June 30, 2009)
- Public Rule LUD-12-1 PR (March 31, 2010), and Appendix A to the Public Rule
- Procedures for Managing Naturally Occurring Large Wood in King County Rivers
- Synthesis of 2013 River Recreational Studies (2014)
- Large Wood Annual Meeting agendas, sign-in-sheets, and project information
- Large Wood Stakeholder Committee Report (2009).

For the four (4) selected project sites, the following information was provided by King County Project Managers (where available):

- Site Management Plans
- Baseline documentation
- Basis of Design reports
- Final design drawings
- As-built drawings and closeout documentation
- Inspection and monitoring reports, including wood investigation reports
- Public records from the design process, public meetings, permit applications, and the State Environmental Policy Act (SEPA) process
- Any available information regarding adaptive management, press releases, or other efforts to disseminate information or advise the public of associated risks.

Upon King County providing the project documents, Part 1 of a two-part kickoff meeting for this work will provide overview presentations by King County Project Managers, background on large wood policies, the intent and role of the EP members, and review of key project milestones. The objective of Part 2 is additional project overviews, background on the Public Rule and Ordinance, review of project goals and objectives (all four sites), and a forum for the project managers to respond to questions from the panel. The intent is to confirm the management objectives of this independent review are mutually understood without dictating how the independent panel will conduct its work or have study questions limited.

Expert Panel Guiding Questions

The following two (2) fundamental questions were developed for the panel to focus on relative to the effectiveness of each project compared to its specific goals:

1. Based on the available documentation and field observation - was public safety of primary consideration in the design and implementation of large wood placements in King County rivers, including flood risk reduction measures, river recreational safety, etc.? If so, in what ways?

2. Were the other stated site-specific project goals and objectives achieved, while minimizing risk to public safety?

To answer these two fundamental questions, the EP will evaluate each of the projects from their respective backgrounds (engineering, science, and safety). To assist in those evaluations, suggested

‘guiding questions’ have been provided, which the EP members may choose to use or they may independently develop their own to respond to these two (2) fundamental questions. In answering the questions (fundamental, general, site-specific, or EP-generated), the panel members should provide the basis of their response for either why the project did or did not achieve a stated goal. Each panel member will address these questions, either through an evaluation of available documents provided through the Consultant Lead, or through direct field verification. It is important to note that the independent review of each project is based on project designs, as-built plans, adaptive management efforts, and the current state of the project identified through field investigation—***and will not*** include any ongoing project-related efforts, monitoring, or mitigation measures for each site.

General (Guiding) Questions

To assist the EP members in their evaluation of each of the projects and in responding to the two (2) fundamental questions, the following additional ‘guiding questions’ have been developed to explore each of the projects deeper:

1. What design elements (signage, ELJs, boulders, barbs, etc.) can be identified that were implemented with public safety as a primary consideration?
2. In the EP members’ opinion, are there any noticeable changes (positive or negative) to the river immediately upstream or downstream as a possible/likely result of the project that impacts either the stated project goals or public safety?
3. Can the EP members identify any unintended safety hazards (i.e., “underwater strainers,” entrapment of natural wood, etc.) that have developed as a result of the implemented projects?
4. Were adaptive management techniques applied at the site (such as reducing the number of unknowns, and better understanding to improve decision making), learning about management outcomes, and incorporating what was learned into ongoing management?
5. What additional data (or data gaps) would be beneficial for King County to collect during ongoing monitoring measures (or as baseline data prior to construction) to evaluate the effectiveness at each project site relative to meeting project goals and objectives? Is there a range of conditions recommended for data to be collected?
6. Has there been any loss or apparent degradation of features designed as public safety measures (i.e., emplaced wood, ELJs, bumper logs, barbs, geogrids for bank stabilization, signage, etc.) after the site has experienced a high flow or flood?

Site-specific questions for the four locations are provided in Tables 2 through 5, along with suggested EP members who might respond to each. The panel may supplement these guiding questions with additional observations, documents, and findings. The documents that were made available by King County were cataloged (see **Appendix C**) and, where they were found applicable to the guiding questions, have been cited as a cross-reference.

2.1 Belmondo Revetment Enhancement

The Belmondo Revetment Enhancement Project is located at RM 9.5 to 10.8 on the Cedar River, with the nearest street address of 16916 Renton-Maple Valley Road. The site was originally an old railroad embankment that had rock piles as part of the shoulder protection. The river (originally) was offset from the embankment, but over time migrated toward the embankment. The original construction was in the late 19th century by the Columbia and Puget Sound Railroad. Today the site is a trail that includes a regionally significant fiber optic cable. During an emergency repair/response in 2009, rock was placed to protect the trail, fiber optic line, and ultimately State Route 169. The embankment was also modified with ELJs, wood, and geogrids, and the rock placed during the emergency repair was left in place. For additional information and a more detailed summary this project, please see the Detailed Project Summary (provided separately to the EP in the Field Notebook).

In total, four projects have been conducted at this location (completed in 2009, 2010, 2012, and 2013); the panel's focus is for the 2013 completed project and its project-specific goals. The guiding questions specific to the stated project goals and objectives of the 2013 Belmondo Revetment Enhancement Project (in which there was a previous emergency repair in 2009) are provided in **Table 2**. These guiding questions are in addition to the two (2) fundamental questions and general questions that would apply to this project site, and should supplement any additional questions and observations the EP independently develop.

Table 2. Guiding Questions for the Belmondo Revetment Enhancement Project.

No.	Guiding Questions	Panel Member	Document Reference
Project Goal No. 1 Enhance the quantity and quality of aquatic habitat to be consistent with federal, state, and county standards for streambank stabilization projects by promoting lateral channel migration and maintaining existing flood protection (i.e., mitigation measures for the emergency rock placement).			
1	Has there been an increase in lateral channel migration and floodplain connectivity, as can be directly or indirectly attributed to the 2013 project construction, including the use of two ELJs?	CE, GM, RS	B-20
2	Were high flows and shear along the left bank deflected, scour pools created, and connectivity with the right-bank floodplain accomplished through the construction of two ELJs?	CE, GM	B-20
3	What physical process-based metric can be used to compare pre- and post-construction, or performance relative to a design flood threshold?	CE, GM	Not available
4	Were mitigating measures taken against left-bank erosion (bank stabilization) for the trail as one critical flood protection measure to be maintained?	CE, GM	Not available
5	Was there an overall benefit (quality and quantity of aquatic habitat) to the implementation of the project design challenges, including increased deflection angle of ELJs, root wads on ELJs, elimination of voids and strainer effect, increased size and boulder space, and no exposed chains or cables?	FB, CE	B-20
6	Were the vegetated geogrids effective in establishing riparian shade and cover for the replaced 2009 emergency riprap repair above the ordinary high water mark?	CE, GM, FB	Not available
Project Goal No. 2 Meet WDFW mitigation requirements for impacts on aquatic habitat associated with a log jam removal at Cedar Rapids in 2011 at RM 7.4 (added during the design and permitting phase of the project).			
7	Were the mitigation requirements for WDFW (impacts on aquatic habitat associated with log jam removals) met at Cedar Rapids (2011, RM 7.4)?	FB	Not available
8	Were fish refuges created through the reduction of local velocities and shear, and increased sediment deposits created through the construction of two complexes of roughness logs?	FB, GM	B-20
CE = Civil Engineer, Mitch Price, PE, CFM - River Design Group, Inc. FB = Fisheries Biologist, Kelly Burnett, PhD GM = Geomorphologist, Stephen Lancaster, PhD - Professor at Oregon State University RS = River Recreational Safety Specialist, Dan Hudson			

2.2 Herzman Levee Repair

The Herzman Levee was originally designed and constructed in 1976, and is located on a sharp outside bend of the Cedar River. The levee protects nearby infrastructure (SE Jones Road), which required repairs in 2010 due to flood damage. These repairs needed to occur prior to the closing of the Cedar River fish window, and included the addition of six large emplaced wood pieces. The intended use of the large wood is to create bank stability and additional fish habitat. For additional information, refer to the Detailed Project Summary (provided separately to the EP in the Field Notebook).

The guiding questions specific to the stated project goals and objectives of the Herzman Levee Repair are provided in **Table 3** and are intended to assist and supplement any questions the EP has independent to the fundamental and guiding questions.

Table 3. Guiding Questions for the Herzman Levee Repair Project

No.	Guiding Questions	Panel Member	Document Reference
Project Goal No. 1 Balance permit-required mitigation for construction impact and recreational user safety			
1	Did the placement of large wood (downstream end of the repair) mitigate for the existing willow canopy and the in-water wood that was lost during the repair of the levee face?	CE, GM	H-13
2	Based on available documents and field investigation, have the vegetated geogrids been effective in establishing habitat conservation measures since installation in 2010, including re-establishment of willow canopy and riparian shade and cover?	CE, GM, FB	H-01, H-02, H-21
3	Has fish habitat (refuges) been created as a result of the levee repair features (repairs to 270 linear feet of eroded facility with geogrids, rock, and six large wood placements)? If so, to what extent is the panel member able to determine if additional habitat was created?	FB	H-02
4	Is there evidence (either through available documents or field verification) of juvenile salmonids post-project construction?	FB	Not available
Project Goal No. 2 Restore the originally intended function (as originally designed) of the facility by repairing damage to face and toe rock on the upstream end of the levee.			
5	Does the levee currently function as originally designed as a result of the repairs made in 2010 (see original drawings, 1976)?	CE	H-07
6	Has there been an impact (positive, negative, or neutral) to local access points (Cavanaugh Pond Natural Area, Cedar River Trail, State Route 169) or downstream parks (City of Renton) as a result of restoring the levee to its originally intended design?	RS	Not available
7	What changes in behavior can be observed (from project documents or site investigation) of the opposite side of the river channel?	All	Not available
8	Have there been any reported incidents as a direct correlation to the addition of four bumper logs and two large wood placed with rootwads (downstream of the bumper logs)? Is any of the placed wood or other 'placed' structures along this reach of the river exposed in such a way that they have increased or decreased river recreational safety?	RS	Not available
9	Has the placement of large wood created areas of decreased velocity in the immediate vicinity of the levee repairs, and pulled the thalweg away from the levee toe?	CE, GM	H-02
Project Goal No. 3 Accomplish repairs during the Cedar River fish window			
10	Where the repairs all accomplished during the Cedar River fish window?	FB	NA

CE = Civil Engineer, Mitch Price, PE, CFM - River Design Group, Inc.
FB = Fisheries Biologist, Kelly Burnett, PhD
GM = Geomorphologist, Stephen Lancaster, PhD - Professor at Oregon State University
RS = River Recreational Safety Specialist, Dan Hudson

2.3 Reddington Levee Setback and Extension

The Reddington Levee (originally constructed in the early 1960s) project included a levee setback and extension (construction completed 2013) in the City of Auburn. The project extends northward (downstream) along the western (left) bank of the Green River, along the southern boundary of Brannan Park near 26th St. NE at RM 29.5, to the southern boundary at the Port of Seattle property at RM 28.2. The project consists of several components, including setback levee construction, existing levee removal, utility construction and relocation, engineered erosion protection, and fish habitat protection measures. For additional information, refer to the Detailed Project Summary (provided separately to the EP in the Field Notebook).

The guiding questions in **Table 4** were developed to assist the panel in evaluating the project relative to specific stated project goals, and are intended to supplement observations from the independent EP and both fundamental and general questions.

Table 4. Guideline Questions for the Reddington Levee Setback and Extension Project

No.	Guiding Question(s)	Panel Member	Document Reference
Project Goal No. 1: Reduce risks from flood and channel migration hazards for residents in the vicinity of the Reddington Levee			
1	Where there design and construction measures implemented that reduced the flood and channel migration hazards for the nearby residents?	CE, GM	Not available
2	Are there recreational safety signs or other means of public notification regarding work at the site as a means to improve the overall recreational safety along this reach of the river?	RS	Not available
Project Goal No. 2: Increase flow capacity and ecological benefits			
3	Does the project as implemented provide an increase in flow capacity, as determined through available documents and field inspection?	CE, GM, RS	Not available
4	Assuming an increase in flow capacity was created through the project, what ecological benefits can be observed (post-construction)?	FB, GM, CE	Not available
Project Goal No. 3: Reduce the vulnerability of the levee to fluvial scour, mass wasting, and channel migration			
5	Can the EP members identify any evidence that demonstrates that the designed/constructed project reduced vulnerability of the levee from fluvial scour, mass wasting, and channel migration?	CE, GM	Not available
Project Goal No. 4: Reduce the long-term costs of flood hazard management			
6	Is the design of the existing project ***conducive*** to reduce the long-term costs of flood hazard management? If so, to what extent is this measurable (and how)?	CE, GM, RS	Not available
7	Are there other design recommendations that might further improve flood hazard management at this site?	CE, GM, RS	Not available
Project Goal No. 5: Allow the river to meander, scour, and develop a more complex ecosystem			
8	Does the project (as designed and constructed) allow the river to meander, scour, and develop a more complex ecosystem, which includes formation of rearing habitat for juvenile salmon?	CE, GM, FB	R-16
9	How can the ecological benefits as an outcome from the constructed project (construction, demolition, engineered erosion protection, and habitat protection) be determined/evaluated?	FB, GM	R-02, R-16
Project Goal No. 6: Protect existing vegetation and restore corridor of native vegetation to increase shoreline and channel-shading support			
10	Was the existing vegetation protected and the corridor restored with native vegetation to increase shoreline and channel shading?	CE, GM	R-16
11	If the existing vegetation and corridor were restored and there was an increase in channel shading, does it improve fish and wildlife habitat adjacent to and within the river channel?	FB	R-16

CE = Civil Engineer, Mitch Price, PE, CFM - River Design Group, Inc.
FB = Fisheries Biologist, Kelly Burnett, PhD
GM = Geomorphologist, Stephen Lancaster, PhD - Professor at Oregon State University
RS = River Recreational Safety Specialist, Dan Hudson

2.4 Upper Carlson Floodplain Restoration

The Upper Carlson Floodplain Restoration includes the removal of 1,650 linear feet of the Upper Carlson Levee (in place since about 1930) and large angular rock to widen the channel and promote natural migration into the right-bank floodplain. The project is located on the eastern (right) bank of the Snoqualmie River, approximately 1 mile downstream of Fall City. It is within the Fall City Natural Area along Neal Road. For additional information, refer to the Detailed Project Summary (provided separately to the EP in the Field Notebook). The guiding questions in **Table 5** were developed to assist the EP in evaluating site-specific stated project goals.

Table 5. Guideline Questions for the Upper Carlson Floodplain Restoration Project

No.	Guiding Question(s)	Panel Member	Document Reference
Project Goal No. 1: Promote more natural rates and frequency of channel and floodplain processes (such as channel migration, overbank flooding, and wood recruitment) to improve salmon spawning and rearing habitat, with the primary focus on restoring mainstem edge and off-channel rearing habitat, and specifically ESA-listed juvenile Chinook salmon and steelhead trout			
1	Does there appear to be restored connectivity with the natural floodplain, or does the floodplain appear to be migrating back to the natural floodplain (right bank) as a potential result of this project?	GM	C-094
2	Does the available data from Water Year 2015 (flood magnitude and duration) indicate that the channel migration and overbank flooding occurred as potential result of this project?	CE, GM	Not available
3	Has there been a reduction in flood flow velocities and channel migration rates as a result of moving approximately 70% of the large and small diameter trees (creating large log clusters) into the floodplain during the single post-construction water year?	CE, GM	Not available
4	Has there been an increase or improvement in salmon spawning and rearing habitat in the mainstem edge, side channels, or off channels as a likely result of this project?	FB	C-098
5	What has been the impact on habitat for ESA-listed juvenile Chinook salmon and steelhead trout?	FB	Not available
6	Has there been an increase in wood recruitment, logjam formation, and other habitat-forming natural processes as result of setting back the levee and revetment in the Snoqualmie River?	GM, CE	C-006, C-095, C-098
7	Has there been a reduction in channel migration along the left bank as a result of reinforcing the downstream 40 feet of the Aldair Levee and bolstering the levee with large angular rock 175 feet upstream of the levee (Adaptive Management Item No.1)?	GM	Not available
8	Has the reinforcement and extension of the Aldair Levee maintained the existing left-bank configuration and pre-project flow orientation?	CE	C-095
Project Goal No. 2: Maintain or improve current levels of flood hazard protection of private property and public infrastructure			
9	Does the project improve levels of flood hazard protection (erosion and flooding), both to private and public property?	CE, GM	C-006
10	Relative to a threshold or a single wet year cycle, is there any evidence of reduced flooding of adjacent property, and if so - what?	CE, GM	Not available
Project Goal No. 3: Address potential impacts on recreational boater safety			
11	Were there recreational safety signs or other means of public notification regarding work at the site as a means to improve the overall recreational safety along this reach of the river?	RS	C-139, C-144, C-147
12	What has been the frequency in emergency calls or reported incidents from local whitewater clubs or public agencies from recreational users (boaters, floaters, and anglers)? Is there an increase (or decrease) to the number of calls compared to pre-construction?	RS	Not available
13	Is there an increased risk to river recreational safety as a result of removing the levee, leaving approximately 91 large wood (> 18-inch diameter) and 157 smaller diameter trees in the floodplain; or as a result of setting back the levee?	RS	C-006, C-095
Project Goal No. 4: Enhance and maintain the native riparian vegetation community			
14	To what extent has the native riparian vegetation community been enhanced as a likely result of this project?	GM, FB	C-098
CE = Civil Engineer, Mitch Price, PE, CFM - River Design Group, Inc. FB = Fisheries Biologist, Kelly Burnett, PhD GM = Geomorphologist, Stephen Lancaster, PhD - Professor at Oregon State University RS = River Recreational Safety Specialist, Dan Hudson			

2.5 Discipline Specific Procedures and Criteria

While evaluating the available information for the four representative project locations, each panel member will use the criteria below as a guide in evaluating each site according to the member's area of expertise, both through the field investigation and review of available documents.

2.5.1 Geomorphology

- Condition of embankment (such as visible erosion, riprap, concrete, rebar, boulders), river substrate/bottom
- Seasonal flow rates, depths, and shifting channel conditions
- Flood hazard risk reduction, including erosion measures
- Adaptive management actions, respective to project effectiveness to meet stated goals

2.5.2 Civil Engineering

- Flood risk reduction and mitigation measures, relative to design and constructed project
- Condition of revetments and levees (before and after construction and improvements)
- Existing infrastructure (bridges, levees, and revetments)
- Naturally occurring large wood, and large wood placed during construction of each project
- Stability of ELJs
- Adaptive management actions, respective to project effectiveness to meet stated goals

2.5.3 Fisheries Biologist

- Substrate, water temperature, turbidity, depth, flow, current (if able to measure in the field)
- Identification and condition of side channels, mainstem edge, and other additional habitat refugia
- List of endangered species (according to ESA) relative to each project location
- Adaptive management actions respective to creating, preserving, or restoring habitat created by the project

2.5.4 River Recreational Safety

- Direction and approach of main current flow
- Varying hydraulic conditions at project (low flow versus high flow)
- Visual observation of river bottom in the direct vicinity of the project site (rock versus sandy) and likelihood to act as 'strainer' that trap shoelaces or clothes
- Identification of possible helical flow (usually closer to shore or near levees) that may impact smaller children
- Overall project effectiveness, relative to public safety and stated project specific goals
- Identifying those design features that can impact boater safety
- Adaptive management actions respective to river safety and project effectiveness
- Efforts to disseminate public safety information or otherwise advise the public of associated risks (through websites, warnings posted at sites, and information kiosks)
- Boater difficulty classification

3.0 Field Observation and Activities (Task 3)

The purpose of the field observation (Task 3) portion of this work is for the EP members to collect any additional information necessary to address the project questions and objectives of each of the four (4) projects. A check-list of 'field observations' that match the guiding questions is provided in **Appendix D** as a resource for the EP members.

The field work will occur from August 24 through August 26, 2015, and each of the representative project locations will be visited. The field work will begin at the Upper Carlton Floodplain Restoration Project in Fall City, where the panel members will assess existing conditions and review design features relative to the stated project goals and objectives. At each of the site visits, the King County Project Manager will provide a site orientation, recap of the key project goals and objectives, and serve as a resource for EP member questions. A site safety review will be provided prior to each inspection, and then the EP will conduct an independent evaluation of the site with a specific focus on their disciplines. Each King County Project Manager's role on site is to serve as a resource, and not provide opinion or recommendations to any of the 'guiding questions.' The Consultant Lead will be responsible for organizing advance field work activities, coordinating with EP members the day of each field visit, facilitating site orientation with the King County Project Managers, debriefing the panel members after field observations, and facilitating follow-up questions from the EP to King County.

The field observation schedule is anticipated to be in the following order, based on King County Project Manager availability, extent and size of project work, and geographic proximity of sites to one another.

Monday, 8/24

10:30AM-2:30PM	Meeting with Panel Members to review fundamental, guiding, and site-specific questions, and project summaries
2:30PM – 5:00PM	**Upper Carlson Floodplain Restoration Project Site** King County PM/POC: Dan Eastman Rally Point with King County PM: Northwest location of project site, directly across from 2412 Neal Rd. SE; team will travel to the southeast along the project site
5:30PM	Panel debrief

Tuesday, 8/25

8:45AM	Panel Members depart for project site
9:30AM – 12:00PM	**Herzman Levee Repair Project Site** King County PM/POC: Wesley Kameda Rally Point with King County PM: SE Renton Maple Valley Road, at the Cavanaugh Pond Natural Area (near 174th Ave SE, Renton, WA 98058)
12:00PM -2:00PM	*Break for lunch and travel to next location*
2:00PM - 4:30PM	**Belmondo Revetment Enhancement Project Site** King County PM/POC: Rally Point: 16916 Renton Maple Valley Road, Rent, WA – note: sufficient parking (2 vehicles) along road, immediately adjacent to the project site
5:00PM	Panel debrief

Wednesday, 8/26

8:45AM	Panel Members depart for project site
9:30AM – 12:00PM	**Reddington Levee Setback and Extension Project Site** King County PM/POC: Erik Peters Rally Point: Brannan Park, RM 29.5 near 26th Street NE (far south end of project site)
12:00PM	Final Debrief (on-site)

At the end of each field inspection day, the panel members will meet with the Consultant Lead to review findings, and list any additional questions or requests. During each site visit, the following approach will be applied to provide consistency and define expectations across each of the locations.

Pre-Field Inspection Activities: King County staff will coordinate right-of-entry with property owners (as necessary to access sites), and field-verify locations with Consultant Leads. Prior to field inspection, each panel member will receive a Field Project Notebook (hard copy), which will include a copy of the Project Work Plan, synthesized project-specific background information, site maps (provided by King County), guiding questions, and note pages for annotating additional field observations.

Rally Point and Safety Briefing: Each day of field inspection will begin at a 'rally point' where the panel members and the Consultant Lead shall review the plan for the day, guiding/list of questions to address, and review of the field inspection approach. Each field inspection day will begin with a safety briefing to include any potential site-specific hazards, site access, and additional required personal protection equipment (PPE) recommended.

Field Investigation: EP members will document existing conditions observed during the site visit, inspection/investigation methods utilized, recreational user safety evaluation, and project effectiveness in the context of satisfying the goals identified for each project. Field documentation will include any major changes to the design observed in the field that the Panelist believes might impact public safety, ecological benefits, or flood protection measures, such as:

- Location of Large Wood in the river (right bank, left bank, center, other)
- Large wood projecting into the river
- Large wood angle – relative to flow direction
- Velocity of river at the project location(s) as low, medium, or high relative to boater safety
- Site distance (boaters' perspective) approaching large wood from upstream
- Adaptive management measures applied
- Access points to the river near project location(s)

Field photographic documentation: the Consultant Lead shall photo document each site. Panelist may supplement this with any site specific photos they elect to collect and include with their field findings.

In-River Activities: It is not currently anticipated that in-river work will be needed by the EP River Recreational Safety Specialist. Should that change, the Consultant Lead will coordinate with King County for site access and safety briefing.

Post Field Investigation: Following the site visits, the Consultant Lead and EP members shall participate in one 2-hour meeting with the County to discuss the site visits and initial findings and address any questions or issues arising from the site visits. King County Project Managers will be available for questions. The Consultant Lead shall prepare a summary of activities and key findings from the site visits, delivered in email format.

4.0 Final Documentation Third-Party Evaluation (Task 4)

This task includes documenting the activities associated with the monitoring, inspection, and evaluation of overall project effectiveness and safety with respect to project goals of restoration, flood-risk reduction, mitigation, and recreational safety. It is important to clarify that in the case of this independent review, the scope of monitoring includes looking at the design, as-built, any adaptive management efforts, and current state of the project; ***not an ongoing study/monitoring*** of each site. The criteria applied to this task include:

- Using the background information reviewed in Task 2 and the field observations from Task 3 to provide an assessment of overall effectiveness of emplaced wood projects with respect to public safety and project goals

- The monitoring and inspections shall consider the volume and skill level of potential river recreational users at each site based on the findings of the King County 2013 River Recreational Study.

- The assessment shall consider physical river conditions including seasonal flow rates, depths, shifting channel conditions, boater difficulty classification, substrate, water temperature and turbidity, naturally occurring large wood, large wood placed during construction of each project, existing infrastructure (bridges, levees, and revetments), and public access to the project reach.

- The assessment shall consider any adaptive management efforts in which the County has engaged, or efforts to disseminate public safety information or otherwise advise the public of associated risks.

- The Consultant Lead shall prepare a preliminary draft report for review by the County. The report shall include a description of each project design, existing conditions observed during the site visit, inspection methods, safety evaluation results, and project effectiveness in the context of satisfying the other goals identified. The County Project Manager shall compile all County staff comments into a single mark-up of the preliminary draft report.

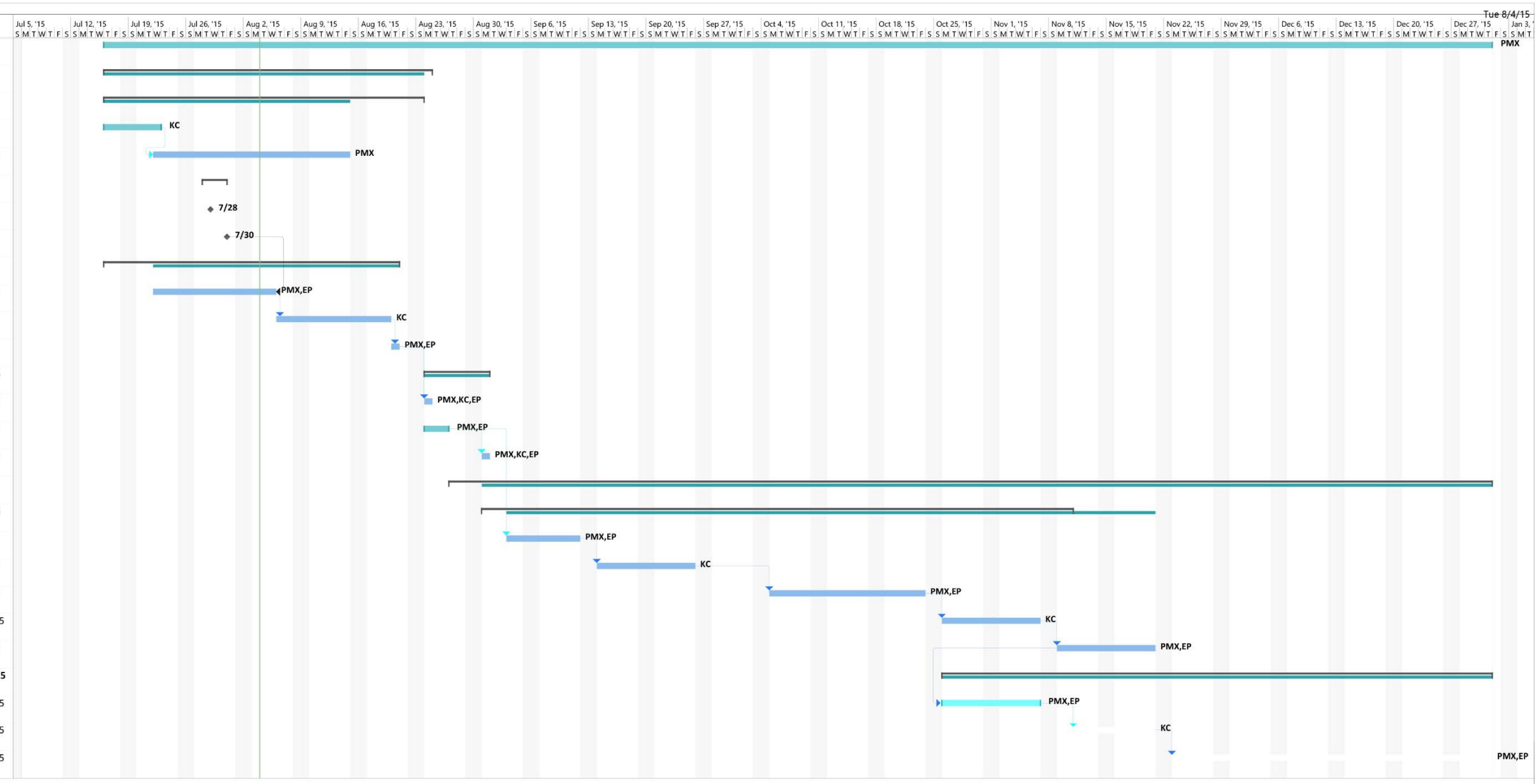
- The Consultant Lead shall address the County's comments on the preliminary draft report and check draft report and submit a final report.

- The Consultant shall prepare and deliver a PowerPoint presentation to the King County Council, with prior review by King County.

5.0 Project Schedule

The project schedule (start dates) for the tasks and activities in this work plan are provided in **Figure 2**.

ID	Task Name	Duration	Start
1	**Task 1 - Project Management/Work Order Contract Administration**	**121 days**	**Thu 7/16/15**
2	**Task 2 - Review Background Information and Panel Kick-off Meeting**	**28 days**	**Thu 7/16/15**
3	**2.1 Background Information**	**28 days**	**Thu 7/16/15**
4	King County Project Managers Provide Background Information	5 days	Thu 7/16/15
5	Synthesis of Project Background Information	18 days	Wed 7/22/15
6	**2.2 Kick Off Meetings**	**3 days**	**Tue 7/28/15**
7	Kickoff Meeting (Part 1)	1 day	Tue 7/28/15
8	Kickoff Meeting (Part 2)	1 day	Thu 7/30/15
9	**2.3 Work Plan**	**26 days**	**Thu 7/16/15**
10	Draft Work Plan	11 days	Wed 7/22/15
11	Review Draft Work Plan	10 days	Thu 8/6/15
12	Final Work Plan	1 day	Thu 8/20/15
13	**Task 3 - Conduct Field Investigation**	**6 days**	**Mon 8/24/15**
14	Pre-Field Visit Meeting with King County PMs and Panel (If Requested by Panel)	1 day	Mon 8/24/15
15	Field Visits	3 days	Mon 8/24/15
16	Post-Field Visit Meeting with King County PMs and Panel (If Requested by Panel)	1 day	Mon 8/31/15
17	**Task 4 - Monitor Project Outcomes and Final Documentation**	**91 days**	**Thu 8/27/15**
18	**Risk Assessment Report**	**52 days**	**Mon 8/31/15**
19	Draft Annotated Outline	7 days	Thu 9/3/15
20	Review Outline	10 days	Mon 9/14/15
21	Draft Report	15 days	Mon 10/5/15
22	Review Draft Report	10 days	Mon 10/26/15
23	Final Report	10 days	Mon 11/9/15
24	**Council Presentation**	**49 days**	**Mon 10/26/15**
25	Draft Council Presentation	10 days	Mon 10/26/15
26	Review Draft Council Presentation	8 days	Wed 11/11/15
27	Final Council Presentation	29 days	Mon 11/23/15



Project: ThirdPartyProjectReviewS

Task | Split | Milestone | Summary | Project Summary | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | External Tasks | External Milestone | Deadline | Progress | Manual Progress

Figure 2. Third Party Review of Project Involving Large Wood Emplacements - Project Schedule

6.0 References

1. Project Specific Documents – provided by King County WLRD (July 22-24, 2015) via FTP site
2. King County 2013 River Recreational Study
3. International Boater Difficulty Rating System for Whitewater Boating: (Accessed August 2, 2015) http://www.americanwhitewater.org/content/Wiki/safety:start?#class_i_rapids
4. Large Wood Stakeholder Committee, Final Report and Recommendations (2009)
5. Reference/Support Documents, as itemized in **Appendix C**

Appendix A - Ordinance 16581 signed on June 30, 2009 and Public Rule LUD 12-1 PR adopted on March 31, 2010

King County

KING COUNTY

1200 King County Courthouse
516 Third Avenue
Seattle, WA 98104

Signature Report

June 30, 2009

Ordinance 16581

Proposed No. 2009-0367.3 **Sponsors** Phillips, Dunn, Ferguson and Lambert

1 AN ORDINANCE requiring the adoption of rules
2 addressing procedures for establishing large wood
3 emplacements in rivers or streams.
4
5 STATEMENT OF FACTS:
6 1. Public agencies, development and habitat restoration project
7 proponents and private landowners have increasingly made use of large
8 wood emplacement in recent years, as a means of enhancing fisheries and
9 aquatic habitat values, reducing erosion and scouring to river banks,
10 deflecting flows to minimize impacts to river banks, offsetting the impacts
11 of development projects and protecting shorelines.
12 2. Public safety concerns have emerged regarding the potential hazard
13 presented by some of these emplacements to recreational boaters, floaters
14 and other water users.
15 3. Based on these concerns, the King County council directed that the
16 department of natural resources and parks prepare a report on the

17 circumstances associated with large wood emplacements, addressing
18 means of mitigating against public safety hazards.
19 4. That report was prepared and presented to the council, noting, among
20 other findings, certain procedural approaches to large wood emplacements
21 that are generally observed by the department of natural resources and
22 parks.
23 5. Those procedural approaches have not been adopted as administrative
24 rules and are not readily available to the public.
25 BE IT ORDAINED BY THE COUNCIL OF KING COUNTY:
26 SECTION 1.
27 A. By March 31, 2010, the executive shall adopt rules addressing the procedures
28 that the King County department of natural resources and parks shall follow when
29 installing large wood emplacements in rivers or streams.
30 B. The rules shall require the department of natural resources and parks to:
31 1. Develop a conceptual design of the wood emplacement for each proposed
32 project. The project-specific conceptual design shall address proposed location, size,
33 shape and anchoring of the wood; whether wood recruitment, which is the intentional
34 accumulation of wood, floating down the river, at the installed emplacement site, is
35 proposed; whether wood is intended to remain fixed or is intended to be moveable; and
36 how the emplacement is to function to meet project goals;
37 2. Include in each conceptual design a description of how public safety
38 considerations have been incorporated into the project's design;

3. Provide timely notice by the department of natural resources and parks to recreational water users, environmental interests, the neighboring community and others indicating an interest, about a proposed project and how interested parties may comment on the conceptual design;

4. Involve interested parties, who commented on the conceptual design, in a discussion and outreach to revise and refine the wood emplacement design for a proposed project, including:

a. identifying the type and extent of recreational use in the project area;

b. identifying public concerns related to the conceptual design; and

c. considering ideas for reducing or eliminating concerns regarding public safety, to the extent possible; and

5. Provide for periodic independent monitoring and inspection of large wood emplacements by an appropriate third-party provider. Reports of such inspections shall be provided to the department and to all councilmembers. Eleven copies of any inspection report made under this subsection shall be filed with the clerk of the council for distribution to councilmembers.

C. The rules shall include reference to the Guidelines for Bank Stabilization Projects in Riverine Environments in King County and the State of Washington's Integrated Streambank Protection Guidelines as the guide for project design for wood emplacements. At least every three years, the department of natural resources and parks shall convene a group of stakeholders, including but not limited to river residents, recreationalists, tribes, river boating interests, appropriate regulatory agencies, King County sheriff office representatives, and water resource inventory area representatives,

62 to review the department's large-wood emplacement rules and update them as needed.
63 The department shall report to the chair of the physical environment committee, or its
64 successor, any changes to the rules resulting from this review process. Two copies of any
65 report made under this subsection shall be filed with the clerk of the council, for
66 distribution to the chair of the physical environment committee, or its successor.
67 D. The adopted rules are intended to support the department of natural resources
68 and parks' process to evaluate various strategies for location and design of wood
69 emplacements, to maximize project benefits and to minimize risks to public safety.
70 E. The rules shall apply over all rivers within the jurisdiction of the department of
71 natural resources and parks.
72 F. In implementing the rules, the procedures and design options affording the
73 greatest safety for river users shall be of primary consideration in design concerns
74 involving a balancing of important public purposes as the county addresses safety issues
75 in large wood emplacements and other in-stream designs.
76

77 G. The rules are supplemental to applicable provisions of the Revised Code of

78 Washington and Washington Administrative Code.

79

Ordinance 16581 was introduced on 6/15/2009 and passed as amended by the Metropolitan King County Council on 6/29/2009, by the following vote:

Yes: 8 - Mr. Constantine, Mr. Ferguson, Ms. Lambert, Mr. von Reichbauer, Mr. Gossett, Mr. Phillips, Ms. Patterson and Mr. Dunn
No: 0
Excused: 1 - Ms. Hague

KING COUNTY COUNCIL
KING COUNTY, WASHINGTON

Dow Constantine

Dow Constantine, Chair

ATTEST:

Anne Noris for

Anne Noris, Clerk of the Council

RECEIVED
2009 JUL 10 PM 3: 18
CLERK
KING COUNTY COUNCIL

APPROVED this 10th day of July, 2009.

Kurt Triplett

Kurt Triplett, County Executive

Attachments None

King County

King County
Public Rules and Regulations

Public Rules

Title	Document Code No.
Procedures for Considering Public Safety When Placing Large Wood in King County Rivers	LUD 12-1 (PR)
Department/Issuing Agency Department of Natural Resources and Parks (DNRP)	Date March 31, 2010
Approved Bob Burns, Interim Director	

1.0 SUBJECT TITLE: Procedures for Considering Public Safety When Placing Large Wood in King County Rivers

1.1 EFFECTIVE DATE: The effective date of this Public Rule is March 31, 2010 or thirty days after filing with the Clerk of the Council, whichever comes later.

1.2 TYPE OF ACTION: New.

1.3 KEY WORDS: (1) large wood; (2) large wood placement; (3) mitigation; (4) public safety; (5) recreation.

2.0 PURPOSE:

2.1 To consider public safety issues in the design of projects involving the placement of large wood in King County rivers and streams.

2.2 To evaluate strategies for design of wood placements that will maximize project benefits and minimize risks to public safety.

2.3 To make available to the public the opportunity to provide input on proposed projects utilizing large wood.

3.0 ORGANIZATIONS AFFECTED:

3.1 The Department of Natural Resources and Parks.

4.0 REFERENCES:

4.1 King County Code chapter 2.98.

4.2 King County Ordinance No. 16581 (2009).

4.3 King County Code Title 21A.

4.4 King County Comprehensive Plan Policies E-405, E-406, E-408, E-422, E-438, E-471 (2008) available at: http://www.kingcounty.gov/property/permits/codes/growth/CompPlan/2008.aspx

4.5 King County Council adopted salmon recovery plans for Water Resource Inventory Areas 7, 8 and 9 (2005 and 2006) available at: http://www.kingcounty.gov/environment/animalsAndPlants/salmon-and-trout.aspx

4.6 King County Flood Hazard Management Plan Policies G-3, G-9, G-10, PROJ-6, RCM-1, RCM-2 (2006) available at: http://www.kingcounty.gov/environment/waterandland/flooding/documents/flood-hazard-management-plan.aspx

5.0 DEFINITIONS:

5.1 Large wood: The term "large wood" refers to downed trees, but does not include rooted, standing vegetation. (Large wood is also known as logs, large woody debris, coarse woody debris, snags, and large organic debris.)

5.2 Large wood placement: The deliberate placement of large wood in rivers and streams by physically depositing pieces in or near the channel, or installing them in an engineered structure, for any purpose, including flood protection, bank stabilization, mitigation, and habitat improvement or restoration.

5.3 Public safety: Unless otherwise noted, the term public safety is used in this document to reflect the safety of members of the public and water users of the rivers and streams in King County

6.0 POLICIES:

6.1 The *Procedures for Considering Public Safety When Placing Large Wood in King County Rivers* contained in Appendix A to this public rule, which is incorporated herein by this reference, presents the processes and procedures that the Department of Natural Resources and Parks shall follow in order to properly consider public safety in the design and implementation of projects involving placement of large wood in King County rivers and streams.

6.2 This Public Rule is exempt from the rule of strict construction and shall be liberally construed to give full effect to the objects and purposes for which it was adopted.

7.0 PROCEDURES:

Action By: Department of Natural Resources and Parks.

Action: Implements the requirements of Ordinance No. 16581 (2009) by developing *Procedures for Considering Public Safety When Placing Large Wood in King County Rivers* set forth in Appendix A of this rule.

8.0 RESPONSIBILITIES:

8.1 Department of Natural Resources and Parks.

8.1.1 Identifies projects involving the placement of large wood to which the *Procedures for Considering Public Safety When Placing Large Wood in King County Rivers*, Appendix A to this public rule, is applicable.

8.1.2 Implements the specific procedures provided for in the *Procedures for Considering Public Safety When Placing Large Wood in King County Rivers,* Appendix A to this public rule.

8.1.3 At least once every three years, or sooner if significant new data becomes available, convenes a group of stakeholders, including but not limited to river residents, recreationalists, tribes, river boating interests, appropriate regulatory agencies, King County sheriff office representatives, Water Resource Inventory Area representatives, and experienced project practitioners to review and comment on the *Procedures for Considering Public Safety When Placing Large Wood in King County Rivers,* Appendix A to this public rule, and update them as needed.

9.0 APPENDICES:

9.1 The *Procedures for Considering Public Safety When Placing Large Wood in King County Rivers*, King County Department of Natural Resources and Parks, Water and Land Resources Division, December 2009 constitutes Appendix A to this public rule.

APPENDIX A

PROCEDURES FOR CONSIDERING PUBLIC SAFETY WHEN PLACING LARGE WOOD IN KING COUNTY RIVERS

I. Purpose

The purpose of this document is to define and document procedures that the Department of Natural Resources and Parks will follow in order to:

a. Consider public safety issues in the design of projects involving the placement of large wood in King County rivers and streams;

b. Evaluate strategies for design of wood placements that will maximize project benefits and minimize risks to public safety; and

c. Make available to the public the opportunity to provide input on proposed projects utilizing large wood.

II. Applicability

This procedure applies to all King County Department of Natural Resources and Parks' projects involving the placement of large wood in King County rivers and streams.

III. Definitions

- Large wood: The term "large wood" refers to downed trees, but does not include rooted, standing vegetation. (Large wood is also known as logs, large woody debris, coarse woody debris, snags, and large organic debris.)
- Large wood placement: The deliberate placement of large wood by physically depositing pieces in or near the channel, or installing them in an engineered structure, for any purpose, including flood protection, bank stabilization, mitigation, and habitat improvement or restoration.
- Public safety: Unless otherwise noted, the term public safety is used in this document to reflect the safety of members of the public and water users of the rivers and streams in King County.

IV. Background and policy context

Pacific Northwest rivers and streams have historically contained large amounts of naturally-deposited large woody materials recruited through bank erosion, channel migration and wind-throw. Wood plays a major role in channel forming and stabilizing processes, physical habitat formation, sediment and organic-matter storage and the formation of flood refuge habitat. However, during the 19th and 20th centuries, logging,

navigational improvements and flood control efforts resulted in the removal of most of the large wood from Pacific Northwest rivers, including those in King County. Moreover, logging and clearing of riparian areas has compromised the future potential for large wood recruitment.

For many reasons, it is neither possible nor desirable to return to the wood clearing practices of the past, and in fact, there are many reasons King County is actively replacing wood in its rivers and streams. At the same time, boating and other water-oriented recreation have a long history in King County. Recreational users may come into contact with the wood being placed in King County's rivers and streams. It is widely recognized that riverine water sports, including fishing, wading, swimming, boating, and floating, can involve considerable risk. The level of risk is influenced by many factors, including the recreationist's health, maturity, level of experience, skill, and judgment; the appropriateness of their vessel and associated safety equipment; river conditions, such as flow levels, depth, turbulence, velocity, temperature, and bank form; and instream elements, such as large wood, boulders, artificial structures and debris. Large wood may be a potential hazard for some recreational water users, depending on its location and positioning within the channel, as well as flow levels and decisions taken by the users themselves. On the other hand, many recreational water users recognize wood as a natural feature of the river which, while requiring caution, can enhance their experiences – for example, wood can make river trips more interesting and aesthetically pleasing and can improve fishing opportunities.

The historic removal of large wood contributed to the degradation of fish and wildlife habitat, including habitat for species currently listed as threatened or endangered under the Endangered Species Act (ESA). It has become widely understood and accepted that placing large wood in local rivers is vital to the recovery of salmonid populations (A bibliography regarding the ecological role of large wood can be found on the County website). Large wood placement is frequently included as a major component of habitat restoration projects in the Puget Sound Salmon Recovery Plan, in part to compensate for the long time-lag between riparian reforestation efforts and subsequent, natural wood recruitment. Wood placement is also often required as mitigation for habitat impacts resulting from public works projects and other human activities.

Since the early 1990s, King County has placed wood in rivers for several reasons. The County places wood in rivers to improve public safety by reducing scour and erosion through the repair and maintenance of streambank protection facilities, and frequently incorporates bioengineered bank stabilization techniques that may include installation of large wood in combination with large rock and live plant materials. The function of the wood is to interact with river sediments, deflect and slow erosive stream velocities along the banks, and provide ecological benefits. In many cases, large wood is needed to comply with permit conditions.

The County also designs and constructs projects that restore the ecological function of wetlands, streams and rivers. Wood is used to improve ecological processes that create complex, productive, self-sustaining aquatic habitats. Large wood installations are necessary for implementation of King County Council approved watershed recovery plans, particularly in the absence of mature riparian corridors that would naturally recruit

wood. The intent of wood installation in this context is to capture and stabilize sediment; absorb hydraulic energy; create geomorphic complexity, such as scour pools and gravel bars; shade and cool water; retain nutrients to support a healthy fauna; and to provide spawning, rearing and foraging habitat for anadromous salmonids as well as other fish and amphibians.

Finally, federal, state, and local regulatory agencies often require King County and other applicants to install wood as mitigation for unavoidable impacts associated with transportation and flood control projects. Regulatory agencies – such as the U.S. Army Corps of Engineers, Washington Department of Fish and Wildlife (WDFW), and the County's Department of Development and Environmental Services – routinely require the placement of large wood in rivers as a condition for approval of permits and final project designs.

Whatever the specific purpose of a large wood placement project, any actions taken by the County must be done in a manner that is consistent with all applicable federal, state, and local policies and regulations. Examples of policies that pertain to the placement of large wood in rivers and streams and the goal of salmon recovery include:

- King County Comprehensive Plan policies E-405, E-406, E-408, E-422, E438, E-471, supporting watershed restoration and protection to support river and stream ecological processes;
- King County Council adopted salmon recovery plans for Water Resource Inventory Areas 7, 8, and 9 (King County Council Action 2005 and 2006) and Federally Approved Endangered Species Act Chinook Salmon Conservation Plan (2007);
- King County Flood Hazard Management Plan (King County Council Action 2007) policies G-3, G-9, G-10, PROJ-6, RCM-1, RCM-2, and other references.

Moreover, up to fifteen permits or environmental review processes are commonly needed for projects in unincorporated King County, including: Hydraulic Project Approval (HPA), National Environmental Policy Act, State Environmental Policy Act, Clean Water Act Section 404, Rivers and Harbors Act Section 10, Endangered Species Act Section 7, Critical Areas Ordinance, clearing and grading permits, and others. Not all permits are required for all projects. The HPA, administered by the WDFW, is the most commonly needed permit for work in rivers, streams and wetlands, and is the most frequent permit to require large wood placement to reduce or mitigate environmental impacts of a project.

It is within this policy and regulatory context that the proposed procedure addresses public safety in King County rivers. This procedure explains the steps to be taken in the design and decision-making process as it relates to public safety, and identifies specific opportunities for the incorporation of public input. The County recognizes that input from knowledgeable members of the public may help to inform the design teams in their efforts to produce projects that meet the County's primary design objectives while minimizing risks to public safety.

As to public safety as it relates to recreational users of rivers and streams in King County, it should be noted that the decision to recreate in rivers is ultimately the responsibility of each individual. Enhancing awareness through public education and outreach – whether by the State, County, or non-governmental organizations – is perhaps the most important strategy for reducing risks for recreational river users.

V. Procedure for considering public safety in the development and design of capital projects that include placement of large wood in rivers and streams in King County

1. Responsibility and use of the procedures

The Department will coordinate the implementation of this procedure. This section describes the process for considering public safety in the development and design of capital projects involving the placement of large wood in King County rivers and streams. The process includes opportunities for public input. Some procedures may need to be modified or streamlined for emergency situations, such as urgent repairs to flood protection facilities. The Department will ensure that, in implementing the rules, the procedures and design options affording the greatest safety for river users shall be of primary consideration in design concerns involving a balancing of important public purposes as the county addresses safety issues in large wood emplacements and other in-stream designs.

2. Assess recreational uses, potential project impacts on public safety, and develop project design

The Department's project design teams rely on sound engineering and design practices in the development of all Department projects and consider a wide range of public safety issues, including recreational safety, as well as potential flooding and erosion effects on infrastructure, neighborhoods, critical facilities, and other land uses. The responsibility for design decisions rests with the County's multi-disciplinary design teams and licensed professional engineers. All projects must be designed to meet their important underlying goals and objectives. Within the context of those goals and objectives, public safety will be of primary consideration in selecting design alternatives.

King County design teams refer to many relevant technical guidance documents in the course of project design, including but not limited to, the King County Guidelines for Bank Stabilization Projects in the Riverine Environments of King County and the State of Washington's Integrated Streambank Protection Guidelines and Stream Habitat Restoration Guidelines. Potential impacts of large wood on public safety are considered on a case-by-case basis during project development and design. Recreational use information and other stakeholder input will be sought during the conceptual design phase (up to approximately 30% design).

A. Conceptual (0%-30%) Design Phase

During the conceptual design phase (resulting in approximately 30% plan development), the design team assembles information and considers the design

objectives, constraints, risks (including, but not limited to, risks to public safety), and potential solutions. Analyses of alternatives may be conducted during this phase and the design team may consider a range of design options for large wood placement. By the conclusion of the conceptual design phase, each project should be developed sufficiently to describe the basic details of wood placement (e.g., number and type of installation, location, approximate size). Project managers will seek input from the public during this phase, when it can most effectively be included in design considerations. The specific mechanisms for sharing information and soliciting public input are described in detail in Section V.3 .

The following describes key steps during the conceptual design phase.

i) In designing the placement of wood in the project, the project team will gather available information and take into account the expected type, frequency and seasonality of recreational uses as an important element in its overall consideration of impacts to public safety of the proposed project.

ii) Consideration of public safety in the conceptual design will include but not be limited to the following factors: the location, orientation, elevation, and size of the wood placement, the method of anchoring or securing the wood placement, the degree of interaction between flowing water and the placed wood during projected flow regimes, including flows commonly experienced in the recreational seasons, and input received through the public outreach process.

iii) In designing the specific placement of large wood, the design team will seek to maximize achievement of stated project goals and objectives while minimizing potential public safety risks, including risks to recreational users, and will seek to ensure that the procedures and design options affording the greatest safety for river users are of primary consideration in design concerns involving a balancing of important public purposes as it addresses safety issues.

iv) Conceptual project designs will be informed by standard design practices with input from professional designers with expertise in fluvial geomorphology, ecology, river hydraulics and civil engineering with hydraulic analysis expertise.

v) All projects that incorporate large wood in rivers and streams will undergo review and approval of engineering plans and analysis from a Licensed Professional Civil Engineer.

vi) All projects that incorporate large wood with the stated objective of providing ecological benefits will undergo review and approval from a professional ecologist (i.e., persons with an advanced degree in aquatic and/or biological sciences from an accredited university or equivalent level of experience).

At the conclusion of the conceptual (30%) design phase, the project manager will document how public safety considerations have been addressed in the design, including why and how any impacts to recreational safety in particular can be or have already been avoided or reduced through the design of the project. Factors that will be addressed may include, as applicable, wood stability and anchoring technique; intended function of placed wood features and how they meet projects goals and objectives; expected longevity and recruitment potential; and a brief description of other design alternatives that may have been evaluated as part of an alternatives analysis.

At the conclusion of the conceptual (30%) design phase, the Department will:

- Update the project list (described in Section V.3, Public Outreach) to reflect project-specific outcomes of the conceptual design; and
- Share the updated list with the public via the procedures described below in Section V.3, Public Outreach.

If the Department determines the project is unable to successfully meet its goals and objectives while minimizing risks to public safety, it may choose to employ any of the following options:

- Work with the King County Sheriff's Office to alert river users to potential hazards using signage or other means, or to restrict use in the project area so that the project can meet its objectives while also protecting public safety; or
- Modify the project to further reduce public safety risks and concurrently implement mitigation measures (such as additional large wood placement at a comparable location in the same river reach) to fulfill the project goals and objectives; or
- Reconsider the scope of the project and whether to proceed or relocate the project, if possible, to an alternative site where objectives and public safety concerns can be fully achieved.

Not all of these options are applicable to all projects, and it will be the responsibility of the Department to make an appropriate selection.

B. Conceptual to Final (30%-100%) Design Phase

In this design phase, the design team will complete any remaining technical studies, refine the project design, and obtain permits.

If the Department determines that substantial changes to the large wood design have occurred during finalization of the design, as a result of permit submittals or other design factors, the Department will:

- Disseminate new design information to, and seek input from the public as appropriate.
- Update documentation of the project design and public safety considerations.

3. Public outreach

Public outreach is intended to reach a broad spectrum of the community, including river user groups, environmental groups, tribes, cities and other public agencies, river residents and property owners, emergency responders and numerous others. The goal of this effort is to keep the public informed and, at the same time, allow for two-way communication between project managers and the public. The Department's public outreach effort for each project using large wood will include one or more of the following: website information, e-mail notification, and public meetings.

A. Development of project list/database

The Department will develop and maintain a list of projects where large wood will be or is likely to be installed in a King County river or stream. This project list will be updated every year and made available by request and via the county website or e-mail notifications. For each project, the project manager will develop the following information for use in the public outreach process:

- Brief project description, including approximate type and amounts of wood expected to be used;
- Location of project;
- Primary purpose of the project and its relative importance to the success of County programs and mandates;
- Project goals and objectives;
- Existing project site conditions;
- Type, intensity and seasonality of recreational uses, if known;
- Intended function of the wood, including identification of how wood meets project goals and objectives;
- Project status and timing of conceptual design input opportunities; and
- Timing of planned and completed project construction.

B. Website information or e-mail notifications

The public outreach process will make use of the King County website or e-mail notifications to the public and interested stakeholders to provide the following types of information:

- Notices of upcoming public meetings;
- Documents, including these procedures, and other pertinent policy or technical documents;
- List of pending projects that are expected to utilize large wood, and notice of opportunities to comment;

- List of completed projects;
- Contact information for project managers; and
- Other resources and information, as appropriate.

The notification process will, at a minimum, include an electronic mailing list that will be established for this purpose. Interested individuals will be able to sign up for e-mail notifications. Printed/mailed notifications may also be used.

Annual notifications will provide a copy or web link to the comprehensive project list/database.

C. Public meetings

The department will hold two meetings every year to discuss the project list. The meetings, though similar in content and intent, will be held at different times and locations to enhance public involvement. One meeting should be held during daytime/business hours, and the other during evening hours. Department staff will describe the project list and each project's status as well as opportunities for public input. Conceptual designs for each project will be presented when available. Attendees will be invited to ask questions and engage in discussion with appropriate staff about the project list.

4. Monitor project outcome and apply adaptive management strategies

- The Department will conduct post-construction monitoring to assess overall project effectiveness and safety, including relevant changes in the function, location, orientation, elevation, and size of the placed wood. The need for, and feasibility of, any maintenance or retrofitting will also be assessed, including any anticipated regulatory requirements. The scope, timeframe and schedule for post-construction monitoring will vary according to project need and availability of funding.
- Monitoring and adaptive management will be used to assess whether any new actions at the sites of large wood installations are warranted. Actions may include:

    a. Issuing bulletins or news releases or disseminating informational materials to advise the public of the potential risks posed by placed large wood in the river; or

    b. Signing a river or a project site as potentially hazardous and warranting particular caution, notifying the King County Sheriff's Office who may impose use restrictions, or both; or

    c. Removing or altering the position of structural components of the placed large wood in order to further reduce any associated risk. This step may require additional regulatory review, permitting, and mitigation actions.

- The Department will provide for periodic independent monitoring and inspection of large wood emplacements by an appropriate third-party provider. This additional monitoring effort will be conducted every three years on a representative sampling of

large wood emplacement projects. Reports of such inspections shall be provided to the Department and to all King County Council members.

5. Final Documentation

- The Department will maintain electronic or paper records of all relevant large wood project documentation in accordance with existing local and state record-keeping requirements for project information, including documentation of public input and any resulting project modifications.

Appendix B: Expert Panel Members' Resumes

KELLY BURNETT, PhD

Fisheries Biologist | US Forest Service

27+ YEARS OF EXPERIENCE

OREGON STATE UNIVERSITY, PhD, FISHERIES SCIENCE

OREGON STATE UNIVERSITY, MS, FISHERIES SCIENCE

BERRY COLLEGE, BS, BIOLOGY & CHEMISTRY

UNIVERSITY OF OREGON SCHOOL OF LAW, MEDIATION TRAINING AND CERTIFICATION

As a researcher with the USDA Forest Service, Pacific Northwest Research Station, Kelly was a principle investigator on several competitively funded research projects. Her research emphasizes evaluating and developing landscape spatial data for stream ecosystems; advancing knowledge of landscape interactions among in-stream conditions, watershed processes, and human activities to inform policy and management; and projecting effects of climate-change induced sea-level rise on coastal salmon populations. Kelly routinely led research teams of GIS analysts, statisticians, and modelers. She has authored numerous refereed peer-reviewed journal articles, book chapters, and reports. Kelly is a certified mediator and consults regularly with governmental and non-governmental organizations including the USFS on climate change vulnerability assessments and the Oregon Board of Forestry in evaluating systematic review techniques for natural resources. She participates on interagency and interdisciplinary panels to translate science for decision makers, which included the Forest Ecosystem Management and Assessment Team convened by President Clinton.

Selected Recent Publications

- Flitcroft, R., K. Burnett, J. Snyder, G. Reeves, and L. Ganio. 2014. Riverscape patterns among years of juvenile Coho Salmon in midcoastal Oregon: implications for conservation. Transactions of the American Fisheries Society 143: 26-38

- Busch, S.D., M. Sheer, K.M. Burnett, P. McElhany, and T. Cooney. 2013. Landscape-level model to predict spawning habitat for Lower Columbia River fall Chinook (Oncorhynchus tshawytscha). River Research and Applications 29: 297–312. doi: 10.1002/rra.1597

- Anlauf, K. J., D.W. Jensen, K.M. Burnett, E.A. Steel, K. Christiansen, J.C. Firman, B.E. Feist, D.P. Larsen. 2011. Explaining spatial variability in stream habitats using both natural and management-influenced landscape predictors. Aquatic Conservation: Marine and Freshwater Ecosystems 21:704-714, DOI: 10.1002/aqc.1221

- Burnett, K.M., G. Giannico, and J. Behan. 2008. A pilot test of systematic review techniques: evaluating whether wood placements in streams of the Pacific Northwest affect salmonid abundance, growth, survival or habitat complexity. 4 February 2008, Report to the Oregon Board of Forestry, Salem, OR.

- Burnett, K.M., G.H. Reeves, D.J. Miller, S. Clarke, K. Vance-Borland, and K. Christiansen. 2007. Distribution of salmon-habitat potential relative to landscape characteristics and implications for conservation. Ecological Applications. 17(1):66-80.

DANIEL HUDSON

River Safety Specialist | Rescue 3 International and Retired Pierce County Sheriff's Department

33+ YEARS OF EXPERIENCE

26 YEARS OF FIELD TRAINING EXPERIENCE

25 YEARS OF SEARCH AND RESCUE EXPERIENCE

11 YEARS OF RIVER/WATER EXPERIENCE

CERTIFIED FIRST AID/CPR INSTRUCTOR

As a retired law enforcement officer, Daniel has over 33 years of experience providing services in the field and 25 years as a Search and Rescue coordinator and team lead, as well as a lead rescue trainer for river/water excursions. He was the technical team lead for his own agency and surrounding agencies. Due to his expertise in Search and Rescue, Daniel worked on specialty assignments for his agency, deploying to 18 national level incidents with FEMA over his career, where he coordinated with FEMA rescue teams and produced Incident Action Plans. His deployments include: the World Trade Center in New York City, 2001; Murrah Federal Building bombing in Oklahoma City in 2003; Hurricane Katrina in New Orleans in 2005; and the Oso Landslide in Washington in 2014.

Selected Project Experience

Hurricane Katrina Response Team – New Orleans, LA

Daniel was deployed to New Orleans on an incident management team as part of the overall Hurricane Katrina response team. While on site, he coordinated with FEMA staff and managing a plans section staff of 37 personnel. Daniel also have managed briefings, Unified Command meetings, and conducted a significant number of presentations while performing various roles with his incident management team.

Mapping Program, Oso Landslide Response – Oso, WA

While deployed as a Search and Rescue Coordinator as part of the response team for the Oso Landslide, Daniel utilized his skills in mapping and display processing to produce a mapping program to assist in the response. This program utilized and displayed data to provide a "trajectory" map that was critical in determining the search efforts and helped prioritize resources at the site. The mapping program also assisted the Medical Examiner's Officer with quick identification of recovered human remains and significantly reduced the time delay for next of kin notification. The program itself received significant attention in the emergency response field and led to an in-person meeting/briefing of the program by Daniel to the FEMA Administrator.

Drowning Prevention Network Assembly, Mount Si High School – North Bend, WA

In conjunction with the Drowning Prevention Network, Daniel was asked to present to the students and staff at Mount Si High School in North Bend on river safety. The program was requested by Mount Si, in the hopes of reducing the number of student related drownings on the Snoqualmie River.

Search and Rescue Experience

- Northridge Earthquake, Los Angeles (1994)
- Murrah Federal Building bombing (1995)
- World Trade Center 9/11 (2001)
- Columbia Shuttle Recovery effort in east Texas (2003)

STEPHEN LANCASTER

Panel Member: Geomorphologist | Associate Professor, Oregon State University

23+ YEARS OF EXPERIENCE

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, PhD, HYDROLOGY

HARVARD UNIVERSITY, AB, GENERAL STUDIES (PHYSICS)

As an associate professor of the Department of Geosciences/College of Earth, Ocean, and Atmospheric Sciences at Oregon State University, Stephen has over 23 years of geoscience and geomorphology experience. He currently teaches a variety of courses related to geomorphic processes at the university. Stephen has also provided consulting services on several river habitat projects, as well as participated in and presented for many public meetings, workshops, and specialist seminars. He has authored numerous peer-reviewed journal articles, abstracts, and reports, and participated as a panelist for the Geomorphology and Land-Use Dynamic Program for the National Science Foundation.

Selected Project Experience

Consultant Services, Porter Creek Salmon Habitat – Oregon

Stephen provided consulting services for the design of log structures to improve coho salmon rearing habitat during field trips with US Forest Service staff to Porter Creek in the Siuslaw National Forest and private industrial forest land owned by Plum Creek Timber. He collaborated with USFS staff in designing specific structures suited to local geomorphic features.

Consultant Services, Bull Run Creek Salmon Habitat – Oregon

Stephen provided consulting services for the evaluation of log structures to improve coho salmon rearing habitat during field trip to Bull Run Creek in the Siuslaw National Forest with US Forest Service staff. He assessed results of advised log placements and developed plans for collaboration in future log placement project on Porter Creek. Stephen's recommendations produced positive results for both rearing and spawning habitat.

Selected Recent Publications

- Frueh, W.T. *, and S.T. Lancaster, 2014. Correction of deposit ages for inherited ages of charcoal: Implications for sediment dynamics inferred from random sampling of deposits on headwater valley floors, Quaternary Science Reviews, 88, 110–124, doi: 10.1016/j.quascirev.2013.10.029. http://dx.doi.org/10.1016/j.quascirev.2013.10.029.

- Lancaster, S.T., E.F. Underwood*, and W.T. Frueh*, 2010. Sediment reservoirs at mountain stream confluences: Dynamics and effects of tributaries dominated by debris flow and fluvial processes, Geological Society of America Bulletin, 122(11/12), 1775–1786, doi: 10.1130/B30175.1. http://bulletin.geoscienceworld.org/cgi/content/full/122/11-12/1775?ijkey=rIbtPzz2RZmak&keytype=ref&siteid=gsabull)

MITCH PRICE, PE, CFM

Panel Member: Licensed Civil Engineer | River Design Group, Inc.

20+ YEARS OF EXPERIENCE

MONTANA STATE UNIVERSITY, MS CIVIL ENGINEERING (WATER RESOURCES)

NEW MEXICO STATE UNIVERSITY, BS CIVIL ENGINEERING

LICENSED PROFESSIONAL ENGINEER, MONTANA, 15676PE

CERTIFIED FLOODPLAIN MANAGER, AMFM, 26264

Mitch has over 20 years of experience in water resources engineering, specializing in river mechanics, and computational hydraulics with a focus on design optimization for hydraulic performance, ecosystem response and risk resilience. His comprehensive technical skill set has directly supported a range of diverse water resource engineering projects throughout the region including: flood hazard assessment and mitigation, hydrologic forecasting, bridge scour and river instability countermeasures, channel and floodplain restoration, dam removal and fish passage, irrigation intakes/screening, and closed conduit pumping/conveyance systems. Mitch is the technical lead for the RDG engineering team in Whitefish; his primary responsibility is the scoping, coordination and execution of analysis and design tasks including: site reconnaissance and terrain modeling, statistical analysis of hydrologic and hydraulic data, multidimensional hydrodynamic and sediment transport modeling, development of project plans and specifications, and preparation of supporting deliverables.

Selected Project Experience

Flathead River IFFA Study – Idaho

Working with the Kootenai Tribe of Idaho and Montana Fish Wildlife and Parks, RDG completed a comprehensive baseline evaluation to quantify the departure in second-order metrics of floodplain processes resulting from first-order changes in hydrology between historical and contemporary conditions. The study domain extended approximately 35 river miles between Hungry Horse Dam and Flathead Lake encompassing approximately 50 square miles of connected floodplain. Mitch developed a multi-step workflow and custom data processing tools to support the analysis, including: statistical evaluation of 17 hydrologic gages, United States Army Corps of Engineers CRT HEC-RAS model refinement and recalibration over a large flow range, calculation of synthetic hydrology, high resolution ($1m^2$) quasi-2D mapping of relevant floodplain hydraulics, and statistical analyses over temporal and spatial scales to compute IFFA departure metrics.

Kootenai River Habitat Restoration Project – Idaho

RDG assisted the Kootenai Tribe of Idaho with a comprehensive Master Plan focused on restoring aquatic habitat and ecosystem function for a 55 mile reach of the Kootenai River in northern Idaho by addressing limiting factors with multiple restoration treatments. Mitch developed engineering analyses and modeling to support baseline assessments for the 2009 Master Plan and subsequent design implementation phases. As RDG's technical lead for the design team, Mitch has completed multiple 2D hydrodynamic and sediment transport modeling analyses to support phased project design and implementation efforts since 2010.

Crooked River Valley Rehabilitation – Idaho

During 2013, RDG provided the United States Forest Service Nez Perce National Forest and Nez Perce Tribe with assessment and design services for addressing two miles of river valley impacted by dredge mining in north-central Idaho. As RDG's technical lead for the project, Mitch completed a hydrologic assessment and phased 1D/2D hydraulic

modeling to optimize the design components and corresponding hydraulic response for the proposed project and a multi-year construction flow bypass.

Recent Assessment Experience

- Bitterroot River Scour Assessment
- Blackfoot River Sediment Transport
- Bridger Creek Flood Hazard Assessment
- Calapooia River Flood Hazard Assessment
- Clark Fork River Sediment Transport
- Cottonwood Creek Fish Passage
- Flathead River Floodplain Study
- Kootenai River Sediment Transport
- Lolo Creek Hydraulic Assessment
- Ninemile Creek Hydraulic Assessment
- Rock Creek Hydraulic Assessment
- Ruby River Hydraulic Assessment
- Snake River Hydraulic Assessment
- Stillwater River Scour Assessment
- Twin Creek Hydraulic Assessment
- Upper Blackfoot Mining Complex Assessment
- Warm Springs Creek Reconnaissance
- Willamette River Levee Assessment
- Yellowstone River Flood Hazard Assessment

Restoration Design Experience

- Clark Fork River—Milltown Restoration
- Crooked River Restoration
- Granite Creek Egg-Take Facility Upgrade
- Jocko River Phase 2 Restoration
- Kootenai River Habitat Restoration
- Noxon Dam Fish Capture Facility

Appendix C – Catalog of King County Project Related Documents

Emplaced Wood Project
King County FTP Document Summary
Belmondo Revetment Enhancement Project

	Folder/File Name	File Date	Description
Belmondo Revetment Enhancement Project			
B-01	Belmondo_BOD_Final_July 23, 2014.pdf	09/18/14	Basis of Design Report, July 23, 2014; missing contents of all appendices, except E, F
B-02	BelmondoBODStamps.pdf	09/18/14	Cover page with engineer's stamps
B-03	Belmondo_BOD_Final_July 23, 2014_Full.pdf	11/01/14	Basis of Design Report, July 23, 2014; missing contents of 4 appendices (H, I, J, K)
B-04	FEMA Form 90-91.pdf	07/16/15	FEMA grant application
	Appendix A, Geotechnical Boring Reports		
B-05	KCDOT Belmondo 2008 Geotech Memo.pdf	03/19/12	Included in Belmondo_BOD_Final_July 23, 2014_Full.pdf
B-06	2010 Geotechnical Report by Perrone Consulting.pdf	11/10/14	Included in Belmondo_BOD_Final_July 23, 2014_Full.pdf
B-07	GeoEngineers Belmondo 2012 Geotech Report.pdf	03/16/12	Included in Belmondo_BOD_Final_July 23, 2014_Full.pdf
	Appendix B, Belmondo Risk Assessment		
B-08	Belmondo 2012 Risk Assessment Final.pdf	05/01/14	Included in Belmondo_BOD_Final_July 23, 2014_Full.pdf
	Appendix C, Belmondo Safety Review		
B-09	Belmondo Safety Review Meeting Memo.pdf	09/18/14	Included in Belmondo_BOD_Final_July 23, 2014_Full.pdf
	Appendix D, Flood Hazard Risk Assessment		
B-10	Flood_Hazard_Risk_Assessment.pdf	11/10/14	Included in Belmondo_BOD_Final_July 23, 2014_Full.pdf
	Appendix E, Hydrology and Hydraulics		
B-11	Probability Plot_USGS 12117600.png	01/03/14	Included in Belmondo_BOD_Final_July 23, 2014_Full.pdf
B-12	HEC RAS Results.xlsx	01/08/14	Included in Belmondo_BOD_Final_July 23, 2014_Full.pdf
B-13	FEMA cross-sections.pdf	03/25/14	Included in Belmondo_BOD_Final_July 23, 2014_Full.pdf
B-14	FIS Cross Section.png	04/30/14	Included in Belmondo_BOD_Final_July 23, 2014_Full.pdf
	Appendix F, Engineered Log Jam Calculations		
	<empty>		Included in Belmondo_BOD_Final_July 23, 2014_Full.pdf
	Appendix G, Roughness Wood Anchoring Calculations		
B-15	Appendix.pdf	11/10/14	Included in Belmondo_BOD_Final_July 23, 2014_Full.pdf
	Appendix H, Scour Apron Memorandum		
B-16	Belmondo 2013 Scour Apron Memo.pdf	01/13/14	scour apron memo
	Appendix I, Herrera Environmental Consultants 2010 Design Report		
B-17	Herrera Belmondo 2010 Design Memo.pdf	07/28/10	2010 design memo
	Appendix J, GeoEngineers 2012 Design Report		
B-18	GeoEngineers Belmondo 2012 Design Report.pdf	10/29/12	2012 design report
	Appendix K, Final Engineering Drawings for Construction		
B-19	Belmondo 2013 100% Record Drawings.pdf	11/10/14	2013 100% record drawings
	Monitoring Reports		
B-20	Belmondo_Report_040215_KA comments.docx	06/24/15	Fish and Aquatic Habitat Monitoring Report, April 2015; appears to be a work in progress
	Permits		
B-21	Belmondo SEPA Addendum 12-11-08.doc	12/11/08	SEPA Checklist addendum describing additional revetment repair project element not addressed in the original Checklist and DNS, dated 12/11/08
B-22	Belmondo DNS.pdf	11/07/11	2012 enhancement project Determination of Non-Significance (State Environmental Policy Act), dated 11/07/11
	Press Release		
B-23	CRT closure_v3.docx	07/22/15	June 13, 2013: Essential repair project leads to closure of 1/2-mile stretch of Cedar River Trail
B-24	09-20 - CRT closure news release lh.docx	07/22/15	September 20, 2013: Cedar River Trail to reopen Oct. 7 as County completes essential repair project
	Public Outreach Presentations		
B-25	Belmondo_Concept_2011.ppt	07/20/11	Belmondo Revetment Repair Phase 2; includes aerial photos/imagery from 1936, 1959, 1980, 1989, 1995, 2000, 2002, 2007, 2011
B-26	Belmondo_Presentation_2011.ppt	11/15/11	Belmondo Revetment Enhancement Project; includes project history, summary of 2012 project plans
B-27	Belmondo_Presentation_2012.ppt	04/24/12	Belmondo Revetment Enhancement Project; includes project history, summary of 2012 project plans, alternatives analysis, design changes
B-28	Belmondo_Presentation_Nov_2012.ppt	10/24/12	Belmondo Revetment Enhancement Project, 2012 Repair; includes project history, photos of 2012 repair work
B-29	Belmondo_LWD_May_2013 CRC Presentation.ppt	05/28/13	Belmondo Revetment Enhancement Project, 2013 Repair; includes photos from 2010 repair and 2012 project, as well as 2013 repair plans
B-30	Belmondo_LWD_November_2013.ppt	11/05/13	Belmondo Revetment Enhancement Project, 2013 Repair; includes project history, 2013 design process and alternatives analysis, photos of 2013 work

Emplaced Wood Project
Other Document Summary
Belmondo Revetment Enhancement Project

Doc#	File Name	File Date	Description
B-31	3rd Party Independent Review_Belmondo.pptx	07/27/15	PowerPoint presentation from 07/30/15 project kick-off meeting
B-32	3rd Party Independent Review_Belmondo.pdf	07/30/15	PDF of PowerPoint presentation from 07/30/15 project kick-off meeting
B-33	Belmondo Revetment Enhancement Project - King County.pdf	08/17/15	Project summary from King County website

Emplaced Wood Project
King County FTP Document Summary
Herzman Levee Repair

Folder/File Name	File Date	Description
Herzman Levee Repair		
H-01 2010.11 Mon Data Form-Herzman_JKo.pdf	07/20/15	project monitoring data form, 11/12/10
H-02 2011.10 Mon Insp Form-Herzman L.pdf	07/20/15	project monitoring data form, 10/05/11
H-03 FEMA, Firm, profile.pdf	07/22/15	FEMA FIRM (1995) profile data for transect AY
H-04 FW Large Wood Placement---public mtgs- date and times.msg	07/21/15	05/12/10 email: May 26, 2010 public meetings re: 2010 projects involving large wood placement in KC rivers and streams
H-05 FW Please forward LWD Projects Hertzman Levee Repair on the Cedar.msg	07/21/15	06/08/10 email: River Safety Council requesting additional information on the Herzman Levee Repair project
H-06 Herzman 1976.pdf	07/21/15	KC Dept. of Public Works construction plan drawing for Herzman Revetment (1976)
H-07 Herzman 2010 Repair Record Drawing.pdf	12/02/11	Record Drawing for Herzman Levee Repair (2010)
H-08 Herzman Aerial & Original Construction Plan.pdf	12/08/09	Original construction plan superimposed on aerial photo (not sure of photo date, maybe 2008)
H-09 Herzman Construction Lessons Learned 2.pdf	07/17/15	07/26/10 lessons learned memo: design or construction issues, property owner issues, construction techniques, permitting issues, construction planning, etc.
H-10 Herzman Easement 1.pdf	06/28/10	legal easement doc
H-11 Herzman Final Plan.pdf	06/28/10	final construction plans
H-12 Herzman HPA.pdf	06/28/10	project Hydraulic Project Approval (Washington Department of Fish and Wildlife)
H-13 Herzman Large Wood Documents.pdf	02/17/11	brief project description in form of County's Instream Project Checklist; email communications re: River Safety Council request for stacked or wall of bumper logs for inner tuber safety during higher flows
H-14 Herzman Large Wood Presentation 2015.ppt	07/22/15	PPT of project: record drawings of repair design, pictures before, during, and after construction
H-15 Herzman Large Wood Publilc Presentation 2010 Meetings.ppt	05/24/10	4-slide PPT; last slide is design drawing excerpts
H-16 Herzman Levee Repair Charter.pdf	07/17/15	project "scope of work" (various tasks, schedules, assumptions, etc.)
H-17 Herzman Project Handoff and Close-Out.pdf	07/16/15	memo recommending project closeout after completion
H-18 Herzman Rock Sizing.pdf	07/17/15	riprap rock sizing summary
H-19 Herzman Rock Sizing.xls	12/14/09	riprap rock sizing calculation spreadsheet
H-20 Herzman Shoreline Exemptiion.pdf	06/28/10	exemption from shoreline substantial development permit
H-21 Inspection Reports - Various.pdf	07/21/15	4 flood protection facility inspection forms (10/11/11, 12/20/10, 03/03/11, 06/17/13); 1 project/property maintenance and monitoring inspection form (03/01/10)
H-22 Large Wood input from Judith Fillips.pdf	06/23/10	letter from River Safety Council re: deflector or bumper logs height wrt flow for inner tuber safety (also in Large Wood Documents.pdf for related KC emails and response)
H-23 LWD project checklist for Herzman.pdf	07/16/15	County's Instream Project Checklist (also in Large Wood Documents.pdf for related KC emails and response)
H-24 RE Herzman Large Wood Public Input.msg	07/21/15	County's email discussion regarding RSC's letter (also in Large Wood Documents.pdf for related KC emails and response)
H-25 RE River Safety Council comments on Cedar River Flood Repair projects at Belmondo and Herzman.msg	07/21/15	follow-up email regarding County's response to RSC's letter
Photos\2010 Construction		
H-26 IMGP1278.JPG	07/15/10	2010 project construction photos
H-27 IMGP1279.JPG	07/15/10	
H-28 IMGP1281.JPG	07/15/10	
H-29 IMGP1284.JPG	07/15/10	
H-30 IMGP1288.JPG	07/15/10	
H-31 IMGP1290.JPG	07/15/10	
H-32 IMGP1291.JPG	07/15/10	
H-33 IMGP1292.JPG	07/15/10	
H-34 IMGP1294.JPG	07/15/10	
H-35 IMGP1296.JPG	07/15/10	
H-36 IMGP1302.JPG	07/16/10	
H-37 IMGP1303.JPG	07/16/10	
H-38 IMGP1315.JPG	07/16/10	
H-39 IMGP1317.JPG	07/16/10	
H-40 IMGP1319.JPG	07/19/10	
H-41 IMGP1323.JPG	07/19/10	
H-42 IMGP1325.JPG	07/19/10	
H-43 IMGP1332.JPG	07/20/10	
H-44 IMGP1334.JPG	07/20/10	
H-45 IMGP1335.JPG	07/20/10	
H-46 IMGP1336.JPG	07/20/10	
H-47 IMGP1355.JPG	07/20/10	
H-48 IMGP1368.JPG	07/21/10	
Photos\June2011		
H-49 Copy of IMGP1663.JPG	06/17/11	2011 post-construction project photos
H-50 Copy of IMGP1668.JPG	06/17/11	
H-51 Copy of IMGP1669.JPG	06/17/11	
H-52 IMGP1664.JPG	06/20/11	

Emplaced Wood Project
Other Document Summary
Herzman Levee Repair

Doc#	File Name	File Date	Description
H-53	Herzman Large Wood Presentation 2015.ppt	07/28/15	PowerPoint presentation from 07/28/15 project kick-off meeting
H-54	Herzman Large Wood Presentation 2015.pdf	07/28/15	PDF of PowerPoint presentation from 07/28/15 project kick-off meeting
H-55	synthesis-of-2013-river-recreation-studies-Oct2014-report-only.pdf	08/17/15	Summary of studies of rec use of rivers in King County
H-56	Herzman Levee Setback and Floodplain Reconnection Project - King County.pdf	08/17/15	Project summary from King County website
H-57	RentonSMP_Inventory.pdf	08/17/15	shoreline inventory and characterization for City of Renton

Emplaced Wood Project
King County FTP Document Summary
Reddington Levee Setback and Extension

Folder/File Name		File Date	Description
Reddington Levee Setback and Extension			
R-01	Reddington Levee Setback and Ext readme.docx	07/23/15	brief info summary for 3rd party review re: site management plan, baseline documentation, inspections and monitoring, adaptive management
R-02	ReddingtonFeasReport-FINAL-CompleteReport corrected ES-7.pdf	04/03/12	Reddington Levee Setback and Extension Feasibility Report (November 2011)
	Basis of Design		
R-03	Basis of Design_2013-04-09_Final.pdf	04/10/13	Basis of Design Report (April 2013)
R-04	Memo NHC Levee Protection Basis Fish Habitat Final v2.pdf	04/04/13	01/16/13 contractor memo re: Erosion Protection Basis of Design Fish Habitat Considerations (not part of BoD Report)
R-05	NHC Tacoma Water Pipeline memo v2_121712.pdf	12/17/12	12/17/12 contractor memo re: Basis of Design for Erosion Protection of the Tacoma Water Pipeline (not part of BoD Report)
	Drawings		
R-06	REDDINGTON LEVEE EXT DRAWINGS 11x17 signed_061114.pdf	06/16/14	Design drawing set for levee extension
R-07	ReddingtonSetbackLevee drawings signed.pdf	04/05/13	Design drawing set for levee setback
	Public Outreach		
R-08	Reddington Large Wood Placement Meeting 062712.pptx	06/27/12	briefing PPT for 06/27/12 Large Wood Placement Mtg
R-09	Reddington Large Wood Website Info.xlsx	06/20/12	brief descriptive info for project website
R-10	Reddington mtg with RME homeowners final 20120509.pptx	05/09/12	briefing PPT for 05/9/12 open house for River Mobile Estates Homeowners' Association
R-11	Redd-Open House annotated agenda and presentation materials to do list.docx	10/30/12	11/13/12 open house annotated agenda and presentation materials to-do list
	SEPA		
R-12	Reddington Notice of Action.pdf	06/17/13	12/14/12 notice of action following SEPA DNS
R-13	Reddington SEPA DNS.pdf	08/15/12	08/15/12 SEPA Determination of Non-Significance (note: SEPA checklist not part of materials provided by the County)

Emplaced Wood Project
Other Document Summary
Reddington Levee Setback and Extension

Doc#	File Name	File Date	Description
R-14	3rd Party Emplaced Wood Review Mtg Reddington Presentation_July2015.pptx	07/28/15	PowerPoint presentation from 07/28/15 project kick-off meeting
R-15	3rd Party Emplaced Wood Review Mtg Reddington Presentation_July2015.pdf	07/28/15	PDF of PowerPoint presentation from 07/28/15 project kick-off meeting
R-16	2014-Reddington-Year-1-Monitoring-Report.pdf	08/12/15	Reddington Levee Setback Project Year 1 Monitoring Report (December 29, 2014)
R-17	reddington-habitat-monitoring-plan-addendum-Nov2013	08/12/15	Addendum to Reddington Levee Setback Habitat Monitoring Plan, Green River, RM 28.2 to 29.5 (November 20, 2013)
R-18	reddington-habitat-monitoring-plan-april2013.pdf	08/12/15	Reddington Levee Setback Habitat Monitoring Plan, Green River, RM 28.2 to 29.5 (April 16, 2013)
R-19	King County Flood Control District to begin Reddington levee replacement project this year - Auburn Reporter.pdf	08/14/15	Auburn Reporter: King County Flood Control District to begin Reddington levee replacement project this year (January 24, 2013, updated January 29, 2013)
R-20	Reddington Levee Setback Project - King County.pdf	08/14/15	website: County's description of the project (last updated June 25, 2015)

Emplaced Wood Project
King County FTP Document Summary
Upper Carlson Floodplain Restoration Project

Folder/File Name	File Date	Description
Upper Carlson Floodplain Restoration Project		
0.1 Project Summary		
C-001 Detailed risk management Gannt 082713.xlsx	07/22/15	chronology of risk assessment and design process
C-002 Project Website.docx	07/21/15	URL for project website
C-003 Upper Carlson Project Summary 1_20_15.docx	01/30/15	brief summary of project (description, location, goals & objectives, milestones, County PM contact info, picture)
C-004 Vicinity Map.docx	05/05/14	project vicinity map
1 Site Management Plans		
C-005 Upper Carlson Site Management Plan to WDFW 020514.pdf	05/01/14	draft site management plan (02/05/14)
C-006 Upper Carlson Site Mgmt Plan 030915.docx	03/09/15	(final?) site management plan (03/15)
2 Baseline Photos		
2 Baseline Photos\As-built		
C-007 IMG_1329.JPG	11/07/14	on-the-ground bank shot
C-008 IMG_1330.JPG	11/07/14	on-the-ground bank shot
C-009 IMG_1333.JPG	11/07/14	on-the-ground bank shot
C-010 IMG_1337.JPG	11/07/14	on-the-ground bank shot
2 Baseline Photos\As-built\As-built Aerials\Nov 2014 aerial photos by Ned		
C-011 1014CarlsonReachSnoqRvr052.jpg	11/04/14	aerial view via helicopter
C-012 1014CarlsonReachSnoqRvr074.jpg	11/04/14	aerial view via helicopter
C-013 1014CarlsonReachSnoqRvr075.jpg	11/04/14	aerial view via helicopter
C-014 1014CarlsonReachSnoqRvr080.jpg	11/04/14	aerial view via helicopter
C-015 1014CarlsonReachSnoqRvr082.jpg	11/04/14	aerial view via helicopter
C-016 1014CarlsonReachSnoqRvr083.jpg	11/04/14	aerial view via helicopter
2 Baseline Photos\photos take outs and put ins us to ds 5-22-14		
2 Baseline Photos\photos take outs and put ins us to ds 5-22-14\1 PSE power house		
C-017 boat access 1.JPG	01/01/08	boat access road at power house below Snoqualmie Falls
C-018 boat access 2.JPG	01/01/08	boat access road at power house below Snoqualmie Falls
C-019 boat access 3.JPG	05/22/14	boat access signage at power house below Snoqualmie Falls
C-020 boat access 4.JPG	05/22/14	boat access signage at power house below Snoqualmie Falls
C-021 boat access 5.JPG	05/22/14	boat access signage at power house below Snoqualmie Falls
C-022 boat access 6.JPG	01/01/08	boat access signage at power house below Snoqualmie Falls
C-023 boat access 7.JPG	01/01/08	boat access at power house below Snoqualmie Falls
C-024 boat access 8.JPG	01/01/08	boat access at power house below Snoqualmie Falls
C-025 boat access 9.JPG	01/01/08	boat access road at power house below Snoqualmie Falls
C-026 entrance.JPG	01/01/08	powerhouse park entrance
C-027 P1010024.JPG	05/22/14	powerhouse park signage
C-028 P1010025.JPG	05/22/14	powerhouse park signage
C-029 P1010026.JPG	01/01/08	powerhouse park signage
C-030 P1010036.JPG	01/01/08	powerhouse
C-031 P1010038.JPG	01/01/08	upper power structure and pipelines to powerhouse
C-032 P1010039.JPG	01/01/08	powerhouse
C-033 P1010040.JPG	01/01/08	powerhouse
C-034 PSE skematic map.JPG	01/01/08	local access map
2 Baseline Photos\photos take outs and put ins us to ds 5-22-14\2 Plum 1 - Tokul Cr		
C-035 parking lot north side.JPG	01/01/08	signage in parking lot (litter)
C-036 parking lot sign 1.JPG	01/01/08	signage at Sani cans
C-037 parking lot sign 2.JPG	01/01/08	signage
C-038 parking lot sign 3.JPG	05/22/14	signage (access pass/permit required); close-up of #2
C-039 parking lot sign 4 again.JPG	01/01/08	signage (hazardous waters)
C-040 parking lot sign 4.JPG	01/01/08	signage (possible presence of ESA-listed salmon & steelhead)
C-041 parking lot sign 6.JPG	01/01/08	signage; close-up of #2
C-042 tokul sign n of road 1.JPG	01/01/08	signage - historical info
C-043 tokul sign no of road 2.JPG	01/01/08	entrance
2 Baseline Photos\photos take outs and put ins us to ds 5-22-14\3 along river between Plum 1 and Plum 2		
C-044 P1010041.JPG	01/01/08	on-the-ground river shot
C-045 P1010042.JPG	01/01/08	on-the-ground river shot
C-046 P1010043.JPG	01/01/08	on-the-ground river shot
C-047 P1010044.JPG	01/01/08	on-the-ground river shot
2 Baseline Photos\photos take outs and put ins us to ds 5-22-14\4 Plum 2		
C-048 P1010001.JPG	01/01/08	parking lot
C-049 P1010002.JPG	01/01/08	parking lot

Emplaced Wood Project
King County FTP Document Summary
Upper Carlson Floodplain Restoration Project

Folder/File Name		File Date	Description
C-050	P1010003.JPG	01/01/08	parking lot; includes main entry sign
C-051	P1010004.JPG	01/01/08	parking lot
C-052	P1010005.JPG	01/01/08	signage (closed at dark; ESA salmon & steelhead)
C-053	P1010006.JPG	01/01/08	signage (access pass/permit required)
C-054	P1010007.JPG	01/01/08	signage, main entry sign; close-up
C-055	P1010008.JPG	01/01/08	signage; close-up on main entry sign re: tuber safety
C-056	P1010009.JPG	01/01/08	signage (trail litter/cleanup)
C-057	P1010010.JPG	01/01/08	trash cans
C-058	P1010011.JPG	01/01/08	signage (dangerous river warning)
C-059	P1010012.JPG	01/01/08	access ramp
	2 Baseline Photos\photos take outs and put ins us to ds 5-22-14\5 Fall City Community Park RB		
C-060	P1010045.JPG	01/01/08	park area
C-061	P1010046.JPG	01/01/08	left side descriptive signage re: habitat restoration project
C-062	P1010047.JPG	01/01/08	right side descriptive signage re: habitat restoration project
C-063	P1010048.JPG	01/01/08	signage (dangerous river warning)
C-064	P1010049.JPG	01/01/08	trail
C-065	P1010050.JPG	01/01/08	back side (?) of new (?) sign kiosk
	2 Baseline Photos\Pre-Project\May 28 3680 cfs at Carnation		
C-066	IMG_3735.JPG	05/29/14	on-the-ground bank shot
C-067	IMG_3736.JPG	05/29/14	on-the-ground bank shot
C-068	IMG_3737.JPG	05/29/14	on-the-ground bank shot
C-069	IMG_3738.JPG	05/29/14	on-the-ground bank shot
C-070	IMG_3739.JPG	05/29/14	on-the-ground bank shot
C-071	IMG_3740.JPG	05/29/14	on-the-ground bank shot
C-072	IMG_3741.JPG	05/29/14	on-the-ground bank shot
C-073	IMG_3742.JPG	05/29/14	on-the-ground bank shot
C-074	IMG_3743.JPG	05/29/14	on-the-ground bank shot
C-075	IMG_3744.JPG	05/29/14	on-the-ground bank shot
C-076	IMG_3745.JPG	05/29/14	on-the-ground bank shot
C-077	IMG_3746.JPG	05/29/14	on-the-ground bank shot
	3 100% Plans		
C-078	Upper Carlson 100% Plans to Procurment 030414.pdf	03/03/14	final design plan sheets
	4 a Basis of Design		
C-079	FINAL Basis of Design-Upper Carlson from HEC 2014 05 02.pdf	05/05/14	Basis of Design Report
C-080	Risk Register Upper Carlson FINAL updated 121014.xlsx	01/20/15	Risk analysis spreadsheet: risk (incl. probability/impact), evaluation methods, mgmt options, mitigations, mitigated probability/impact, long-term risk with adaptive mgmt
	4 b Interim results from rec use study 092413		
C-081	2013 River Recreation Study web page.msg	03/09/15	03/09/15 email re: permanent link for County's 2013 River Recreation Study
C-082	FW King County River Recreation Study - summary statistics.msg	09/24/13	07/25/13 email re: summary statistics from the Snoqualmie field observations to date, current version of fieldwork log
C-083	Lower Snoq River Rec Study - summary findings 9-30-13.xls	10/01/13	Snoqualmie field observations from 2013 river recreation study
C-084	Number of Observation Days by Site.pdf	08/19/13	figure: Snoqualmie - Total Number of Observation Days by Site as of August 11, 2013 for the King County River Recreation Study, King County, Washington
C-085	Observations by Day of Week.pdf	08/19/13	figure: Snoqualmie - Observations on Weekends and Weekdays as of August 11, 2013 for the King County River Recreation Study, King County, Washington
C-086	Snoqualmie field observations - sites_by_day.pdf	08/19/13	table: Snoqualmie - number of groups by location by date
C-087	Total Observations.pdf	08/19/13	figure: Snoqualmie - Total Observation Counts as of August 11, 2013 for the King County River Recreation Study, King County, Washington
C-088	Total People and Age Break-Downs.pdf	08/19/13	figure: Snoqualmie - Total People Observed and Age Categories as of August 11, 2013 for the King County River Recreation Study, King County, Washington
	4 c Wavetrek 30% evaluation of wood design		
	4 c Wavetrek 30% evaluation of wood design\Deliverable		
C-089	Wave trek Project Safety Review.docx	07/01/13	safety review of project at 30% design, completed by Ryan Murphy, Wave Trek Rescue
	5 As-Built Drawings		
C-090	AS-built drawing from Roads CMI group 112014.pdf	11/20/14	project as-built drawing set (appear to be red pencil mark-ups of final design drawings)
	6 Monitoring		
C-091	042415 Jet boat Inspection with Sherriff.MOV	04/27/15	4.25-minute video of 04/24/25 right bank inspection (voice ID's marker #s 17 down to 1)
C-092	FloodVideo_Jan05_2015.wmv	03/12/15	1-minute composite video (time-lapse photos and video) of January 2015 flooding
C-093	uc app 1 4-24-15_20150428154828.pdf	04/28/15	hand-written visual inspection form completed for 4/24/15 inspection (see Upper Carlson Inspection 4-24-15.docx)
C-094	Upper Carlson Bank Retreat and Habitat photos 042815.pdf	04/28/15	bank retreat and habitat formation after two floods
C-095	Upper Carlson Inspection 4-24-15.docx	04/28/15	typed visual inspection form completed for 4/24/15 inspection (see uc app 1 4-24-15_20150428154828.pdf)
C-096	Upper Carlson Inspection data and write up.msg	04/27/15	04/27/15 email: inspection data and write-up (hazard assessment, geomorphic assessment, habitat assessment, public relations)
C-097	Upper Carlson Response presentation.pptx	06/23/15	brief analysis of change since project: hydrologic, bank retreat, sediment movement, floodplain, large wood budget/mobility
C-098	UpperCarlson_MM_Plan_March04-2015.docx	03/04/15	monitoring and maintenance plan (03/04/15)
	7 a Boater Safety Outreach		
C-099	CONTACT LIST Recreational Safety Focus Group.xlsx	06/16/14	Snoqualmie at Fall City (SAFC) River Recreation Safety Work Group (contacts for 09/19/14 meeting; and others not contacted)

Emplaced Wood Project
King County FTP Document Summary
Upper Carlson Floodplain Restoration Project

Folder/File Name		File Date	Description
C-100	FINAL Survey Results Summary 11-19-13.docx	11/27/13	survey results for site management plan (dated 10/17/13)
C-101	Response to rec concerns.docx	07/22/15	input/concerns received and responses, including actions taken or discussed, remaining concerns
C-102	SMP handout 11-19-13 work group final.docx	11/19/13	draft Site Management Plan handout for 11/19/13 RRSWG meeting
C-103	Snoqualmie River RecreationGroup Framework 9-19-13.doc	09/19/13	RRSWG framework (09/19/13 draft)
C-104	Upper Carlson Site Management Plan 043014 workgroup.pdf	05/05/14	draft Site Management Plan (02/14)
	7 a Boater Safety Outreach\Agendas, presentations and notes from meetings		
C-105	Agenda Recreational Safety Mtg 1.doc	08/12/13	RRSWG 08/21/13 meeting agenda
C-106	Agenda Recreational Safety Mtg 2 10-2-2013.doc	10/02/13	RRSWG 10/02/13 meeting agenda
C-107	Agenda Recreational Safety Mtg 9-19-13.doc	09/18/13	RRSWG 09/19/13 meeting agenda
C-108	AgendaSafety Mtg 3 11-19-2013.doc	11/19/13	RRSWG 11/19/13 meeting agenda
C-109	Notes Safety Work Group 3.docx	11/19/13	11/19/13 RRSWG meeting notes
C-110	NOTESSafety meeting #2 10-2-2013.docx	10/15/13	10/02/13 RRSWG meeting notes
C-111	NotesSafety meeting 9-19-13mm.docx	09/30/13	09/19/13 RRSWG meeting notes
C-112	SIGN IN Meeting # 2 10-2-2013.xlsx	10/02/13	sign-in sheet for 10/02/13 RRSWG meeting
C-113	SIGN IN Meeting #1 9-19-2013.xlsx	10/02/13	sign-in sheet for 09/19/13 RRSWG meeting (attendees identified)
	7 a Boater Safety Outreach\Comments from Safety Group		
C-114	Bullet summary of 60% checklist updates 111813.docx	11/18/13	summary of 60% LWD checklist updates
C-115	Bullet summary of RSC concerns raised 111813.docx	11/18/13	RSC (River Safety Council) concerns
C-116	From Judy philllips July 24th 2013.docx	09/27/13	09/24/13 email text from Judy Fillips (RSC) with design questions
C-117	King Co. Ordinance 16581 7-10-09 from RSC.pdf	09/27/13	PDF of King County Ordinance 16581
C-118	Martha Parker recieved 092313.doc	09/23/13	"observations, concerns, and recommendations" for project from Martha Parker
C-119	Mike graijalva 092313.docx	09/23/13	09/22/13 email from Mike Grijalva with comments on project
C-120	Snoq Upper Carlson 1-23-14 letter from Judy.pdf	02/28/14	01/23/14 letter from RSC (Judy Fillips) re: clarification of RSC policies, inquiry re: proposed mitigation for safety issues
C-121	Snoq Upper Carlson 9-27-13 from RSC.pdf	09/27/13	09/27/13 letter from RSC (Judy Fillips) re: comments on 30% design
	7 a Boater Safety Outreach\Presentations		
C-122	Boater meeting #2 SMP discussion.pdf	01/30/15	PDF of slides from Boater meeting #2 SMP discussion.pptx
C-123	Boater meeting #2 SMP discussion.pptx	10/02/13	PowerPoint slides for 10/02/13 (?) boater meeting re: site management plan
C-124	Boater meeting #3 Design Update and SMP discussion 111913.pdf	01/30/15	PDF of slides from Boater meeting #3 Design Update and SMP discussion 111913.pptx
C-125	Boater meeting #3 Design Update and SMP discussion 111913.pptx	11/19/13	PowerPoint slides for 11/19/13 boater meeting re: design update SMP
C-126	Wood and boater meeting #1 091913.pdf	01/30/15	PDF of slides from Wood and boater meeting #1 091913.pptx
C-127	Wood and boater meeting #1 091913.pptx	09/24/13	PowerPoint slides for 09/19/13 wood and boater meeting
	7 a Boater Safety Outreach\Responses to Safety Group		
C-128	Response to Judy Fillips and RSC 111913.pdf	11/19/13	11/19/13 letter responding to 09/27/13 comments from RSC (Judy Fillips)
C-129	Response to Martha Parker 111913.pdf	11/19/13	11/19/13 letter responding to 09/23/13 comments from Martha Parker
	7 a Boater Safety Outreach\SEPA comments		
C-130	2013 SVPA response to Carlson Project from Erick Haackenson 100913.docx	10/09/13	Snoqualmie Valley Preservation Alliance comments on project's SEPA Determination of Non-significance
C-131	Carlson Floodplain Restoration Letter from Ian Macrae 100913.doc	10/09/13	Ian Macrae comments on project's SEPA DNS
C-132	Dans response to Ian and Erick 103013.pdf	10/30/13	County project PM's responses to SVPA and Ian Macrae comments
C-133	Snoqualmie Comment Letter 100913.pdf	10/09/13	Snoqualmie Tribe comment letter
	7 b LWD Checklist		
C-134	Final 30% LWD Checklist for Website 082813.pdf	08/28/13	County Instream Project Checklist for 30% design
C-135	Upper Carlson LWD Instream Checklist 60% updated 012915 with post construction inspection info.pdf	01/30/15	County Instream Project Checklist for 60% design, updated with design changes to 60% plans
	8 Adaptive Management, Press Releases, Risk Notification		
C-136	Final Kiosk.pdf	03/05/15	final kiosk sign at project site?
	8 Adaptive Management, Press Releases, Risk Notification\River Closure During Construction		
C-137	Closure language fm Sheriff.msg	05/12/14	05/09/14 email with press release from Sheriff's Office re: river closure for construction
C-138	Final Press 051214.docx	05/12/14	05/08/14 County press release regarding project, river closure (final)
C-139	River Closure May '14.doc	05/09/14	press release attached to 05/09/14 email
C-140	upper carlson.docx	05/09/14	05/08/14 County press release regarding project, river closure (no difference from final?)
	8 Adaptive Management, Press Releases, Risk Notification\River Closure During Construction\Sheriff patrols		
	<empty>		
	8 Adaptive Management, Press Releases, Risk Notification\River Closure During Construction\SIGN		
C-141	9021550_2x2_signs.pdf	03/04/15	river closure sign design (2' x 2')
C-142	9021550_4x4_Parks_signs.pdf	03/04/15	Fall City Natural Area closure sign designs (4' x 4')
C-143	9021550_4x4_signs.pdf	03/04/15	river closure sign designs (4' x 4')
C-144	ClosureSigns_v2.jpg	05/14/14	closure sign locations on aerial image
C-145	Parks signs language.docx	05/20/14	text for Fall City Natural Area closure signs
C-146	qrcode.22528018.png	05/23/14	QR code (for FCNA closure signs)
C-147	ReOpen Snoq River.doc	03/04/15	08/08/14 press release for re-opening of river
C-148	snoqRIVsignage(v2).pdf	03/04/15	river safety sign

Emplaced Wood Project
King County FTP Document Summary
Upper Carlson Floodplain Restoration Project

	Folder/File Name	File Date	Description
	Supplemental Information		
C-149	Snoqualmie at Fall City Feasibility Report FINAL FINAL 081511.pdf	08/17/11	Snoqualmie at Fall City Reach Restoration Assessment (08/11)
C-150	Upper Carlson Alternative Analysis 041513 FINAL.docx	04/11/13	03/25/13 project alternatives analysis
	Supplemental Information\General Project Outreach		
C-151	Agenda Fall City Reach Public Meeting8-28-13v2.docx	08/12/13	08/28/13 project update public meeting (draft version?)
C-152	Agenda Upper Carlson Public Meeting.docx	08/28/13	08/28/13 project update public meeting (final version?)
C-153	Aug 28 sign in sheet upper carlson.xlsx	09/27/13	08/28/13 project update public meeting sign-in sheet
C-154	Detailed risk management Gannt 082713.xlsx	08/27/13	chronology of risk assessment and design process
C-155	FINAL Media Release Public meeting for 8-28.docx	08/19/13	08/19/13 final version of press release for 08/28/13 public meeting
C-156	FINAL Public Outreach Plan_Upper Carlson 1-7-13.doc	03/09/15	01/08/13 public outreach plan
C-157	Notes from the August 28 2013 UC public meetingmm.docx	09/30/13	08/28/13 project update public meeting notes
C-158	Upper Carlson Public meeting 082813 final 082613.pptx	08/28/13	08/28/13 project update public meeting PowerPoint
C-159	Upper Carlson Public meeting invite list working.xlsx	08/26/13	08/28/13 project update public meeting invitation list

Note: Files in the folder **Upper Carlson Floodplain Restoration Project\4 c Wavetrek 30% evaluation of wood design\Work Order Documents** were not provided to Expert Panel members due to the potentially sensitive contracting nature of the documents.

Emplaced Wood Project
Other Document Summary
Upper Carlson Floodplain Restoration Project

Doc#	File Name	File Date	Description
C-160	Upper Carlson 3rd Party LWD Review with DE edits 072715.pptx	07/28/15	PowerPoint presentation from 07/28/15 project kick-off meeting
C-161	Upper Carlson 3rd Party LWD Review with DE edits 072715.pdf	07/28/15	PDF of PowerPoint presentation from 07/28/15 project kick-off meeting

Appendix B

Independent Expert Panel Site Visit Field Reports

Parametrix
ENGINEERING . PLANNING . ENVIRONMENTAL SCIENCES

719 2ND AVENUE, SUITE 200 | SEATTLE, WA 98104 | P 206.394.3700

MEMORANDUM

DATE:	September 8, 2015
TO:	Monica Walker, King County Water and Land Resources Division
FROM:	Kristie Casarez, PE
SUBJECT:	General Field Observations for Emplaced Wood Project Review
CC:	Project File
PROJECT NAME:	Emplaced Wood Project Review

Parametrix (Consultant Lead) is supporting King County's ongoing monitoring and evaluation of Water and Land Resources Division (WLRD) projects in King County rivers that include emplaced wood and were designed and constructed after 2010 when Public Rule LUD-12 PR was adopted. The Consultant Lead assembled an independent panel to serve in the capacity of third-party provider, comprised of the following specialists.

- Civil Engineer: Mitch Price, PE, CFM – River Design Group, Inc.
- Fisheries Biologist: Kelly Burnett, PhD – U.S. Forest Service Pacific Northwest Research State (retired)
- Geomorphologist: Stephen Lancaster, PhD – Professor at Oregon State University
- River Recreational Safety Specialist: Dan Hudson – Rescue 3 International

Of the 15 completed projects since the public rule was adopted, four were selected to serve as representative sample locations:

- Upper Carlson Floodplain Restoration
- Herzman Levee Repair
- Belmondo Revetment Enhancement
- Reddington Levee Setback and Extension

The panel and Consultant Lead visited each of the four sites between August 24 and 26, 2015. The purpose of this memorandum is to provide King County with initial observations from the four projects.

UPPER CARLSON FLOODPLAIN RESTORATION

On Monday, 8/24/2015 (2:00PM), the Independent Panel attended a site walk to observe the constructed project with the King County Project Manager, Dan Eastman. The Panel provided the following field observations:

- The project intent appears to be a very positive one, with reactivation of the right-bank floodplain (via de-armoring) and providing additional right-bank erosion protection at the downstream end of the project site (i.e., the 'Catcher's Mitt/Thumb') to protect Neal Road.
- The 'Catcher's Mitt/Thumb' at the downstream end may maintain the existing a pinch point, thus potentially lending to additional erosion on the left bank (downstream of the project), which might require subsequent mitigation through possible adaptive management measures.
- Channel shaping of the thalweg and pointbar downstream of the project might be considered as a future project to redirect flow and adjust the pinch point. Note: The Panel does not believe that the project created the pinch point, but that the flow vectors are unknown and unpredictable.

- Based on the initial observations, the river is expected to develop bends naturally over time, rather than through one large event. Predicted maximum magnitude of bank erosion versus time is based on historical migration rates and is therefore at least approximately correct, with the caveat that the timing of large events is unpredictable, and the frequency of high-flow events may increase over time due to urbanization and climate change (more precipitation as rain, less as snow, for example). However, the predicted pattern of bank erosion seems inconsistent with typical meander wavelengths elsewhere on the river. Based on those wavelengths, the development of two bends within the project reach seems more likely.
- The project appears to allow the channel to widen without lots of meandering, with 'stop points' along Neal Road through the placement of ELJs. The river is, in the geomorphologist's opinion, unlikely to engage the stop points along the road in the next 10 years or so. However, given the existing, abandoned channel adjacent to the road, construction of those stop points was prudent, even if for no other reason than to address the potential concerns of property owners.
- The project is accomplishing in-channel migration without getting into the channel itself, by creating 'soft areas' to promote migration and adjacent bed development.
- The project is creating potential for increased bank complexity (compared to existing conditions) and should increase as the channel continues to migrate back toward the placed wood. Note: This is difficult to determine today based on current stage of project.
- The project does appear to provide flood hazard reduction based on the general premise of increasing conveyance area and floodplain connectivity as the right channel bank migrates. A flood hazard consideration are the upstream side channel inlet (near station 0+00) and the other right bank notches, which were anecdotally reported to have generated some unsteady flooding patterns (related to how overbank flow was routed onto and over the floodplain) during the January 2015 flooding event. Although the notches are small, it appeared that they may allow flow to enter the floodplain depending upon the river stage and tailwater. The January 2015 flooding patterns may not necessarily be related to the right bank notches or the side channel inlet near station 0+00. The relationship between these structures and flooding patterns could be evaluated using the design hydraulic model to develop rating curves for floodplain connections to the main channel.
- Another minor flooding consideration is that as the channel widens and the local sediment contribution is routed it may "lag" and temporarily deposit above the existing pinch point near the downstream end of the project coincident with the existing lateral bar. Depending on magnitude and configuration of the deposition, local water surface elevations may be increased upstream (albeit slightly).
- Habitat: The young willows appear to already be capturing some of the naturally recruited wood; removal of knotweed and other clearings provide better environment for woody vegetation; small fish were observed along/close to the bank.
- Safety: As the channel widens, the deposition of gravel/rock along the left bank would be expected to provide additional areas of lower velocity, maintaining a "safe passage" route for recreational use, both as an exit point for floaters/tubers and to provide surface for anglers. In addition, 'information and management activities' occurring with a local business upstream of the project site are expected to reduce the likelihood of unplanned tubers/floaters in this reach of the river. Clearly worded warning signs are placed at prominent locations throughout the project reach.
- See Attachment 1 for additional notes and sketches and Attachment 2 for site photographs.

HERZMAN LEVEE REPAIR

On Tuesday, 8/25/2015 (9:30AM), the Independent Panel attended a site walk to observe the constructed project with the King County Project Manager, Wes Kameda. The Panel provided the following initial observations:

- A benefit of observing the structure under lower flows was the ability to view more of the placed structure(s) and have better access to the site.

- Emplaced wood along the right bank was originally planned for the entire levee; however, only one (1) location was constructed at a point where the rock was in need of repair. The wood was placed in a location that appeared to be the 'least hazardous' location to recreational users at the downstream end of the revetment. Design elements of the emplacement included two protruding logs and four bumper logs with a stepped rock toe to address potential for undercut formation.
- The upstream rock appears to have changed the flow vector away from the bumper logs. The rock is sitting where the flow is now swiftest, and high flows seem most likely to exert the greatest near-bank shear stresses. The rocks may promote dissipation of those stresses upstream of the logs.
- While repairing the revetment, there was an opportunity to think 'out of the box' by leaving the smaller rock (from damaged revetment) as a design element that provided increased near-bank roughness as a channel feature.
- If water levels rose above the top of the levee, it would 'scoop out' the top and back of the levee (rock only on the face of the levee).
- Habitat restoration measures (placed willows) appear to be surviving quite well and providing shading along the embankment.
- Fish were not observed during the visit, but field observations found some roughness, but not found to be intrinsically a good habitat for fish and would not be anticipated to be improved during higher flows.
- Signage for recreation use was at the entrance of the walking trail, and would very likely not be seen by floaters/tubers who accessed the site upstream.
- Recreational flows are closer to a 2-year event and would put the water level at the mid-point of the placed logs (5-year event would place the water level above the logs).
- See Attachment 1 for additional notes and sketches and Attachment 2 for site photographs.

BELMONDO REVETMENT ENHANCEMENT

On Tuesday, 8/25/2015 (1:00PM) the Independent Panel attended a site walk to observe the constructed project with the King County Project Manager, Mason Bowles The Panel provided the following initial observations:

- The floodplain on the right bank did not currently appear engaged due to low flows, but may also not engage for low return period flows. Construction of one or more meander cutoff channels with emplaced wood to protect against avulsion potential could be implemented for additional rearing habitat creation; and would divert some flow away from the revetment to provide indirect bank protection through near-bank stress reduction. This could be considered for a future adaptive management strategy.
- The downstream structure appears to be in the hydraulic shadow of the 2013 upstream ELJs. This seems to have reduced the potential for scour at the downstream barb, which lacks a pool feature.
- The project appeared to achieve near bank roughness, with fine sediment deposition observed during the low flow conditions.
- Active side channels appear to be forming along the left bank, creating a potential for increased habitat.
- Diversity was observed in salmonid life stages associated with structures and mid-channel bars (eddy along river bottom creating pools).
- Vegetative geogrids appear to be functioning (provide bank stabilization via growth media retention), although the upstream barb may have made stabilization largely unnecessary.
- Vegetation in the drip-tape irrigated sections appears to be responding better than in the non-irrigated sections.
- River recreational safety: Large signage found upstream of the project to warn users; and bumper logs appear to be deflecting current flow vector and would sweep recreational users away from the structures; safety chains along embankment do not appear to be maintained and were partially damaged/taken down in some areas.
- Anchoring of wood appear to be intact and solid, with exception of possible broken/missing chain, but the log had three additional anchor points along the structure.

- There is some concern with the two upstream root wads engineered into the upper structure just below the waterline below the lower of the two bumper logs. At the extreme low water levels currently being experienced, these root wads would extend into the safe swimming space the bumper logs are designed to provide.
- See Attachment 1 for additional notes and sketches and Attachment 2 for site photographs.

REDDINGTON LEVEE SETBACK AND EXTENSION

On Wednesday, 8/26/2015 (9:30AM) the Independent Panel attended a site walk to observe the constructed project with the King County Project Manager, Eric Peters. The Panel provided the following initial observations:

- The project required addressing multiple urban constraints, including contaminated soils, residential relocation, and a stormwater pump station intake.
- The placed wood was set back (closer to the new setback levee), designed to engage at higher flows when recreation use is anticipated to be lower (thus reducing risk).
- Barbs were designed to be tapered to engage at different flows and redirect the flow to the opposite river bank.
- Being a regulated upstream, the design discharge range is fairly flat (e.g., bankfull flow is 5,800 cfs, and 100-year return period flow is about 12,000 cfs).
- Erosion is occurring naturally at the old levee face/location.
- The post construction flows since 2013 did exceed bankfull, initiating localized erosion between the hardened barbs and partially exposing buried Barb #6.
- Slopes on both sides of the river are steep in multiple locations, with some sand bars near recreational sites; additionally the river is 'looping' naturally, creating scallops and natural meandering patterns.
- The project design approach of setting back the levee and allowing the river to erode unarmored fill and reconnect some historical floodplain appears to maximize the site/sub-reach potential for channel migration.
- The hard points (rock barbs), bankfull bench log roughness elements and maintaining existing trees and vegetation where possible would be expected to provide flow steering and levee erosion protection without requiring contiguous surface revetment. Further, the design components of buried rock and wood features in the floodplain would be expected to function similarly once the channel migrates to their location.
- The emplaced wood features around the rock barbs appear to be well retained and are set low enough (and back far enough from the main channel) as not to create any floater safety issues during summer recreation flows.
- Smaller angular rock from the previous revetment was observed in small quantities at the base-flow channel edge in the upper reach, but not the lower reach (perhaps more was removed during construction or was buried by new deposition/bar formation).
- The channel bed in the upper reach appeared to still have a discernible deeper thalweg for baseflow fish passage. Conversely, the channel bed in the lower reach was characterized by a more plane bed, which may be a result of medium gradation sediment infill from localized bank erosion in the upstream reach. The plane bed response in the lower reach may not necessarily be a permanent feature and would be expected to re-adjust in future years depending on flow magnitude and duration and sediment supply.
- The mulch trap (vs. silt fence) seems to be working well as a BMP.
- In the upper project area, surfaces below bankfull elevation have recruited new willow and appear to be surviving well. Conversely, being such a dry year, the planted vegetation on the bankfull bench and higher elevations are suffering and will likely require more thorough and frequent watering to survive. The panel recommends addressing the vegetation as soon as possible, especially at the levee toe/slope-break where the vegetation could really help provide erosion protection once the channel edge reaches the levee.
- There was more existing channel margin shade present in the upstream vs. downstream reach. This may have been similar in the existing condition and not necessarily a result of the constructed project.

- Diverse habitat was observed, including multiple possible fish and water fowl.
- Habitat restoration (plantings) used varied watering methods (irrigation totes, no added watering, etc.) with varied results.
- Low flow water/river conditions were observed, but the River Recreational Specialist noted tubers/floaters on previous visit to the site (July, 2015 – see photographs in Attachment 3).
- See Attachment 1 for additional notes and sketches and Attachment 2 for site photographs.

Attachments:

1. Transcribed field notes from Dr. Stephen Lancaster (panel geomorphologist)
2. Site visit photographs of all four projects
3. July 2015 photographs of tubers/floaters at the Reddington Levee Setback and Extension project

ATTACHMENT 1

TRANSCRIBED FIELD NOTES FROM
DR. STEPHEN LANCASTER (PANEL GEOMORPHOLOGIST)

NOTES FROM KING COUNTY WOOD EMPLACEMENT SITE VISITS

STEPHEN LANCASTER

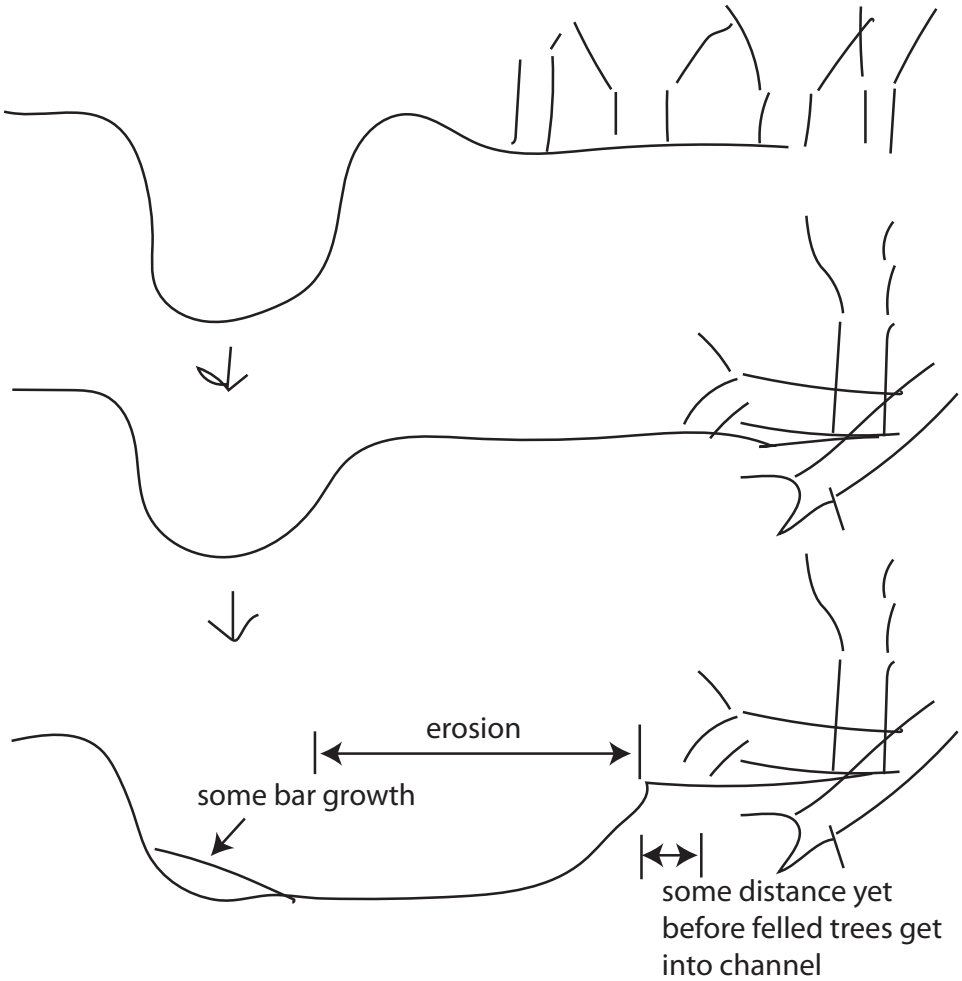
8/24/15 King County, Upper Carlson floodplain

Partly cloudy, high near 80 °F?

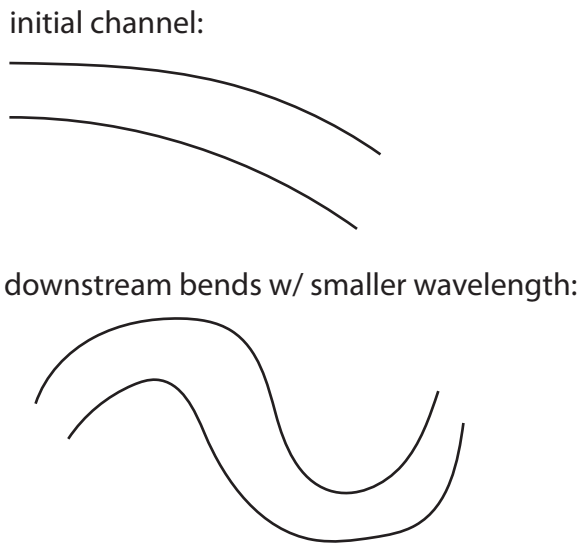
Aldair levee? Left bank, permitted but not done (yet; maybe).

Sediment budget: Todd Hurley

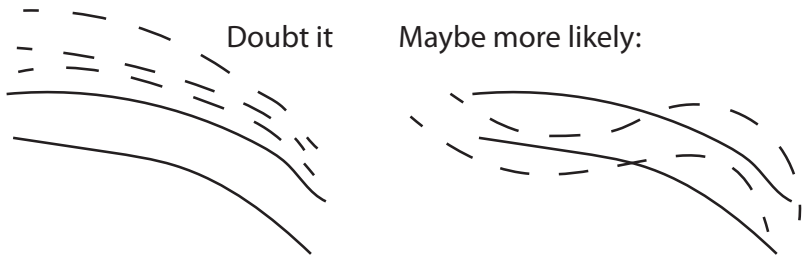
This, of the 4 sites, is the true restoration site. Reach was artificial to begin with and reveted on both sides (and w/ levees). Levee/revetement on right bank removed, and trees within some distance of bank removed and pulled back from bank and placed in various configurations to become in-stream wood after some amount of bank erosion. 10-yr flood in 1st year, bank erosion substantial but not yet to point of much wood input to channel.



Bank erosion projections seem to assume coherent migration of the "bend." But it's not really a bend; it;s a nearly straight section cutting off an old bend. A new bend, or bends, have not yet been established, and it may form more than one bend initially.



So it's particularly difficult to say what will happen here. Predicted erosion is probably reasonable in terms of magnitude; maybe not in its spatial distribution:

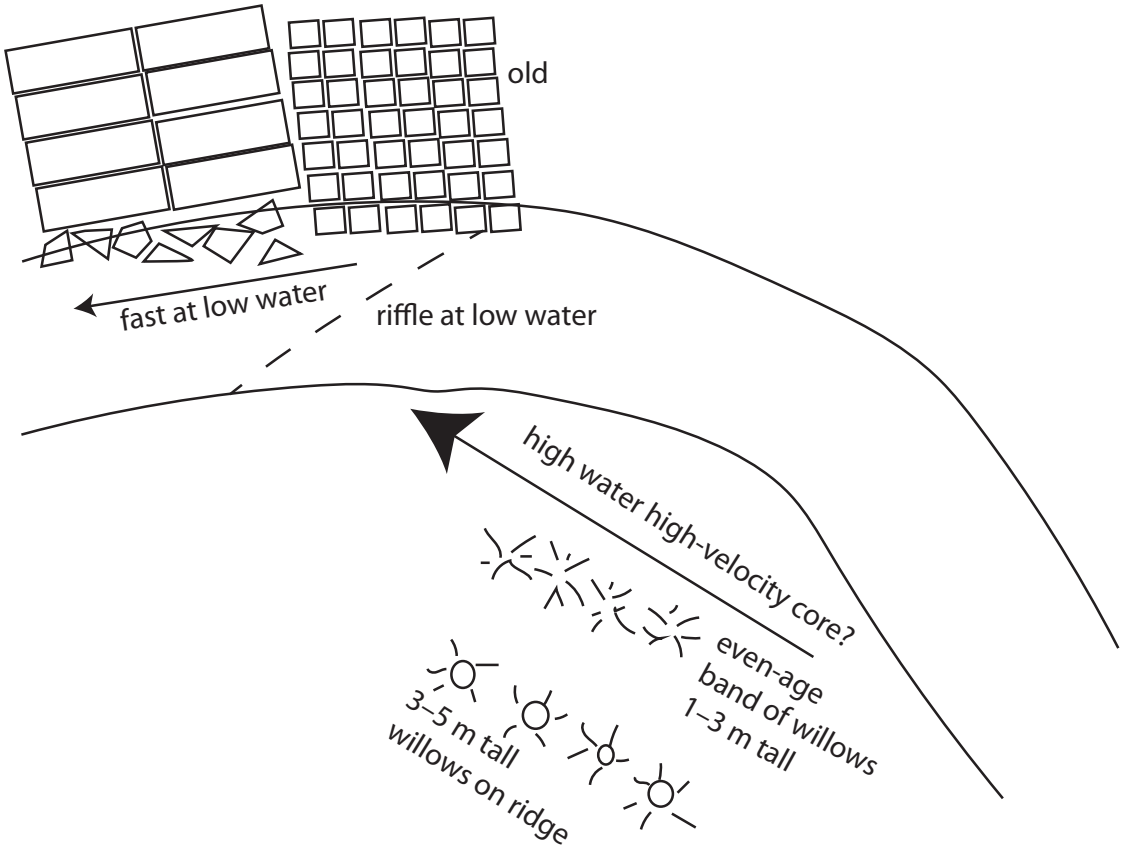


8/25/15 Herzman site

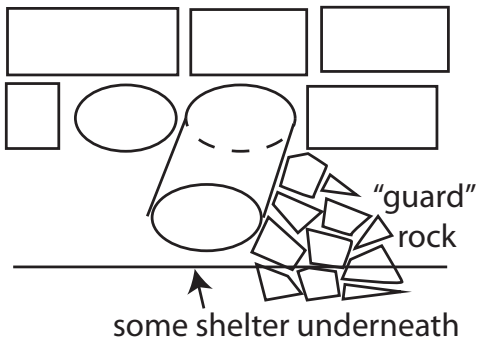
Sunny morning w/ wispy clouds. Conversed w/ Kelly about dreams & bike wrecks.

This is a levee repair, after flood damage, completed in 2010.

Pretty straightforward repair job: big rocks spec'ed to > 30 in. (much bigger; prob'ly ~ 1 m $\times 2$ m $\times 2$ m?) Old smaller ($\sim 30 \sim 50$ cm) rock left at toe of levee. Toe of project is now above water level. Some big logs, one w/ root wad, buried at downstream end of repair. Permitting people wanted wood incorporated along length of project, but safety issues raised by stakeholders led to compromise of wood just at downstream end. Result is no wood where high velocity is directed at bank, where there's a riffle at low water (today).



Makes sense that old levee rock armor would fail where high-vel. core hits bank. Old rock not all removed; rock in stream and on lower bank likely fell in when undermined by erosion/removal of old rock at toe. Repair job left that stuff alone. Now functions as in-stream/near-bank roughness. Similar-size rock "guards" upstream sides of large wood pieces near water level to prevent people (boaters, tubers) from being drawn under the wood.



Belmondo site on Cedar R.

Warm afternoon, sunny.

Un-engineered revetment/railroad bed fill before failure.

Emergency repair after 2009 flood w/ large rock to arrest erosion.

Finally, reviewed & permitted project to replace emergency repair: large rock taken out except at toe, bank over-excavated, filled w/ geogrid (growth medium wrapped in fabric); big-rock barbs w/ rock aprons & bumper logs; big logs chained to large buried rocks between & downstream of barbs.

[After emergency repair, before project, log crib built at upstream end of bend to arrest apparent bank erosion.]

New HEC-RAS has RAS-mapper, replaces Geo-RAS, which was ARC GIS. RAS has quasi-2D and fully 2D. Quasi-2D attaches local 2D flow to x-sec's of 1D model (Steve Goodell blogs about HEC-RAS)

General comment: Grain-size data? Pebble counts are easy and reliable for area included.

2D modeling might've...[finished upon transcription] revealed areas more and less likely to experience scour or deposition. Specifically, both barbs were designed with scour in mind. The bed on the upstream side of the upstream barb has been scoured deeply, so that bedrock is exposed in the bottom of the pool formed by that scour. The near-bank area is largely depositional from the downstream side of the upstream barb through the rest of the project, including the downstream barb. Design and construction of both barbs was effectively identical. The fact of sedimentation at the downstream barb up to the date of the site visit does not make later scour impossible, but the same degree of armoring of the downstream barb does not appear to be necessary. This issue was the motivation for my question after the tele-meeting presentation about the different possible roles of in-stream wood and whether any modeling had, say, predicted which logs or structures would promote scour vs. those that would lead to deposition.

8/26/15 Reddington site on Green River, Auburn WA

Wispy high clouds, sunny.

Levee set back. Goal 1 is to reduce risks from flooding & channel migration; moreover, increase flood capacity...

White R. was sometimes tributary, locked off. Howard Hansen Dam is primarily flood control.

2-yr flood = 9000 cfs

100-yr flood = 12,000 cfs

Gravel bed transitions to sand downstream of project. Had degraded; seems to have stabilized.

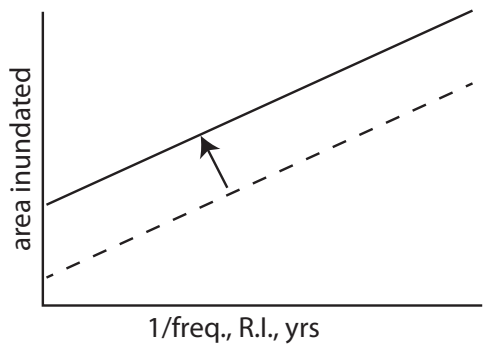
Bankfull/channel-forming flow = 6000 cfs based on newest floodplain surfaces in unconstrained reaches; 1.2-yr RI

Downstream, still degradation.

Old levee rock $\sim$ 0.5 m, steep.

Observations, etc. Interesting to see the change in the stream from the upstream end to downstream. Upstream end is relatively narrow and deep w/ many large angular boulders (old levee rock) on the bed, which is silty & largely covered w/ macrophytes. This character seems persistent through the extent of significant recent bank erosion. Downstream of this erosion, the channel is shallower, maybe a little wider (but maybe not), and the bed is covered w/ gravel (eyeball est. of $D_{90} \approx 5$ cm). Many salmonids were swimming through, or holding in, this reach. Seems likely that the fish must also be passing through the upstream reach, but are simply not readily visible in the deeper water. The downstream reach was more pleasing to my eye because of the sorted gravel bed & visible fish, but I don't know that it *is* better habitat.

The project seems an obvious win for flood control. The bank erosion following construction may supply the gravel in the bed of the downstream part, and this gravel may improve habitat quality. Well, that's biology. From a geomorphic standpoint, the new gravel source provides what seems to be lacking at the upstream end, vis á vis necessary & sufficient conditions for bar formation and, therefore, channel dynamism and formation of new floodplain surfaces. It's likely that new floodplain surfaces will have lower elevations than the current left-bank-adjacent surface. As the channel-floodplain system evolves, then, average elevation within/betw. the new levee & right-bank embankment will (probably) decline, with concomitant increase in flood capacity and/or decrease in flood flow velocities; and frequency vs. area of inundation (within the floodplain) curve will rise:



ATTACHMENT 2

SITE VISIT PHOTOGRAPHS OF ALL FOUR PROJECTS

Upper Carlson Floodplain Restoration Project

Site Visit Photographs Taken August 24, 2015

Side channel in the ‘Catcher’s Mitt/thumb.’

Channel and pointbar at the lower end of the project.

Pinch point and erosion area along left bank downstream of the project.

Gravel bar forming along the left bank at the upper end of the project.

Eroding bank and placed wood along the right bank.

ELJ placed at lower end of project to protect Neal Road.

ELJ placed along the side channel to protect Neal Road.

Naturally recruited wood captured by young willows.

Herzman Levee Repair Project

Site Visit Photographs
Taken August 25, 2015

Emplaced wood structures at lower end of project.

Smaller rocks at toe of levee providing increased near-bank roughness.

Signage at the entrance of the walking trail to left bank across from project. Note the yellow warning sign on the tree in the upper left corner of the photograph.

Belmond Revetment Enhancement Project

Site Visit Photographs
Taken August 25, 2015

Floodplain along the right bank (across from the project).

Left bank with roughness logs between project structures.

Sediment deposition and side channel at lower structure.

Sediment deposition below upper structure.

Non-irrigated vegetation at the top of both structures appeared dead.

Areas of sediment deposition and side channel forming along left bank between the structures.

Side channel with small fish present under the roughness logs between the two structures.

Left side of the river channel on the upstream side of the upper structure, scoured to bedrock.

Deep pool on upstream side of the upper structure, scoured to bedrock. A large salmon was observed holding in this pool during the site visit.

Upper structure with naturally recruited log.

Root wad on upstream end of upper structure, below bumper logs..

Close-up of root wad on upstream end of upper structure, below bumper logs.

Reddington Levee Setback and Enhancement Project

Site Visit Photographs Taken August 26, 2015

Placed wood set back from the river.

Placed wood set back from the river along the setback levee.

Placed wood on levee side of reconnected wetland at River Mobile Estates

Erosion along the old levee face.

Erosion along the old levee face.

Barb #6 partially exposed by localized erosion.

Looking downstream, slope steepness and vegetation vary along the river.

Looking upstream, slope steepness and vegetation vary along the river.

Logs anchored along the river channel.

Mulch fence used instead of a silt fence to capture sediment from runoff.

Planted willow (taller growth toward levee) and naturally recruited willow.

River channel at lower end of levee setback.

Remaining earthen levee structure at lower end of project.

Salmon in the lower end of the project.

Planted vegetation (non-irrigated) on and around the two upper buried barbs.

Top of bank between the setback levee and river channel (non-irrigated planting).

Top of bank between the setback levee and river channel (non-irrigated planting).

Planted willows at lower end of the project with irrigation tanks.

ATTACHMENT 3

JULY 2015 PHOTOGRAPHS OF TUBERS/FLOATERS AT THE REDDINGTON LEVEE SETBACK AND EXTENSION PROJECT

Reddington Levee Setback and Extension Project
River Recreation Photographs
Taken by Dan Hudson, River Recreational Safety Specialist, July 2015

Tubers/floaters on the Green River near Isaac Evans Park.

Tubers/floaters and other beach-based water recreationists in the Green River at Isaac Evans Park.

Beach signage at Isaac Evans Park.

Appendix C

Independent Expert Panel Draft Evaluation Reports

EXPERT PANEL REVIEW FINDINGS: MITCH PRICE, LICENSED PROFESSIONAL CIVIL ENGINEER

1.1 Belmondo Revetment Enhancement

Public Safety Considerations – Design and Implementation Phases
Identify the ways in which public safety was taken into consideration during the design, implementation, and/or adaptive management measures (i.e., public meetings, revisions to the design at/after 30 percent, other safety considerations, in-river signage during construction, etc.).
In reviewing the provided information for the Belmondo project design and implementation, public safety appears to have been considered throughout the entire project design and implementation phases. As part of the design development process, ten alternatives were evaluated and scored for multiple criteria including stability and boater safety. It was determined that floodplain ELJ structures upstream of the proposed project (previously considered following implementation of the 2010 project) had the potential to promote split flow and could create unmitigated floater hazard risks. Despite not scoring the highest for boater safety, the configuration with two rock/ELJ structures was selected and considered a reasonable balance of all criterion. General design features including limiting protrusions on any wood structure faces, placement of deflector logs, reducing structure porosity, and minimizing exposed fasteners were included for the conceptual design. The consideration of recreational safety issues resulted in design changes at both the 30 percent and 90 percent design levels. Key changes to the design to address boater safety include (1) adjusting the rock/ELJ structures to be no more than one-third the channel width and angled 45 degrees downstream with additional horizontal bumper logs on the upstream face and around the root-wads such that boaters would be redirected away from versus into the structure and new log recruitment would be minimized; (2) infill of void space with large rock to reduce entrapment and straining risk, (3) orientation of root wads downstream to reduce entrapment risk for approaching floaters; (4) provision of sufficient clear passage between the project and the right bank with slackwater over the pointbar in the upper and lower meander segments. At this time, no adaptive management measures for recruited wood have been noted or implemented, although there is one recruited log on the upstream groin structure that may create some hazard potential for the unskilled recreational floater.

Site-specific Project Goals and Objectives
Were the Belmondo 2013 Project Goals and Objectives achieved while minimizing risk to (or not impacting public safety?
Overall, Yes, the goals and objectives for the 2013 Belmondo Project were achieved while minimizing risk to public safety with some caveats. The primary goal of the project was to mitigate the 2009 emergency repair with features that enhance the quantity and quality of aquatic habitat by promoting lateral channel migration and maintaining existing flood protection. The secondary purpose of the project was to meet WDFW mitigation requirements for impacts to aquatic habitat associated with a 2011 log jam removal ~2.5 miles downstream of the project at Cedar Rapids. Over a longer term time frame, both of these goals would be expected to result from implementing the 2013 project components on the left bank; note however that it is not known what aquatic habitat impacts were actually associated with the aforementioned log jam removal but log complex roughness elements were added to the project to mitigate prior impacts. Regarding the project objectives, it is certainly a matter of semantics, but it is worth noting that some of the documented objectives for the project rely upon a project geomorphic or biologic response that is expected to occur. For the anticipated biologic response to project implementation, the April 2015 monitoring report documents a positive response; however, there is not yet any documented analysis for or monitoring of the anticipated geomorphic response. The three project objectives related to construction: (1) Replace 2009 emergency riprap repair above OHW with vegetated geogrids, (2) construct two ELJs, and (3) Construct two complexes of roughness logs, were all constructed and thus achieved. The complimentary anticipated response from these objectives, including: (1) supporting the establishment of riparian shade and cover, (2) deflect high flows and shear away from the left bank, scour pools, and promote lateral channel migration and connectivity with the right bank floodplain, and (3) reduce local velocity and shear, promote sediment deposition and provide fish refugia, have not yet all been achieved. The establishment of riparian shade and cover in response to the vegetated geogrids appears to be slowly progressing with a much better survival rate in watered areas that are using drip-tape. Due to such a long dry summer, some un-watered areas do exhibit plant mortality especially near the top of the bank. The deflection of high flows and shear away from the left bank, scouring of pools, promotion of lateral channel migration and connectivity with the right bank floodplain as a response to ELJ construction is variable. The ELJ structures appear to have deflected recent flows away from the bank, however only the upstream structure is maintaining a scour pool while the downstream structure currently is not. The reduction in local velocity and shear, and promotion of sediment deposition does appear to be occurring in the local vicinity of the “roughness” log complexes, which were

added to the project to provide additional habitat benefit. Design of the "roughness" log complexes included buried concrete with 5/8" Grade 70 chain anchoring to insure they would remain immobile for the 100 year flood flow. Over the very long term, as the wood complexes decompose, chain anchors are safer than steel cable in that they will sink to the channel bottom and not provide any entanglement risk. The roughness log complex features are installed within the hydraulic shadow (slackwater) of the ELJ structures, which likely also contributes to localized dampening of hydraulics and subsequent sediment deposition. While the roughness log features were installed lower than initially designed to improve contact with lower flows, they were still dry during the very low (~86 cfs) flow conditions of the site visit. They do appear to provide good interstitial space which would be expected to provide aquatic refugia once the logs are submerged. More detail regarding goals and objectives is provided in the response to the remaining guiding questions below.

A detailed project monitoring and wood management plan for addressing post implementation site changes was not provided with the project documentation. Post implementation monitoring of Habitat for the Belmondo project is detailed in the February 2015 Aquatic Habitat Monitoring Report. The monitoring study methods included mapping of low velocity edge habitat and corresponding fish use and preference by species type. Additional implementation and effectiveness monitoring to evaluate project adjustment and channel migration, flow patterns and floodplain connectivity, and log recruitment, collection of some geomorphic monitoring data is recommended. Generally this would include repeat bathymetric cross sections and a longitudinal profile and possibly surficial sediment gradations over multiple water years as deemed appropriate based on observed site changes.

Belmondo GC#1. Has there been an increase in lateral channel migration and floodplain connectivity, as can be directly or indirectly attributed to the 2013 project construction, including the use of two ELJs.

At the time of the August 2015 site visit, the Belmondo project site had experienced two runoff seasons, the 3/10/2014 peak flow of 3,170 cfs had a return period of ~3.4 years, and the 1/5/2015 peak flow of ~2,750 cfs had a return period of ~2.6 years (**estimated from the BOD – Appendix E FFA).

The Belmondo project reach does have a history of frequent natural channel migration; a cursory evaluation of recent air photos and documented site history suggests that the site has experienced significant channel planform adjustment in response to previous flood events ≥ a 10 year return period. The largest recent adjustment appears to have resulted from the 11/30/95 ~25 year flood, which caused an avulsion that shifted the planform from two smaller channels with well vegetated margins to a wider dominant single thread channel with more extensive depositional features within the bankfull channel margin. Documented avulsions in

the project reach are typically 75-100 feet per flood event. Once this single thread planform was established starting WY1996, subsequent floods (such as ~10 year floods of 2006 and 2011, and the ~46 year flood of record in January of 2009) continued to promote downstream meander translation and corresponding left bank erosion. In addition, the presence of weathered bedrock (observed in the channel bed at the upstream pool and at the downstream end of the project) would be expected to inhibit vertical channel migration; the weathered bedrock on the left bank toe of slope at the downstream end of the project appears to function as an effective hard point, resisting any erosion since it exposed in the November 2006 flood.

The 2013 project goal (#1a) of "promotion of lateral channel migration" for the project is a desired response from the construction of two ELJs. This goal is assumed to refer to the installed structures preventing any future lateral erosion of the left bank and encouraging channel migration towards the right bank. At this point, there does not appear to be a notable increase in lateral adjustment of the right bank through the project reach. This is not surprising considering the relatively low flood flows and short time frame since the project was implemented. However, one observation is that the upstream Rock/ELJ structure from the 2013 project appears to be creating a hydraulic shadow (as evidenced by the formation of a mid-channel bar and increased bed deposition on the downstream left-half of the channel extending ~300 feet from the lower structure to the meander point of curvature. If this aggradation increases to a relative elevation greater than that of the downstream right bank pointbar, it would be expected to help promote channel migration towards the right bank. Conversely, if the sub-reach meander sequence were to migrate downstream, then this would be expected to promote right bank erosion upstream of the project and left bank erosion downstream of the project. Note however that the design documents indicate the presence of a significant rock outcropping is expected to minimize this potential.

Regarding the project goal (#1b) to "promote connectivity with the right bank floodplain, the installation of the two rock/ELJ structures would be expected to help redirect overbank flood flows away from the left bank and thus onto the right bank floodplain surface across from the project. What is difficult to ascertain however is whether this has been achieved since the 2013 implementation, and if so to what degree. Within this context, it is assumed that the "floodplain" refers to the right bank surface exceeding main channel bankfull elevation. Unfortunately, none of the documentation provided for this review (including the basis of design report and supporting appendices) appears to provide any mention or documentation of the bankfull elevation at which the right bank floodplain would be considered active. An attempt to sleuth through the terse hydraulic information provided and the record drawings does indicate that the OHWM of ~202.0 is about a half-foot less than the typical summer high flow of 1,100 cfs and that the 2-year return period flow of 2,366 cfs probably interacts with the right bank floodplain. From a geomorphic perspective of floodplain connectivity, it does appear that there are some relict channels through the floodplain surface that may inundate at lower flows depending on connectivity with the main channel. From a quantitative

perspective, a standard method to evaluate floodplain connectivity through the project reach would be to utilize the project hydraulic model to evaluate the shift/departure in discharge/stage rating curves for both existing versus design conditions as well as existing vs. post-implementation conditions. In addition, since lidar is available for the project reach it should be trivial to intersect the hec-ras hydraulic model results with the floodplain surface to develop inundation depth grids for the various return period flows presented in Appendix E. Finally, the preferred way to evaluate whether these two geomorphic objectives of promoting channel migration and floodplain connectivity are being maintained or improved as a result of the project implementation is to complete a comparative analysis based on quantitative field data collected as part of some repeat monitoring plan over multiple water years. It is recommended that repeat geomorphic monitoring include at a minimum some type of channel survey through the project reach (e.g. cross sections, longitudinal thalweg profile, bank-lines, high-water marks etc.). Two additional measures of floodplain connectivity to consider for project monitoring include the installation of crest-stage gages or low cost water level loggers.
Belmondo GC#2. Were high flows and shear along the left bank deflected, scour pools created, and connectivity with the right bank floodplain accomplished through the construction of two ELJs?
During the site visit on 8/25/2015, it was observed that the left bank rock/ELJ structures were intact since 2013 implementation which would suggest that flows and shear along the left bank were deflected. However, the highest flow observed since project implementation was 3,170 cfs with a return period of ~3.4 years which would not be considered a “high flow”. For the 100 year design flow of 9,491 cfs, the supporting calculations provided with the basis of design report do indicate that the structures will not be overtopped continue to function as groins, were designed to resist expected forces, and thus remain intact. For the 100-year flow, the terse hydraulic modeling indicates an anticipated wsel of ~204.5 feet which is still ~2 feet below the top of the rock/ELJ structure and thus if the structures remain intact, they would be expected to deflect shear along the left bank. What is lacking however is any hydraulic modeling to support a more detailed evaluation of expected hydraulic performance such as angle of attack, shear stress magnitude, hydraulic deflection spatial pattern, etc. In regards to the creation of scour pools, only the upstream structure of the 2013 project currently has a scour pool while the location and orientation of the downstream structure appears to be within the hydraulic shadow of the upstream structure (for the flows experienced so far). Considering that the flow steering and shear signature through the project is stage progressive, it will take either additional hydraulic modeling or post runoff monitoring following higher flows in order to ascertain if the second (downstream) rock/ELJ structure is able to develop and sustain a scour pool. From the record drawings, it appears that a pool was constructed as part of the downstream structure, and is currently filled in.

Connectivity with the right bank floodplain was discussed above in response to Belmondo GC#1.
Belmondo GC#3. What physical process-based metric can be used to compare pre- and post-construction, or performance relative to a design flood threshold.
Evaluation of how the Belmondo project left bank installation will resist various structural failure modes such as geotechnical slope failure, scour and erosion were thoroughly analyzed using conservative standard methods and equations and well documented in the basis of design report and appendices. Conversely, regarding how the Cedar River through the Belmondo project reach responds to various flood events and whether the pre-project flood risk is maintained or improved, a comparison of how the river is expected to respond to various flood events with how it actually does may be warranted. Based on the information provided, it appears that a coarse scale HEC-RAS model was utilized to perform a zero-rise analysis for FEMA compliance and some general section averaged velocity values were extracted from that model to support subsequent structural stability calculations. Further, in reviewing the terse information provided in the BOD Appendix E, it is not possible to determine very much about the hydraulic model including how the project components were represented and what was the basis for calibration. The low resolution image of the model schematic looks like blocked obstructions may have been used but since no model cross sections were provided this is only a guess. Considering the overall cost of this project, it would be remiss not to note that the supporting hydraulic modeling is woefully brief and very poorly documented. Nonetheless, while a zero-rise analysis is a good first step to estimate stage response for a 100-year event and mark a checkbox for NFIP compliance, from a design and performance perspective it would be much more informative to utilize the hydraulic model to develop rating curves at multiple cross sections through the project reach such that the relative departure in stage, velocity, and shear stress between existing and post-project conditions could be quantitatively considered. Updating the model with repeat cross sections collected as part of the monitoring plan would require a trivial level of effort and allow for comparing hydraulics with various field indicators (e.g. observed stage, bed mobility, pool scour/deposition, etc.) to determine if the project reach is actually responding as anticipated.
Belmondo GC#4. Were mitigating measures taken against left-bank erosion (bank stabilization) for the trail as one critical flood protection measure to be maintained?
Yes. The design components to mitigate against left bank erosion were very thoroughly designed using conservative standard methods and equations and implemented accordingly. These measures included a contiguous large rock toe and scour apron supporting two rock/ELJ structures for flow steering, a mechanically stabilized earth bank with vegetated

geogrids, and anchored longitudinal log features between the structures. The use of a scour-apron was selected for the rock/ELJ groins in lieu of driven piles to mitigate for a maximum probable scour depth of 18 feet. These project components are configured and designed to act together to resist left bank erosion during a 100-year flood event.
Belmondo GC#5. Was there an overall benefit (quality and quantity of aquatic habitat) to the implementation of the project design challenges, including increased deflection angle of ELJs, root wads on ELJs, elimination of voids and strainer effect, increased size and boulder space, and no exposed chains or cables?
Overall, the 2013 Belmondo project appears to have created some net positive benefit from a habitat perspective, especially in comparison to the original revetment and existing conditions. Despite the project design challenges, the installed wood elements in the groin structures and the near-bank logs all appear to be able to provide increased roughness and corresponding low velocity edge habitat. As discussed in GC#2 above, the scour pool created at the upstream structure also appears to be preferred aquatic habitat. While some exposed chains were observed for the installed roughness elements, they would not be expected to negatively impact the habitat potential of the emplaced wood elements themselves.
Belmondo GC#6. Were the vegetated geogrids effective in establishing riparian shade and cover for the replaced 2009 emergency riprap repair above the ordinary high water mark?
The vegetated Tensar biaxial geogrids (BX1120) have generally be effective in establishing vegetation for the replaced 2009 emergency riprap repair above the ordinary high water mark. From the perspective of riparian shade and cover, the efficacy appears to be slowly progressing with a much better survival rate in watered areas that are using drip-tape. Due to such a long dry summer, some un-watered areas do exhibit plant mortality especially near the top of the bank. If the dry conditions of 2015 persist into the next water year it is recommended that an aggressive watering plan be implemented to protect the existing planting investment.

1.2 Herzman Levee Repair

Public Safety Considerations – Design and Implementation Phases
Identify the ways in which public safety was taken into consideration during the design, implementation, and/or adaptive management measures (i.e., public meetings, revisions to the design at/after 30 percent, other safety considerations, in-river signage during construction, etc.).
Public safety considerations influenced the design of the 2010 Herzman Levee Repair project. Two key elements, the location of the project on the outside meander bend combined with the amount of recreational use at the project location were considered. The resulting design limited the placement of large wood only to the downstream end of the construction limits, and the two rootwad pieces were installed angled towards the channel bed (with two-thirds of the length anchored in the levee for stability) and downstream of four bare bumper logs. In addition, the design elevations for the bumper logs were adjusted following public comment to insure sufficient protection for a range of summer recreational flows from 150 to 500 cfs. Monitoring for the Herzman Levee project is conducted by the King County Flood Control District and documented using a standard field form. Visual monitoring elements include flow conditions, identification of structural damage, toe and LWD condition, and planting conditions above the ohwm. No adaptive management information was found in the provided project documentation.
Site-specific Project Goals and Objectives
Were the 2010 Herzman Levee Repair Goals and Objectives achieved while minimizing risk to (or not impacting) public safety?
Yes, the goals and objectives for the 2010 Herzman Levee Repair Project were achieved while minimizing risk to public safety. The primary goals of the project were to: (1) balance permit-required mitigation for construction impacts and recreational user safety, (2) have the levee function as originally designed, and (3) conduct repairs during the Cedar River fish window. All three of these goals were achieved within the short time frame of completing the project objectives. The project objectives were to: (1) repair 260 lf of levee along the face and toe of the upstream end, (2) replant the willow on the levee, and (3) place large wood at the downstream end of the repair to mitigate for the existing canopy of willow and the wood in the water that was lost during the repair of the levee face. Since repairing the 260 lf of levee, the levee is able to function better than originally designed, and the replanted willows above

the OHWM on the levee are thriving. Relative to public safety, the side slopes of the levee repair were slightly flattened from 1.5:1 to 2:1 wherever possible to reduce stability risk, and the large wood pieces were scaled back, re-located, and re-oriented to address public safety concerns. Mitigation for loss of the existing willow canopy seems well on-track based on the high survival rate and density of the willow plantings. As discussed further below under guiding question #1, the ability of the placed wood to mitigate for the existing condition wood loss is possible but indeterminate.
Herzman GC#1 Did the placement of large wood (downstream end of the repair) mitigate for the existing willow canopy and the in-water wood that was lost during the repair of the levee face?
The Herzman project included 6 logs total, two of the pieces were intended to be would roughness elements and the remaining four were installed as bumper logs. The existing condition was documented to include two pieces of large wood in the water and a dense corridor of willow on the levee face. The emplaced wood would not be expected to mitigate for the existing willow canopy, except perhaps during the short term post construction window while the willow plantings were establishing. However, based on the count, it appears that wood could have mitigated for that in the existing condition. One caveat however are the details regarding the existing wood (including size, degree of protrusion into the channel, presence or absence of root-wads, degree of undercutting, voice spaces, etc.) and how that relates to habitat suitability. Due to river safety concerns, the installed wood of the 2010 project lacked key habitat suitability features and thus may not necessarily have mitigated for the habitat conditions related to the two existing pieces of large wood. While the project documents indicate that two of the wood pieces had root wads and should provide an area of slower velocity for juvenile salmonids, the root balls seemed insufficiently small to provide any notable habitat benefit. Further, the creation of increased roughness and localized velocity reduction while possible, is hard to ascertain based on the provided documentation and the very low flows (~ 86 cfs) observed during the site visit. Perhaps consider documenting this during a representative flow condition. As a general note, on future projects, a more suitable comparison for pre/post project mitigation could detail the habitat conditions and aquatic suitability and not solely the wood count.
Herzman GC#2. Based on available documents and field investigation, have the vegetated geogrids been effective in establishing habitat conservation measures since installation in 2010, including re-establishment of willow canopy and riparian shade and cover?
The Herzman project utilized infill willow plantings and stakes with coir fabric between the revetment rock lifts. Based on the 8/25/2015 field investigation, the willow cuttings appear to be thriving with a very high survival rate. In comparison to the June 2011 photos, most of the

upper 3/4 of the revetment is blanketed with thick willow, and some of these do extend out over the wetted channel approximately 1 meter, providing some riparian shade and cover. The lower ~1/4 of the revetment does not contain any willow, however this is likely below the OHWM and thus would not have been expected to support willow during the existing condition either.
Herzman GC#3. Has fish habitat (refuges) been created as a result of the levee repair features (repairs to 270 linear feet of eroded facility with geogrids, rock, and six large wood placements)? If so, to what extent is the panel member able to determine if additional habitat was created?
Based on the information provided and the 8/25/2015 field investigation, it is difficult to determine if fish habitat refuges have been created as a result of the levee repair features. There is some riparian shade and cover as previously discussed, however, the actual habitat related to the six large wood placements is indeterminate.
Herzman GC#5. Does the levee currently function as originally designed as a result of the repairs made in 2010 (see original drawings, 1976)?
Yes, the Herzman Levee as repaired in 2010 exceeds the function as originally designed in 1976. Based on the provided plan-set, the design and construction appears consistent with current standard practices and the repair design includes increased rock size gradation for the revetment toe and face. Further, the repaired levee does provide some additional flood protection in that the top elevation of 131 feet does provide freeboard relative to the 1 percent annual base flood elevation of ~127.5 feet.
Herzman GC#7. What changes in behavior can be observed (from project documents or site investigation) of the opposite side of the river channel?
It is difficult to identify what changes have occurred on the opposite side of the river channel in that this was not documented in the provided information. During the site visit, it was observed that the left side of the Cedar River is establishing a fence of willow slightly below bankfull elevation. The left overbank surface across from the Herzman Levee repair project that is accessible to the channel for low return period flood events is constricted by the walking trail and limited to about 1.5 acres based on the January 2011 flood (~9 year return period) airphoto. The trail is armored with coarse angular rock material which would be expected to provide some erosion protection and did not appear to contain any significant erosion in the area immediately across from the Herzman revetment. Conversely, in the subreach upstream of the Herzman

revetment, some erosion of the Cedar River right bank was evident where the trail is close to the river channel.

It was difficult to determine based on the project documentation, but from the field visit and flood series airphotos it does appear that the trail upstream of and portions adjacent to the Herzman Levee project may be near to or equal in elevation to the top the Herzman Levee itself. The trail appears to isolate the Cedar River channel from Cavanaugh Pond for more than a quarter mile upstream of the levee, which ultimately results in higher near bank velocity and shear stress along the Herzman Levee than would be expected for pre-development conditions. Historical flood photos indicate that Cavanaugh Pond did receive some flood water during the December 1995 (~25 year) and January 2009 (~46 year) flood events but many portions of the trail itself remained dry. Currently, the primary conveyance for flood flows to access this floodplain area appears to be through some isolated lower elevation areas ~500 feet downstream of the Herzman Levee as backwater.

Considering that Cavanaugh Pond is part of the historical Cedar River floodplain adjacent to the project and that future phases for the Herzman project are slated for 2018 implementation, King County and it's designers are encouraged to analyze the feasibility of adjusting the trail profile and /or alignment to provide improved Cedar River floodplain connectivity for lower return period flood events. This could provide as much as an additional 20 acres of reconnected floodplain, provide improved water quality and aquatic habitat, and help to reduce near bank velocity and stress at the toe of the right bank Herzman Levee. One potential concept would be to re-grade the trail with sag areas and additional culverts such that overbank flood waters would flow through Cavanaugh pond for the ~2-year return period flood event of ~2,300 cfs or perhaps the ~5-year return period flood event of ~3,700 cfs. In addition to the re-grading and increased conveyance, the trail embankment and surface should also include sufficient revetment to mitigate against channel avulsion risk.

Herzman GC#9. Has the placement of large wood created areas of decreased velocity in the immediate vicinity of the levee repairs, and pulled the thalweg away from the levee toe?

Project documents indicate that the placed wood would create localized velocity reduction via increased roughness and shift the thalweg away from the levee toe. While this may be possible, it is hard to ascertain based on the provided documentation and the very low flows (~ 86 cfs) observed during the site visit. If these are performance metrics that needs to be verified, then it is suggested that ADCP velocity profiles and repeat cross sections be collected through the Herzman Levee repair project reach coincident with representative flows.

1.3 Reddington Levee Setback and Extension

Public Safety Considerations – Design and Implementation Phases
Identify the ways in which public safety was taken into consideration during the design, implementation, and/or adaptive management measures (i.e., public meetings, revisions to the design at/after 30 percent, other safety considerations, in-river signage during construction, etc.)
No specific safety plan or safety review with public comments related to the emplaced wood design components was found in the provided project documentation. For the design phase for the Reddington setback levee project, boater safety was noted as an important design objective that required consideration, especially where the designs include large wood placements. As part of the ELJ design process, various modes of failure were considered to insure that the ELJ structures (whether bank-attached or independently ballasted) were designed to be stable and could not move in such as way as to increase boater risk. These analyses evaluated ballast requirements to offset buoyancy, sliding risk, fasteners and connection sizing. In the upstream project reach, during the alternatives analysis it was determined that there was insufficient room for a full width active channel between potential ELJ locations and the setback levee which raised concerns for boater and recreational safety. Other concepts including incorporating wood into rock barbs, and a log revetment toe were also not preferred as it increased the risk of voids within the structure. Alternatively, rock barbs were selected for the upstream reach and independently ballasted wood clusters were placed behind the barbs in the hydraulic shadow to alleviate boater safety concerns. In the downstream reach, the eight bank-attached ELJs were designed to remain intact and settle/rotate into the bed as localized scour hole develops. These structures are located well behind a diverse riparian corridor with large trees and are not expected to create any direct boater hazard. As new trees are recruited at the left-bank margin, they would not be expected to affect recreational boater safety as long as they point downstream and do not occupy more than 15 percent of the active channel width.
Site-specific Project Goals and Objectives
Were the Reddington 2014 Project Goals and Objectives achieved while minimizing risk to (or not impacting public safety?
The Reddington project is the largest setback project constructed by King County on the Lower Green River. Objectives for the 2013 Reddington Levee setback and 2014 extension project were accomplished while minimizing risk to public safety and the project appears on track with both short term and long term goals. The four documented project objectives were

to: (1) Replace the levee that does not meet modern structural standards and has a history of seepage problems; (2) Construct a new set back levee to reduce the susceptibility to scour and allow more natural channel movement within the project area; (3) Increase the flow containment capacity to meet the revised 100-year discharge of 14.9 kcfs plus 3 feet of freeboard; (4) Construct / extend the levee system north for ~1/3 mile. The first goal to reduce risks from flood and channel migration hazards in the vicinity of the Reddington Levee along the Green River has been directly met through project implementation and is discussed in more detail in GC#1 below. The second goal to increase the width of the riparian corridor in the project reach with a resulting increase in flow capacity and ecological benefits has started following project construction and would be expected to continue as detailed in GC#3 and GC#4 below. The third goal to reduce the vulnerability of the levee to fluvial scour, mass wasting, and channel migration has been achieved through project implementation as discussed in GC#5 below. The fourth goal to reduce the long-term costs of flood hazard management would be expected to be achieved as impacts from future flood events are attenuated (see GC#6 below). The fifth goal to allow the river to meander, scour and develop a more complex ecosystem is consistent with the project design and would be expected to be achieved over the long term as discussed in GC#8 below. Lastly, the sixth goal to protect existing vegetation and restore a corridor of native vegetation appears to generally be on-track with some exceptions as discussed in GC#10 below. Post implementation performance monitoring of the Reddington project is detailed in the 2013 habitat monitoring plan and addendum with a ten year schedule. Monitoring of ecological performance is tied to general indicators such as: side channel connectivity and wetland development, placed/recruited wood stability, vegetative cover, and low velocity salmonid edge habitat. Categorized monitoring tasks identify performance standards, monitoring methods, and adaptive management strategies for select habitat indicators. No long term physical channel monitoring such as repeat bathymetric cross sections and longitudinal profile were identified in the provided documents and may be intermittently warranted within the 10 year timeframe to insure the channel adjustment and corresponding flood conveyance capacity is performing as intended.
Reddington GC#1 (Goal#1): Where there design and construction measures implemented that reduced the flood and channel migration hazards for the nearby residents?
Yes, the Reddington Levee Setback and Extension Project was specifically designed and constructed to reduce the flood and channel migration hazards for the nearby residents, primarily the developments on the left over bank of the river including River Mobile Estates, Riverpointe Development, and Riverpark Estates Development as well as developments further North. The right overbank of the project reach is mostly undeveloped and includes the Auburn Regional Gold Course and Isaac Evans Park and thus has a lower public safety flood risk. The project required balancing objectives with multiple constraints, including a high

degree of urbanization, a stormwater pump station, and in-situ containment of contaminated soils.

From a flood threshold elevation perspective, the setback levee was constructed to contain the USACE revised 500-year annual flood event of18.8 kcfs and provide 3 feet of freeboard for the revised 100-year annual flood event of 14.9 kcfs. Conversely, the original levee elevations were only sized to contain a 100-year annual flood event of 12 kcfs (without freeboard) which was no longer sufficient given the increased urbanization relative to historical agricultural conditions.

The design process for erosion protection of the setback levee divided the project reach into characteristic segments and performed a sequential alternatives analysis to identify the relative risk within a 20-year design timeframe and corresponding cost effective erosion mitigation strategy. For erosion risk, the channel scour, migration and avulsion risk was comprehensively evaluated and mitigation addressed using multiple design components. Scour risk was evaluated using hydraulic modeling results and multiple equations for long-term, contraction, general, and bend scour. More detailed scour estimates were then developed on a per-site basis considering risk, geomorphic context, and tempered with engineering judgment. Migration risk was analyzed using geomorphic analogs and field observations to spatially delineate migration rates and estimate future migration buffer distances and subsequent risk zones.

The final project design relied upon a combined approach of constructing a new set back levee to increase conveyance area and mitigating for river erosion using a system of rock barbs, rock revetments, and engineered logjams. At the upstream (south) end of the project, nine rock barbs were installed with launchable toe revetment to provide scour protection below excavation depths of ten feet. These structures oriented at 45 degrees downstream to steer/deflect flows away from the face of the setback levee, have tapered tips to reduce local bed scour, and are spaced to provide alcoves of reduced velocity and shear stress. The rock barb structures have independently ballasted wood clusters in the downstream alcove. At the downstream (north) end of the project, channel migration risk was considered high but rock barbs were undesirable due to potential impacts in the existing wetland. To protect the set-back levee, the face was directly armored and a bench of launchable toe material was constructed. In addition, eight bank-attached engineered log jams were installed on the river side of the rock bench. From a recreational safety perspective, the structure construction allows the landward side to remain at the bench elevation while the river side will flexibly deform, rotate downward, and settle into localized scour holes as they develop. Two segments that were deemed to not require scour protection due to a low channel migration threat were the undeveloped areas upstream and downstream of River Mobile Estates.

Reddington GC#3 (Goal#2): Does the project as implemented provide an increase in flow capacity, as determined through available documents and field inspection?
The primary strategy for increasing flow capacity through project reach was to construct a new set back levee and remove existing armoring to allow the Green River to naturally erode the existing soils in the landward margin between the old and new setback levee alignments. In the 2013 project phase, ~4,700 linear feet of existing levee prism and rock revetment were removed between RM 28.6 and 29.5 with subsequent construction of an improved setback levee. In the 2014 project phase, an additional ~1,500 linear feet of levee was constructed to extend the project North to the Monterey Park Development. The levee setback alignment was designed to maximize the amount of floodplain while minimizing the impacts to private land parcels, existing wetlands, and contaminated soils. At the upstream end of the project (adjacent to Brannan Park) the available area for setback was limited to less than 100 feet on average. The setback distance progressively increased below RM 29, averaging ~150 feet adjacent to the Riverpark Estates Development, and ~250 feet downstream of the Riverpointe Development. During the field visit on 8/26/2015 it was observed that the process of natural erosion for near-bank terraces is progressing and lower elevation surfaces that were previously isolated from the main channel are now reconnected. Hydraulic modeling for the proposed design indicates that although the setback levee allows for the development of increased conveyance area through erosion, the area added by reconnecting the isolated wetland/floodplain around RM 28.7 reduces the energy grade line and velocity causing a increase in water surface elevation of ~0.34 feet for the 100-year annual event. Despite this slight rise, the net increase in conveyance area combined with the improved setback levee, supporting structures, and reduced near bank stresses would be expected to reduce the overall flood risk through the project reach while improving ecological potential.

Reddington GC#4 (Goal#2): Assuming an increase in flow capacity was created through the project, what ecological benefits can be observed (post-construction)?
Ecological goals for the project were developed in accordance with the 2005 WRIA 9 Salmon Habitat Plan including the formation of refuge and rearing habitat for juvenile salmon, providing near bank roughness with engineered log jams, side channel reconnection, and revegetation with native riparian trees and shrubs. The increase in flow capacity for the project was intended to be progressive following armor removal on the existing revetment allowing the Green River to meander and naturally scour low terrace soils behind the

historical levee alignment. In lieu of direct excavation, allowing for natural river processes would be expected to promote the development of a wider more complex riparian corridor. Allowing the river to erode native soils also provides some ancillary sediment input which was notably reduced following the relocation of the White River and closure of Howard Hansen Dam. This additional sediment is expected to help promote the development of low inset depositional features over the existing channel bed.

Although flows were extremely low (~ 260 cfs) during the 8/26/2015 site visit, some positive ecological response was observed through the project reach. In the upstream reach near Brannan Park, the excavation of three shallow alcoves between barbs 6-9 appears to be able to generate localized zones of reduced velocity and corresponding juvenile salmonid refugia. This should provide some immediate short term ecological benefit while the rest of the project reach continues to erode and adjust. From an ecological perspective, the Types 1 and 2 log clusters placed between the barbs would be expected to provide some habitat as they settle into the channel bed following terrace erosion. The cluster density did seem somewhat sparse upstream of barb #6 and an increased density would be preferred if possible without degrading river safety. The lower terrace surface around the barbs (~elevation 54 feet to 58 feet) are maintaining a good revegetation cover of willow with active recruitment, while the higher elevation band within 3 feet of the levee top was noticeably drier with observable vegetation mortality. If the extremely dry conditions of 2015 persist into future years, a more aggressive watering effort may be required to improve vegetation survival. Below RM 29, some localized trees were also observed to be falling into the river while near-bank willow growth appeared to be much less than at the upstream end of the project.

In the reach downstream of RM 28.8, even though the inlet elevation was constructed one foot higher than the design grade, the constructed notches do appear to be allowing for flow-through conditions such that the left overbank side channel /wetland adjacent to River Mobile Estates near RM 28.8 can interact with the river for flows below the 2-year annual event. The wetland area is approximately five feet lower than the post-regulation inset floodplain elevation, and has been isolated from the river since levee construction in the 1960s. The installation of eight large buried ELJ structures near the toe of the wetland meander revetment are comprised of more than 100 pieces of structural and racking wood and are much more comprehensive than the log clusters placed between the barbs in the upstream reach. While not yet active with the main channel, these structures would be expected to provide flow deflection, reduction in near bank velocity, and a future positive ecological response. Also observed in the lower reach was that as the channel erodes the low terrace behind the historical levee, the widening of the channel is also decreasing in depth. The channel bed in this area was characterized to have a relatively featureless plane-bed which may be a combined result of reduced transport capacity and increased sediment input from localized upstream or adjacent terrace erosion. This increase in the width/depth ratio may only be a short term response however as the project adjusts post-construction; it will likely

take multiple runoff cycles of flows exceeding 10 kcfs for the margin erosion and geomorphic response to stabilize.
Reddington GC#5 (Goal#3): Can the EP members identify any evidence that demonstrates that the designed/constructed project reduced vulnerability of the levee from fluvial scour, mass wasting, and channel migration?
The Reddington setback levee design aimed to provide containment and conveyance of the 500-year annual exceedance event while mitigating for erosion using a design approach that balanced risk with cost in project sub-segments. As discussed in GC#1 above, the final design utilized a system of rock barbs, rock revetments, and engineered logjams to protect the levee from river erosion. Based on the geomorphic, hydraulic, and design information provided, the project as constructed would be expected to reduce the vulnerability of the levee from fluvial scour, mass wasting, and channel migration. However, considering the relatively short timeframe that has elapsed since project completion, it is too early to identify any definitive evidence that demonstrate this.
Reddington GC#6 (Goal#4): Is the design of the existing project conducive to reduce the long-term costs of flood hazard management? If so, to what extent is this measurable (and how)?
The overall project cost was on the order of $17M and was intended to be a proactive flood hazard mitigation investment by the King County Flood Control District. Project documents indicate that the Reddington Levee protects nearly 600 parcels roughly half of which are residential and half commercial with an assessed value of $680M. Considering that the Reddington setback levee project is designed to convey the 500-year annual exceedance event, and that the historical levee capacity was limited to the 100-year event, quantifying the per-parcel risk reduction and economic savings as a result of project implementation is certainly possible. In the simplest direct ratio sense the Reddington set back levee project represents a risk reduction investment of 2.5 percent of average parcel value. While it is beyond the scope of this review to provide detailed methodology, there are standard approaches to quantifying flood damage risk and cost as outlined in USACE EM-1110-2-1619 and EM 1105-2-101.

Reddington GC#7 (Goal#4): Are there other design recommendations that might further improve flood hazard management at this site?
As of the time of this review, I do not have any other design recommendations that might further improve flood hazard management at this site. The Reddington levee setback project has a long history of stakeholder involvement, and the current design appears to address flood risk mitigation requirements while providing some habitat benefit as recommended in the 2005 WRIA 9 Salmon Habitat Plan. Considering that the project relies upon allowing the river to meander and erode native soils, frequent monitoring is essential to insure project performance criteria are met.
Reddington GC#8 (Goal#5): Does the project (as designed and constructed) allow the river to meander, scour, and develop a more complex ecosystem, which includes formation of rearing habitat for juvenile salmon?
Yes, the project as designed and constructed does allow the river to meander, scour, and develop a more complex ecosystem. Note that this reach of the river is characterized as fairly geomorphically static following the relocation of the White River and the upstream regulation from Howard Hansen Dam. The setback levee alignment was developed to maximize the potential for developing an inset riparian bankfull floodplain. Both rock and wood structures were installed to provide flow steering, increase near bank roughness, and provide for the development of improved aquatic habitat while mitigating for levee erosion risk. More detail is provided in the response to GC#4 above.

Reddington GC#10 (Goal#6): Was the existing vegetation protected and the corridor restored with native vegetation to increase shoreline and channel shading?
Overall, yes. Based on the information provided, it appears that the intent to protect existing vegetation was considered as part of the setback levee design. On the site clearing and grading plan-set sheets, trees were delineated as to whether they should be removed or protected with a quantified buffer zone. In addition, the design included a detailed planting plan. During the site visit on 8/26/2015, it was observed that a good revegetation cover of willow with active recruitment is occurring on the lower terrace surface around the barbs (~elevation 54 feet to 58 feet), and on the lower inset floodplain surface around RM 29. Conversely, along most of the project, the higher elevation band near the levee top was noticeably drier with observable vegetation mortality. According to the December 2014 monitoring report, the plant survival was variable, only meeting the performance standard of 80 percent survival in about half of the planting areas. Considering the extremely dry low water conditions during most of 2015, this is expected to be worse. If such conditions persist into future years, a more aggressive watering effort may be required to improve vegetation survival on higher elevation surfaces. Below RM 29, the relative left-bank vegetation density decreases, however there are substantial areas of riparian cover further landward which are expected to become the left bank once the left channel bank erodes to that point and these would be expected to provide increased shoreline shading.

1.4 Upper Carlson Floodplain Restoration

Public Safety Considerations – Design and Implementation Phases
Identify the ways in which public safety was taken into consideration during the design, implementation, and/or adaptive management measures (i.e., public meetings, revisions to the design at/after 30 percent, other safety considerations, in-river signage during construction, etc.)
Public recreational safety for the Upper Carlson project was considered between the 30 and 60 percent design phases. The review process included identifying potential risks, collecting data and evaluation to understand specific risk causes and conditions, public coordination with the recreation community, and incorporation of measures to reduce short term risks. The design team acknowledged that the inherently unpredictable natural processes of post implementation channel migration and wood recruitment are expected to create most wood hazards, rather than the specific design components. Design components to address safety included: (1) removal of 250 high risk trees from the rapid channel migration zone, (2) no in-stream wood placement, (3) no permanent ELJ structures in the upstream reach, (4) overbank felled trees oriented based on natural reference conditions and (5) placed coincident with a wider predicted low flow channel. Additional modifications at the 60 percent design level included: (1) removal of seven buried logs in Zone 5 floodplain, (2) minimized removal of existing mature floodplain trees, (3) reduced quantity of felled trees/log clusters placed in the floodplain and (4) staggered to moderate the recruitment rate. For the setback revetment area Near Neal Road, the design safety considerations included: (1) locating permanent ELJ structures near the downstream end of the site to reduce potential boater interaction, (2) constructing the flow-deflector ELJ-1 nearest the main channel downstream at an offset location that will promote wood recruitment upstream and where it will take several years to interact with the main channel at low flows, (3) modifying the more porous piling based ELJ-1 structure with a denser ballasted structure lower in the water column. ELJ structures were anchored to driven wood piles ballasted with native spoils to withstand buoyant flood forces; additionally, racking logs and slash material was attached with steel cabling to minimize flow piping and straining potential. Because the Upper Carlson project will create a more dynamic and natural environment, it was not possible to mitigate all risks through the design itself. Alternatively, King County has developed a site management plan with mitigation measures to minimize recreational boater risk to inevitable natural hazards expected to occur. The February 2014 Site Management Plan approach is to identify a series of progressive steps that will allow for a flexible effective response. This five stage sequential approach includes: (1) monitoring, education outreach, and signage; (2) signage and portage improvements; (3) small scale wood manipulation; (4) temporary river restrictions or closure, and lastly (5) large scale modification of

accumulated woody debris to allow for safe passage during recreational flows. Wood removal, especially that requiring heavy equipment is recognized to not be an effective long term strategy and such removal or modification would be limited to select situations where other less intrusive options cannot effectively abate the hazard. Potential wood hazards for floaters and boaters with an expected response level were categorized as: (1) low risk – stage 1 response, (2) moderate risk – stage 2 response, (3) high risk – stage 3 response, and (4) extreme risk – stage 4 response. A stage 5 response of large scale wood manipulation will only be considered if impassable to boaters or posing threat to property or infrastructure. Example wood hazards were documented using a reference reach ~1.5 miles downstream of the project site.

Site-specific Project Goals and Objectives

Were the Upper Carlson 2014 Project Goals and Objectives achieved while minimizing risk to (or not impacting public safety?

The Upper Carlson project is to be commended for its goals of reconnecting the historical side channel and floodplain in an effort to improve habitat quality by providing for natural processes without increasing the relative flood risk. The documented project objectives were accomplished during 2014 project implementation. These were to: (1) Remove approximately 1,600 feet of existing levee and allow the river to expand, migrate, and reconnect with former channels within this reach; (2) construct approximately 1,200 feet of setback revetment to protect Neal Road and the adjacent Carlson property; (3) incorporate input from the local recreational boating community into the Design Plans and the Site Management Plan and implement this plan to manage risk to recreational boaters at the site and in the reach, and; (4) re-vegetate areas disturbed during construction and areas where invasive plants have been treated with herbicide; continue to manage invasive plants and promote native communities. Further, the Upper Carlson project has a well-documented adaptive management strategy to mitigate for future uncertainty.

The first goal to promote more natural rates and frequency of channel and floodplain processes has begun following the removal of the revetment levee and is discussed further in GC#1-8 below. As discussed in GC#9 and #10, the second goal to maintain (or improve) current flood hazard protection levels appears likely based on project design estimates but should be actively monitored with air-photos, stage recorders and synoptic water surface surveys during future flood events to insure the project is performing as anticipated. The third goal to address potential impacts on recreational boater safety has been considered throughout the design and construction process but will require frequent monitoring to insure the site management plan can effectively mitigate for variable future hazards. The fourth goal

to enhance and maintain the native riparian vegetation community is consistent with connecting the right overbank floodplain and historical side channel. Post implementation monitoring of the Upper Carlson project is noted in the basis of design report as being necessary to evaluate project performance. From a safety perspective related to wood risk, the monitoring approach is comprehensively detailed in the February 2014 site management plan and relies upon a standardized visual inspection form. Conversely, documentation for planned physical monitoring was not provided with the project documentation. In order to document physical reach scale adjustments as the right bank continues to erode into the floodplain, it is recommended that repeat bathymetric cross sections and a longitudinal profile be collected through the project reach and extend at least ten bankfull widths upstream and downstream of the implemented project as well as the next meander downstream of the Aldair levee. Additional survey of the side channel and right overbank may also be warranted depending upon the observed degree of physical adjustment.
Upper Carlson GC#1 (Goal#1). Does there appear to be restored connectivity with the natural floodplain, or does the floodplain appear to be migrating back to the natural floodplain (right bank) as a potential result of this project?
The levee and revetment removal for the 2014 Upper Carlson project has initially restored connectivity with the right overbank floodplain, especially for larger flood events. Until the right bank erodes further beyond the ~60 feet wide rapid adjustment buffer zone, it appears that the primary means for lower return period overbank flood water to access the right overbank floodplain is through a few low grading swales between some levee spoils. Anecdotally it was reported that the right overbank flooding during the January 2015 event was inconsistent which may be a result of the swale locations and grades.
Upper Carlson GC#2 (Goal#1). Does the available data from Water Year 2015 (flood magnitude and duration) indicate that the channel migration and overbank flooding occurred as potential result of this project?
The Upper Carlson project, completed in 2014, experienced only six days of flows exceeding 12 kcfs, all of which occurred during the first half of the water year. These flows were characterized by short duration flood peaks all of which were less than the 1.25 return period flow of 20.1 kcfs. The primary flood peak of ~50.1 kcfs occurred on January 5, 2015, with an approximate 8.9 year return period; this event lasted approximately two days with a flood volume of ~52 kaf, a 13-hour time to peak and 36-hour time to descent. As evident in the provided video monitoring of this flood, the water surface elevation was at or near the right top of bank elevation and the side channel inlet was conveying overbank flood water onto the floodplain and the downstream field between the Snoqualmie River and Neal Road was also

flooded. Anecdotal information provided during the site visit 8/24/2015, indicates that the right overbank flood routing was inconsistent, with substantial flow being routed downstream into the agricultural fields before returning to the main channel. Monitoring photographs indicate that with the training levee removed, the right bank started to slowly retreat during the fall of 2014; following the January 2015 food, the right bank had retreated ~60 feet to the tree line resulting in the addition of more than 1.5 acres of aquatic mainstem habitat which also exposed some localized areas of residual rock from the historical levee. Being on the outside of the meander bend, the eroded banks are relatively steep (and some are undercut) but would be expected to flatten somewhat as the erosion migrates into the existing vegetation. The magnitude and alignment of the bank retreat as surveyed April 2015 was consistent with the design analysis prediction for rapid expansion.
Upper Carlson GC#3 (Goal#1). Has there been a reduction in flood flow velocities and channel migration rates as a result of moving approximately 70 percent of the large and small diameter trees (creating large log clusters) into the floodplain during the single post-construction water year?
In general the reduction in flood flow velocities and channel migration rates as caused by installing large floodplain log clusters was difficult to specifically verify. Removal of the levee revetment obviously increased right bank erosion which may be controlled to a more gradual rate by the log clusters. The log clusters were constructed using ~300 trees from the rapid widening zone, and retaining those trees for overbank roughness was preferred over losing them to erosion. During the 8/24/2015 site visit, localized areas of sand deposition were observed which could be characteristic of reduced velocity depending on the prior conditions. Comparison of April 2015 and 2011 Lidar data indicates localized areas of deposition on the right overbank floodplain surface. Hydraulic modeling for the design condition 10-year return period flood of ~53 kcfs does predict an increase in flow velocities at the right bank toe and a decrease in overbank velocities coincident with the tree line. Nonetheless, increasing floodplain roughness using log clusters would generally be expected to result in localized areas of decreased velocity and possibly erosion rates (depending on other factors such as configuration, orientation, and wood density).
Upper Carlson GC#6 (Goal#1). Has there been an increase in wood recruitment, logjam formation, and other habitat-forming natural processes as result of setting back the levee and revetment in the Snoqualmie River?
In general, the Upper Carlson project does appear to be on track to increase some natural processes that promote habitat formation. Since only a short amount of time and a single moderate flood has occurred since the project was completed, only an initial limited geomorphic response would be expected to date. During the 1/5/2015 flood event, incoming

wood was observed at a rate of 5-10 large logs per minute; based on the April 2015 monitoring information and 8/24/2015 site visit, it appears that a limited number of new racked trees were recruited along the right bank. Being on the outside of the meander bend, most of this recruitment was isolated and is only a precursor of potential future logjam formation. On the right overbank floodplain surface, a substantial volume of trapped wood was observed, especially in the thicker willows at the downstream end of the project. Now that the rapid expansion zone has been eroded, there is a significant supply of trees and wood debris at the immediate channel margin which would be expected to more directly interact with the channel following substantial future flood events. Project predictions indicate that up to ~25 trees are expected to leave the site during each large future flood. From a sediment perspective, the post-project sediment storage has increased in the channel adjacent to the levee removal; this deposition is characterized by a net increase in gravel storage by ~150 percent relative to 2011 conditions, more specifically in the middle-half of the meander. This deposition is expected to effect the bed profile and elevation which may increase surface and hyporheic connection to adjacent off-channel habitat.
Upper Carlson GC#7 (Goal#1). Has there been a reduction in channel migration along the left bank as a result of reinforcing the downstream 40 feet of the Aldair Levee and bolstering the levee with large angular rock 175 feet upstream of the levee (Adaptive Management Item No.1)?
Note that this adaptive management action hasn't happened yet. See GC#8 below.
Upper Carlson GC#8 (Goal#1). Has the reinforcement and extension of the Aldair Levee maintained the existing left-bank configuration and pre-project flow orientation?
It is important to clarify that the reinforcement of the downstream 40 linear feet of the Aldair Levee with an additional 175 linear feet extension upstream was permitted as an adaptive management action and has not yet been implemented. The stated purpose of this work would be to reduce the potential for the Upper Carlson project to increase the current rate of left bank channel migration on the Richmond property by maintaining the existing left-bank configuration and pre-project flow orientation. As documented in the April 2015 monitoring presentation, the left bank of the Snoqualmie River immediately downstream of the project has continued to migrate south over many years, even prior to the implementation of the Upper Carlson project. This area of erodible sandy soils should be considered a high priority concern for King County and monitored annually as the upstream right bank floodplain continues to erode and the meander wavelength increases. The transition between the downstream end of the Upper Carlson project and the Aldair Levee represents a planform discontinuity with a pinch point. Immediately downstream of this point, the bankfull channel width rapidly expands

~250 percent with a large wide point-bar. As observed during the low water of the 8/24/2015 site visit, there is a noticeable depositional feature immediately upstream of the pinch point which may be a result of slightly backwater conditions during higher flows, the increased sediment supply from the rapid expansion erosion zone upstream, or both.

The preferred outcome would be that as the main channel migrates into Upper Carlson right bank floodplain, it eventually intercepts the near channel ELJ structures and the left bank point-bar continues to grow through the meander. Ideally this lengthening of the meander would help to shift the alignment such that the thalweg downstream of the current pinch point would also slightly shift the thalweg towards the right bank, ultimately decreasing the width of the point-bar. However, there is also potential that the flow direction exiting the downstream ELJ could inadvertently increase the angle of attack on the Aldair Levee and the downstream left bank which could exacerbate the current erosion trend and continued abrupt transition between the two channel segments.

Regardless of the trend, the current adaptive management design to reinforce and extend the Aldair Levee appears fairly limited and would not be expected to address the discontinuity in alignment and hydraulic geometry between these two reaches. It is suggested that other alternatives for this site be considered and should evaluate working on both sides of the river as well as some channel bed shaping through the transitions. Generally, maintaining the pre-project flow orientation seems undesirable as the pre-project thalweg is adjacent-to and actively eroding the left bank. Alternatively, for the left bank, either increasing near bank toe roughness with LWD and vegetation or perhaps constructing multiple small (≤ 20 percent of the bankfull width) flow steering structures with constructed pools and submerged wood roughness would be recommended along the upper 2/3 of the ~1,750 linear feet meander in combination with flattening the upper bank slopes to 3:1 or more with dense revegetation. The use of structures and constructed pools would help to hold the thalweg away from the left bank while providing aquatic habitat in the velocity shadow behind the structures. In addition, shaping the upstream end of the right-bank point-bar and the hydraulic geometry/facet-slopes of the channel run should be evaluated for the ability to minimize the potential for abrupt deposition of the input sediment supply from the Upper Carlson project as it continues to erode. There appears to be sufficient bankfull channel width through the Aldair meander to provide safe floater passage to the right of any installed left bank structures.

Upper Carlson GC#9 (Goal#2). Does the project improve levels of flood hazard protection (erosion and flooding), both to private and public property?
Over the long term the floodplain reconnection component of the Upper Carlson project would be expected to improve levels of flood hazard protection with some caveats. The hydraulic modeling information provided for the design concluded that for the 1 percent annual flood event of ~80.8 kcfs, the average water surface elevation will be lower than existing conditions, potentially reducing flood impacts at the developed floodplain fringe while focusing flood flows within the corridor surrounding the active channel. More specifically, wsel is expected to drop as much as 0.2 foot in the right overbank and 0.1 foot in the left overbank, which was concluded to provide flood reduction benefits upstream of the project area. For smaller floods, such as the 10-year and 25-year, hydraulic modeling identified no water surface elevation increases greater than 0.1 foot except at two locations, on Neal Road next to the setback revetment facility and right bank overflow near the downstream corner of the Carlson property. Relative to erosion hazard, allowing the channel to widen and reconnect with the right bank floodplain would be expected to reduce near left-bank stress across from the project but not necessarily downstream of the Aldair levee where existing erosion rates are as high as 15 feet per year. Mitigation against future erosion risk in the far right overbank of the historical side channel adjacent to Neal road is provided via floodplain roughening, 1,200 linear feet of buried setback revetment, and large bank deflector ELJ structures. At the downstream end of the project, two ELJ flow deflectors near the channel are intended to redirect the flow transition downstream.
Upper Carlson GC#10 (Goal#2). Relative to a threshold or a single wet year cycle, is there any evidence of reduced flooding of adjacent property, and if so - what?
As discussed in GC#9 above, based on the project documentation provided, the project is anticipated to reduce average water surface elevations for the 100-year event. However, during the January 2015 flood event (<10-year return period) variable flooding of the right overbank was anecdotally noted as a result of unsteady effects where the lowered grading swales between levee spoils did not provide sufficient means for the overbank flows to return to the main channel. This appears to have resulted in short term flooding and localized sandy sediment deposition of the fields downstream of the project and south of Neal Road.

REVIEW OF KING COUNTY WOOD EMPLACEMENTS

STEPHEN LANCASTER

1. Executive Summary

2. Introduction

3. Assessment Methodology

4. Expert Panel Review Findings

4.1. **Belmondo Revetment Enhancement.**

Public Safety Considerations – Design and Implementation Phases. [Identify the ways in which public safety was taken into consideration during the design, implementation, and/or adaptive management measures (i.e., public meetings, revisions to the design at/after 30%, other safety considerations, in-river signage during construction, etc.)]

The major safety concern was that floaters, especially those floating in inner tubes, might get drawn under one of the large wood structures and drown. Design and implementation addressed this concern and changed the design by 1) incorporating bumper logs on upstream sides of barbs to deflect floaters; 2) filling voids below water with rock ballast to stall any flow going through the structures and thereby eliminating the "strainer" effect; 3) placing any exposed rootwads on the downstream sides of structures to reduce the chances of rough landings by floaters; and 4) placing clear signage upstream to warn floaters about the structures and identify portage take-outs so that floaters can avoid interaction with the log structures altogether. In addition, initially proposed floodplain ELJs upstream of the revetment were eliminated from the design because they presented risks that could not be effectively mitigated, in the opinion of King County personnel.

Site-specific Project Goals and Objectives. [Were these achieved while minimizing risk to (or not impacting) public safety?]

Goals

1. Enhance the quantity and quality of aquatic habitat to be consistent with federal, state, and county standards for streambank stabilization projects by promoting lateral channel migration and maintaining existing flood protection
2. Meet Washington Department of Fish and Wildlife (WDFW) mitigation requirements for impacts on aquatic habitat associated with a log jam removal at Cedar Rapids in 2011 at RM 7.4.

Objectives

1. Construct 370 linear feet of enhanced bank stabilization and compensate for log jam removal at Cedar Rapids
2. Replace 2009 emergency riprap repair above the ordinary high water level with vegetated geogrids to support the establishment of riparian shade and cover
3. Construct two engineered log jams (ELJs) to deflect high flows and shear away from the left bank, scour pools, and promote lateral channel migration and connectivity with the right-bank floodplain
4. Construct two complexes of roughness logs to reduce local velocity and shear, promote sediment deposition, and provide fish refuge

Another reason for the elimination of the upstream floodplain ELJs was the concern that they might prevent the river from migrating away from the revetment. The barbs do appear effective in that regard: the upstream barb deflects the current, which would otherwise tend to hug the left bank through this bend in the river, toward the right bank. At least at low flow, the thalweg is against the gravel bar on the right bank. The effect at high flows is apparent from the pattern of deposition since construction: downstream of the first barb, the area adjacent to the revetment is largely depositional. Gravel bars have grown, and there is even deposition of fine sediment in the backwaters on the downstream sides of the barbs, especially the downstream barb.

The revetment has apparently caused the formation of diverse aquatic habitats, at least in terms of flow velocities and water depths. Scour on the upstream side of the upstream barb, where the main high-velocity core of the flow impinges directly on the structure, has created a deep pool with bedrock exposed at the bottom. On the day of the site visit, we observed several large salmonids, as well as other, trout-sized fish, holding in this pool. At higher flows, the downstream sides of both barbs create slackwater.

4.1.1. *Geomorphology.* [Stephen: Summarize findings for this site based on:

- Guiding questions, including adaptive management measures identified either through document review, site observations, or questions to King County Project Manager
- Consideration of the geomorphic consequences of the design and/or implementation that considers public safety, including but not limited to the interaction between flowing water and the placed wood (under projected flow regimes experienced during typical recreational seasons)]

Guiding Questions (General)

1. *What design elements (signage, ELJs, boulders, barbs, etc.) can be identified that were implemented with public safety as a primary consideration?*

   These are described above, but specifically, public safety is the primary, if not the only, reason for bumper logs and "internal" rock ballast.

2. *In the EP members opinion, are there any noticeable changes (positive or negative) to the river immediately upstream or downstream as a possible/likely result of the project that impacts either the stated project goals or public safety?*

The changes are summarized above and are somewhat captured by a figure taken from the monitoring report (B-20; Fig. 1). The figure shows clearly that significant erosion of the right bank has occurred since construction. From a map with scale in the basis of design report (B-03), the right bank has retreated 40 to 60 ft. That erosion has created a smooth gravel bank adjacent to the fastest flow, an apparent "win" for public safety. That is, the first barb, which presents a relatively smooth log bumper to the current and any floaters riding that current, diverts the flow toward the right bank, which is also smooth, perhaps as a result of recent bank erosion, and away from roughness elements on the downstream side of the barb and through the rest of the revetment. The area adjacent to the revetment downstream of the first barb is therefore shallow slackwater. Any floaters that did find themselves in this area would not be threatened by swift currents past rough rootwads; more likely, they would simply come to rest on a gravel bar, at least at low water, when most floaters are most likely to use the river.

I can't rule out the possibility of swift currents during high water, but those seem unlikely in light of the growth of deposits near the left bank. This growth is apparent but not obvious from Fig. 1. Superficially, the mapped water lines seem to indicate post-restoration shrinkage of the near-left-bank gravel bar, but correct interpretation requires consideration of the discharge values corresponding to the different water lines. The yellow line indicates the greatest exposed bar area but corresponds to less than half of the flow corresponding to the green line, and the green-line discharge is greater than the magenta-line discharge. Pre-restoration mapping indicates a large emergent bar at 495 cfs, a bar that is apparently submerged at 906 cfs. Post-restoration mapping shows that the bar is emergent not only at the smaller discharge, 860 cfs, but also at the greater, 1150 cfs, so the bar must have grown. Again, bar growth is a good thing for both habitat and public safety.

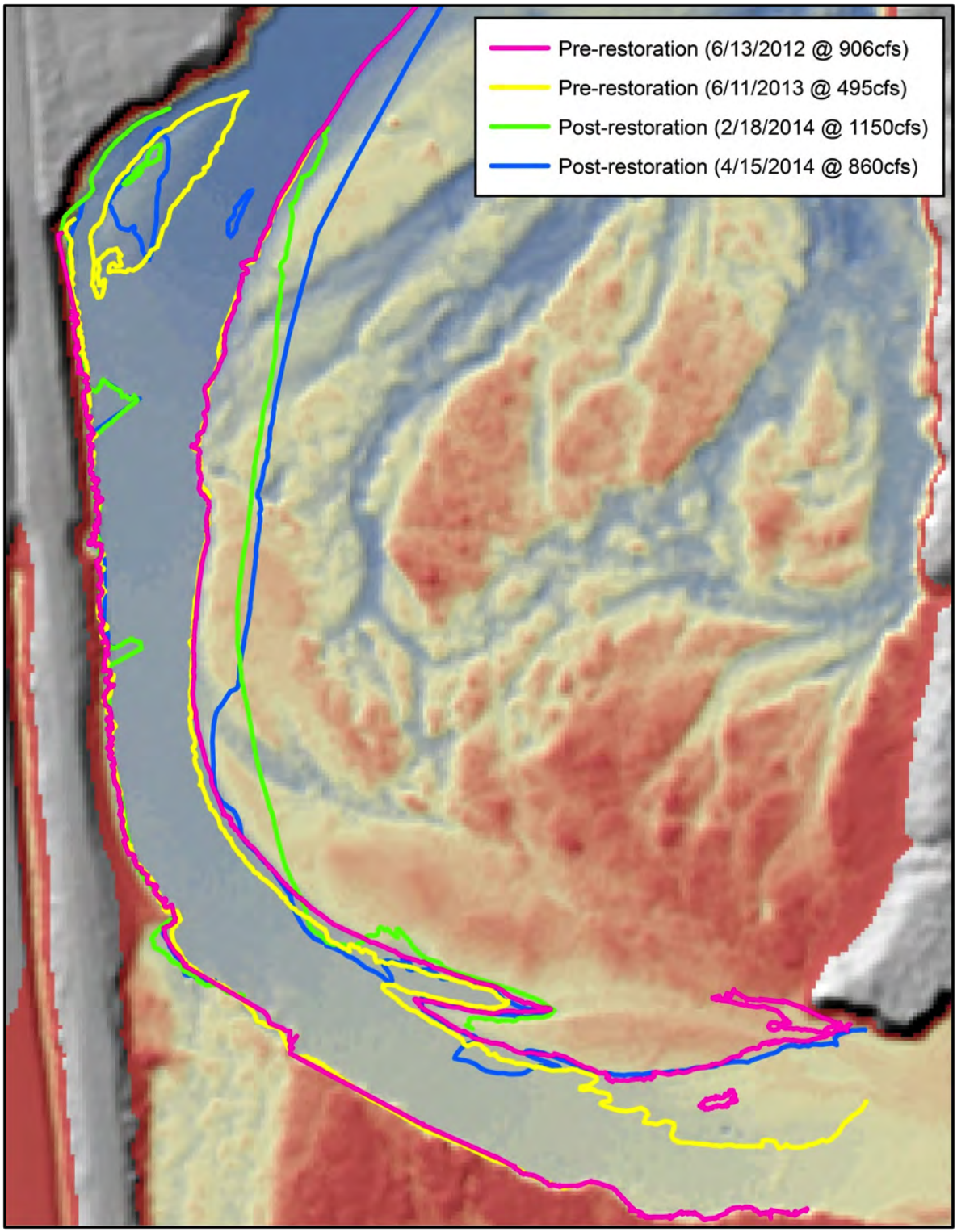


Figure 1. Digital elevation model (DEM) of Belmondo site (redder = higher, bluer = lower) with superimposed edge-of-water mapping at four different times, two before construction and two after. This reproduces figure 7 from the Belmondo monitoring report (B-20). Scale bar absent in original. The greatest of the flow rates at times of surveys is similar to the smallest of the annual peak flow, with average recurrence interval of 1.01 yr (Fig. 2).

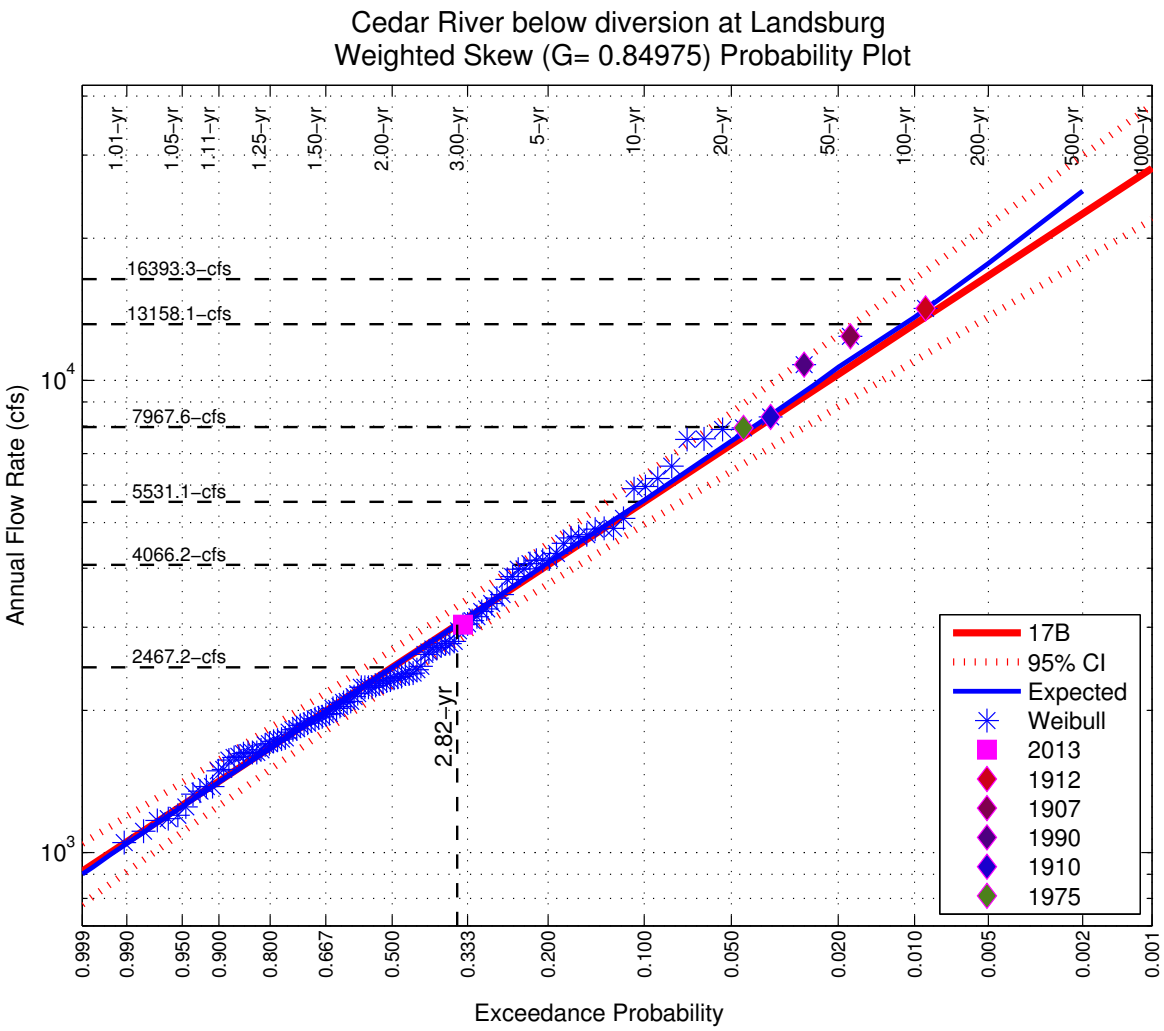


Figure 2. Flood frequency distribution for Cedar River below the diversion at Landsburg (USGS 12117600), a gauge reasonably representative of flows at the Belmondo and Herzman sites. Flood frequency analysis uses annual peaks for 1904–2013 and sets generalized skew equal to station skew, because generalized skew does not apply to regulated flow.

3. *Can the EP members identify any unintended safety hazards (i.e., underwater strainers, entrapment of natural wood, etc.) that have developed as a result of the implemented projects?*

   None were observed. Now, it is possible that someone on an inner tube could go under the first bumper log, but that "someone" would find themselves in a relatively still part of the pool, sheltered from the current by bumper logs. I consider such a scenario unlikely. Even if their momentum did cause them to hit the bumper log, the primary current would then sweep them off of and away from that bumper and toward the opposite bank. If anything, the second barb is "over-engineered" with respect to safety features, which are similar to those of the first barb, but whereas scour has exposed the rock apron on the first barb, the second is buried in sediment up to the low water level.

4. *Were adaptive management techniques applied at the site (such as reducing the number of unknowns, and better understanding to improve decision making), learning about management outcomes, and incorporating what was learned into ongoing management?*

   The project was so well (if perhaps over-) designed that adaptation appears unnecessary, unless they would like to forego unnecessary precautions and over-engineered design elements for future projects. Along those lines, I do have some suggestions, below.

5. *What additional data (or data gaps) would be beneficial for King County to collect during ongoing monitoring measures (or as baseline data prior to construction) to evaluate the effectiveness at each project site relative to meeting project goals and objectives? Is there a range of conditions recommended for data to be collected?*

   The design process might have benefitted substantially from two-dimensional hydraulic modeling. Such modeling might have revealed areas more and less likely to experience scour or deposition. Specifically, both barbs were designed with scour in mind. The bed on the upstream side of the upstream barb has been scoured deeply, so that bedrock is exposed in the bottom of the pool formed by that scour. The near-bank area is largely depositional from the downstream side of the upstream barb through the rest of the project, including the downstream barb. Design and construction of both barbs was effectively identical. The fact of sedimentation at the downstream barb up to the date of the site visit does not make later scour impossible, but the same degree of armoring of the downstream barb does not appear to be necessary. If nothing else, a 2-D model might have led to an understanding of the potentially different roles of in-stream wood and better predictions of which logs or structures would promote scour vs. those that would lead to deposition, which would likely be subjected to swift currents and steep shear stress gradients vs. providing shelter in slackwater, and which would and would not present potential hazards to the public.

   Also, my comments about collection of grain size data at the upper Carlson site also apply here. At Belmondo, grain size data and 2-D hydraulic modeling might have allowed reasonable prediction of the depth of the scour pool on the upstream side of the first barb, the texture of sediments deposited downstream, and the likelihood of erosion on the right bank.

6. *Has there been any loss or apparent degradation of features designed as public safety measures (i.e., emplaced wood, ELJs, bumper logs, barbs, geogrids for bank stabilization, signage, etc.) after the site has experienced a high flow or flood?*

   No such degradation was apparent.

Guiding Questions (Site-specific)

1. *(CE, GM, RS) Has there been an increase in lateral channel migration and floodplain connectivity, as can be directly or indirectly attributed to the 2013 project construction, including the use of two ELJs? (ref. B-20)*

2. *(CE, GM) Were high flows and shear along the left bank deflected, scour pools created, and connectivity with the right-bank floodplain accomplished through the construction of two ELJs? (ref. B-20)*

3. *(CE, GM) What physical process-based metric can be used to compare pre- and post-construction, or performance relative to a design flood threshold? (no ref.)*

   These points are addressed above.

4. *(CE, GM) Were mitigating measures taken against left-bank erosion (bank stabilization) for the trail as one critical flood protection measure to be maintained? (no ref.)*

   I believe the probability of left-bank erosion is negligible during anything short of the 100-yr flood, and probably not even then. Now, as indicated above, it would be nice to have 2-D hydraulic modeling results to corroborate that belief.

5. *(FB, CE) Was there an overall benefit (quality and quantity of aquatic habitat) to the implementation of the project design challenges, including increased deflection angle of ELJs, root wads on ELJs, elimination of voids and strainer effect, increased size and boulder space, and no exposed chains or cables? (ref. B-20)*

   As indicated above, implementation of design challenges on the upstream barb appear to benefit quality and quantity of aquatic habitat, but the same implementation on the downstream barb appears to provide little or no additional benefit.

6. *(CE, GM, FB) Were the vegetated geogrids effective in establishing riparian shade and cover for the replaced 2009 emergency riprap repair above the ordinary high water mark? (no ref.)*

   The plantings on the geogrids appear healthy and small. On the day of the site visit, they provided negligible shade and cover. They might be effective for shade and cover at higher stages. At least, I think they would withstand the potential onslaught of the flow at high water.

7. *(FB) Were the mitigation requirements for WDFW (impacts on aquatic habitat associated with log jam removals) met at Cedar Rapids (2011, RM 7.4)? (no ref.)*

8. *(FB, GM) Were fish refuges created through the reduction of local velocities and shear, and increased sediment deposits created through the construction of two complexes of roughness logs? (ref. B-20)*

   These measures did result in reduction of local flow velocities and shear stresses, as noted above.

Discipline-specific Procedures and Criteria Geomorphology: Use the criteria below as a guide in evaluating each site according to the members area of expertise, both through the field investigation and review of available documents.

- Condition of embankment (such as visible erosion, riprap, concrete, rebar, boulders), river substrate/bottom
- Seasonal flow rates, depths, and shifting channel conditions
- Flood hazard risk reduction, including erosion measures
- Adaptive management actions, respective to project effectiveness to meet stated goals

I believe these are addressed above.

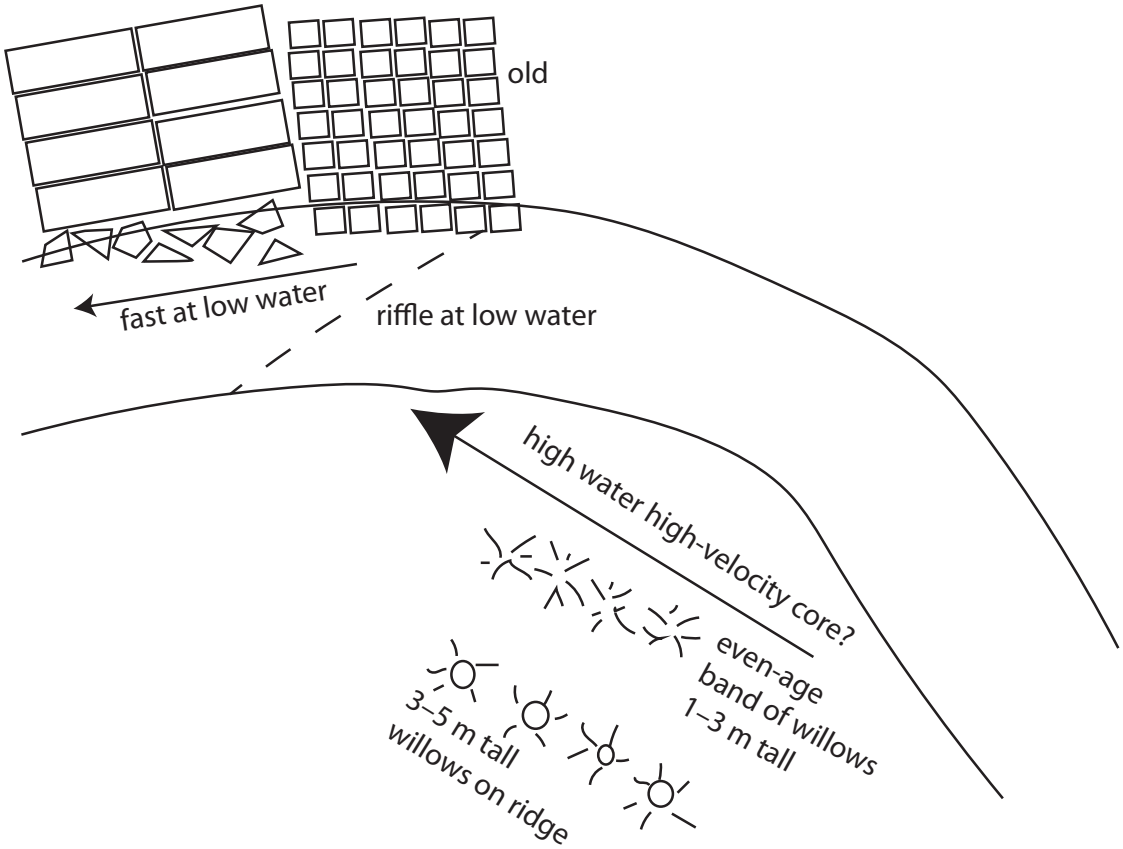


Figure 3. Copy of sketch made in the field of Herzman levee repair. Sketch shows trajectory of high-velocity flow at high water, as surmised from the location and orientation of even-aged bands of vegetation (similar to those described by *McKenney et al.*, 1995) on the floodplain. Old levee rock armor appears to have failed where the high-velocity core of the flow hits the bank during high water. Rock that likely entered the channel when the old levee armor was undermined was not removed during levee repair and remains in the stream and on the lower bank. This old rock now functions as in-stream and near-bank roughness.

4.2. **Herzman Levee Repair.**

Public Safety Considerations – Design and Implementation Phases. [Identify the ways in which public safety was taken into consideration during the design, implementation, and/or adaptive management measures (i.e., public meetings, revisions to the design at/after 30%, other safety considerations, in-river signage during construction, etc.)]

Permitting requirements originally called for incorporation of wood along the length of project, but safety issues raised by stakeholders led to scaling back on wood placements, and wood was incorporated only at the downstream end. As a result, the design included no wood where high-velocity flow is likely directed at the bank during high water, and where there was a riffle observed during the site visit at low water (Fig. 3). Rock on the lower bank and in the channel increases channel roughness locally and may mitigate somewhat for the roughness that might have been provided by incorporation of wood in the levee repair

at this upstream point. This rock is not part of the design; rather, failure of the old levee is the likely source of this rock, and it was not moved during levee repair (Fig. 3).

The wood structures were designed to minimize hazard to passing floaters (Fig 4). Structures each incorporate smooth log protruding from the bank on the upstream side and, on the downstream side, another protruding log but with attached root wad. The smooth, upstream log protrudes farther, so that floater-rootwad close encounters are unlikely. Rocks, small relative to those facing the levee, are placed in piles as "guards" on the upstream sides of large wood pieces near water level to prevent people floaters from being drawn under the wood.

Site-specific Project Goals and Objectives. [Were these achieved while minimizing risk to (or not impacting) public safety?]

Goals

1. Balance permit-required mitigation for construction impacts and recreational user safety

2. Have the levee function as originally designed; repairs are required due to flood damage to the face and toe of the upstream end of the levee; conduct repairs during the Cedar River fish window

Objectives

1. Repair 260 linear feet of levee along the face and toe of the upstream end

2. Replant the willows on the levee

3. Place large wood at the downstream end of the repair to mitigate for the existing canopy of willow and the wood in the water that was lost during the repair of the levee face

The goals were modest and the objectives straightforward for this project. The rock armoring the face of the repaired levee is much larger than in the original levee, as is evident at the seam between the original and repaired parts of the levee (Fig. 3). The larger rock should allow the levee to function as the original levee was intended. (Obviously, its builders did not intend for it to fail.) The willow plantings are healthy and robust (Fig. 4). The wood remains in place and provides some shelter and shade next to the right bank, where the flow is otherwise swift.

Figure 4. Photo of Cedar River and Herzman levee repair at downstream end. Flow is from right to left. Wood structures are visible protruding from the rock work just above the water line.

I do wonder whether the repair may have allowed a fundamental flaw of the original levee to remain in place. The old levee is presumed to have failed due to direct removal of rock by high-velocity flow or undermining of the rock face due to scour of the bed. Either of these explanations is consistent with observations stating,

> The levee has severe flood damage with several areas where the face rock is missing and bare soil is exposed. The levee face is eroded to a near vertical slope and the thalweg is close to the levee toe. (H-13)

Levee failure also occurs when the levee is over-topped by rising flow, and that plunging flow attacks the unarmored back side of the levee. Or, over-topping may follow as a consequence of mass failure, or slumping, which becomes more likely as water from the river permeates the levee, and rising pore pressures in the levee matrix reduce its effective strength. The effect is clear in the equation for the factor of safety for an infinite slope,

$$F_s = \frac{(\sigma - u)\tan\phi' + C'}{\tau}, \tag{1}$$

where σ is the normal stress due to the component of gravity normal to the failure plane; u is pore pressure; ϕ' is the saturated angle of repose; C' is the effective saturated cohesion; and τ is the shear stress due to the component of gravity parallel to the failure plane.

4.2.1. *Geomorphology.* [Stephen: Summarize findings for this site based on:

- Guiding questions, including adaptive management measures identified either through document review, site observations, or questions to King County Project Manager

- Consideration of the geomorphic consequences of the design and/or implementation that considers public safety, including but not limited to the interaction between flowing water and the placed wood (under projected flow regimes experienced during typical recreational seasons)]

Guiding Questions (General)

1. *What design elements (signage, ELJs, boulders, barbs, etc.) can be identified that were implemented with public safety as a primary consideration?*

   As described above, the design, number, and location of the log structures were largely driven by public safety concerns.

2. *In the EP members opinion, are there any noticeable changes (positive or negative) to the river immediately upstream or downstream as a possible/likely result of the project that impacts either the stated project goals or public safety?*

   I observed no such changes.

3. *Can the EP members identify any unintended safety hazards (i.e., underwater strainers, entrapment of natural wood, etc.) that have developed as a result of the implemented projects?*

   As described above and shown in Fig. 4, flow under the logs is blocked by rocks.

4. *Were adaptive management techniques applied at the site (such as reducing the number of unknowns, and better understanding to improve decision making), learning about management outcomes, and incorporating what was learned into ongoing management?*

   I could not identify any need for adaptive management in this case. One could argue that the design was not particularly ambitious, but then again, this levee is due to come out in 2018.

5. *What additional data (or data gaps) would be beneficial for King County to collect during ongoing monitoring measures (or as baseline data prior to construction) to evaluate the effectiveness at each project site relative to meeting project goals and objectives? Is there a range of conditions recommended for data to be collected?*

   I would have been curious to know how pore pressures in the levee matrix respond to river stage. Relative to construction costs, logging pressure transducers are cheap. In my research, we put them in shallow "wells" made from sections of steel fence post pipe (the sort used in chain-link fencing). One end is pinched shut, and the pipe at that end is perforated and wrapped in metal screening, which is secured with hose clamps. We use Solinst Levelloggers. Hobo also has some.

6. *Has there been any loss or apparent degradation of features designed as public safety measures (i.e., emplaced wood, ELJs, bumper logs, barbs, geogrids for bank stabilization, signage, etc.) after the site has experienced a high flow or flood?*

   I observed no such degradation. Everything is in good shape.

Guiding Questions (Site-specific)

1. *(CE, GM) Did the placement of large wood (downstream end of the repair) mitigate for the existing willow canopy and the in-water wood that was lost during the repair of the levee face? (ref. H-13)*

   From the qualitative descriptions given, there is no way to quantify the benefits of what was lost relative to what was replaced. The comparisons do seem a bit like apples and oranges. At this point, the replanted willows likely mitigate for what was lost, and we would like the logs buried in the bank to mitigate for the lost in-stream wood. I am skeptical on the second point, but I would need some quantitative basis on which to say anything beyond speculation.

2. *(CE, GM, FB) Based on available documents and field investigation, have the vegetated geogrids been effective in establishing habitat conservation measures since installation in 2010, including re-establishment of willow canopy and riparian shade and cover? (ref. H-01, H-02, H-21)*

   Although the willows appear robust, they were effectively the equivalent of large shrubbery at the time of the site visit and provided little shade to the river. However, I think it is fair to say that, given time, the willows will do the job.

3. *(FB) Has fish habitat (refuges) been created as a result of the levee repair features (repairs to 270 linear feet of eroded facility with geogrids, rock, and six large wood placements)? If so, to what extent is the panel member able to determine if additional habitat was created? (ref. H-02)*

4. *(FB) Is there evidence (either through available documents or field verification) of juvenile salmonids post-project construction? (no ref.)*

5. *(CE) Does the levee currently function as originally designed as a result of the repairs made in 2010 (see original drawings, 1976)? (ref. H-07)*

6. *(RS) Has there been an impact (positive, negative, or neutral) to local access points (Cavanaugh Pond Natural Area, Cedar River Trail, State Route 169) or downstream parks (City of Renton) as a result of restoring the levee to its originally intended design? (no ref.)*

7. *(All) What changes in behavior can be observed (from project documents or site investigation) of the opposite side of the river channel? (no ref.)*

   A band of even-aged willows, 1 to 3 m tall, is growing outboard of another, older band of willows on the point bar (Fig. 3). The sizes of the willows appear consistent with germination after the 2009 flood. I am not comfortable with attributing these willows to any change in behavior or saying that they are associated with the levee repair. It is good, and a little surprising, to see them. Similar vegetated bands are characteristic features of most actively migrating rivers. They are a key first stage in the succession of floodplain forests. However, this river has been frozen in place for some time by a levee. Eventually, halting migration also halts the formation of new floodplain forest, as the initiation of new bands of willows, the first successional stage, becomes less likely without the formation of new bar surfaces.

8. *(RS) Have there been any reported incidents as a direct correlation to the addition of four bumper logs and two large wood placed with rootwads (downstream of the bumper logs)? Is any of the placed wood or other placed structures along this reach of the river exposed in such a way that they have increased or decreased river recreational safety? (no ref.)*

9. *(CE, GM) Has the placement of large wood created areas of decreased velocity in the immediate (ref. H-02) vicinity of the levee repairs, and pulled the thalweg away from the levee toe?*

   At least at low water, like that on the day of the site visit, the thalweg and fastest flow hugged the levee toe. (Note the rougher water surface next to the bank in Fig. 4.) I would not expect the wood structures to have much effect on the flow field beyond the scale of local turbulence.

10. *(FB) Were the repairs all accomplished during the Cedar River fish window? (no ref.)*

Discipline-specific Procedures and Criteria Geomorphology: Use the criteria below as a guide in evaluating each site according to the members area of expertise, both through the field investigation and review of available documents.

- Condition of embankment (such as visible erosion, riprap, concrete, rebar, boulders), river substrate/bottom
- Seasonal flow rates, depths, and shifting channel conditions
- Flood hazard risk reduction, including erosion measures
- Adaptive management actions, respective to project effectiveness to meet stated goals

4.3. **Reddington Levee Setback and Extension.**

Public Safety Considerations – Design and Implementation Phases. [Identify the ways in which public safety was taken into consideration during the design, implementation, and/or adaptive management measures (i.e., public meetings, revisions to the design at/after 30%, other safety considerations, in-river signage during construction, etc.)]

Site-specific Project Goals and Objectives. [Were these achieved while minimizing risk to (or not impacting) public safety?]

Goals

1. *Reduce risks from flood and channel migration hazards for King County residents in the vicinity of the Reddington Levee along the Green River*
2. *Increase the width of the riparian corridor along the Green River in the vicinity of the Reddington Levee, with a resulting increase in flow capacity and ecological benefits*
3. *Reduce the vulnerability of the levee to fluvial scour, mass wasting, and channel migration*
4. *Reduce the long-term costs of flood hazard management*
5. *Allow the river to meander, scour, and develop a more complex ecosystem, which includes formation of rearing habitat for juvenile salmon*

6. *Protect existing vegetation and restore a corridor of native vegetation to increase shoreline and channel shading, support the riparian food web, and improve fish and wildlife habitat adjacent to and within the river channel*

The goals have, for the most part, been met without significant risk to public safety.

Objectives

1. *Replace levees that do not meet modern structural design standards and have a history of seepage problems*

2. *Set the levees back to reduce their susceptibility to scour and allow more natural channel movement within the project area*

3. *Increase the flow containment capacity of the levee system beyond 12,000 cubic feet per second (cfs) to 14,900 cfs plus 3 feet of freeboard*

   Yes to these, but I have some comments.

   This number is not based on the most recent estimate of the 500-yr recurrence interval flood; that most recent estimate is 18,800 cfs. USACE accurately refers to it as the 0.2% flood, because average recurrence interval is simply the inverse of the exceedance probability of a flow, so the 500-yr flood value has a 1/500 chance of being equalled or exceeded in any given year.

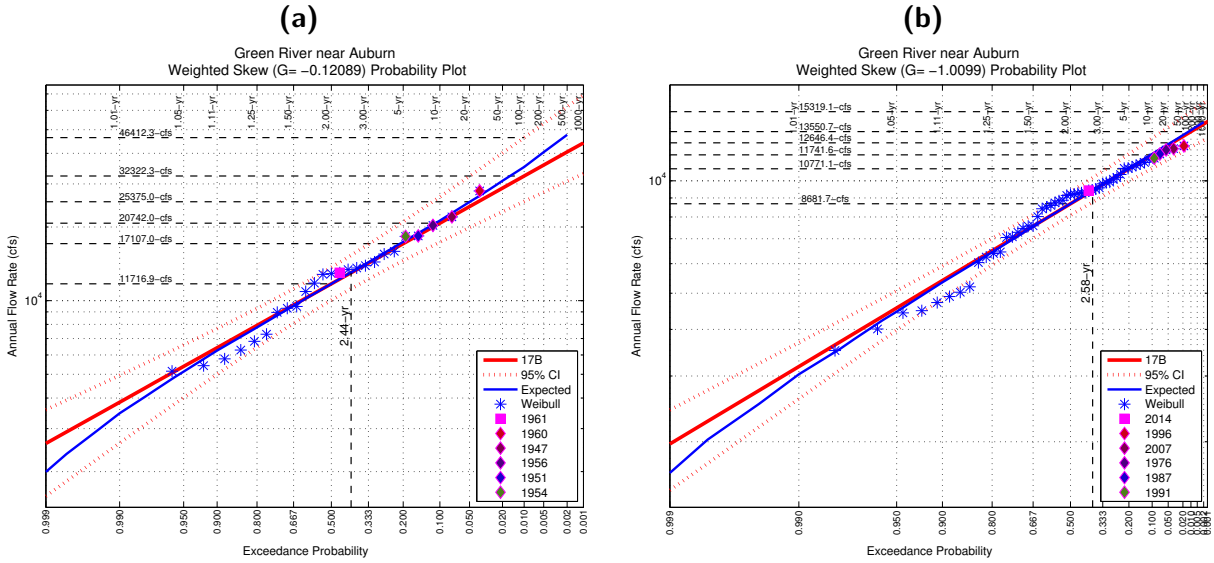


Figure 5. Flood frequency analyses for Green River near Auburn (USGS 12113000) for periods before (a) and after (b) the closing of Howard Hanson Dam, WY 1937–1961 and WY 1962–2014, respectively.

This estimate is not necessarily intuitive and therefore worth some explanation. Since flow regulation in this reach began in WY 1962 with the closing of Howard Hanson Dam (HHD), the flood of record peaked at 12,400 cfs on February 8, 1996. Naively basing a flood frequency analysis on only the post-dam record, 14,900 cfs corresponds to an annual peak flow with an average recurrence interval of $> 10,000$ yr. Getting a little smarter

and looking at the record before the construction of HHD, 12,000 cfs corresponds to an annual peak with average recurrence interval of 2.1 yr; for the same pre-dam period, 18,800 cfs is a 6.5-yr flood, and 14,900 cfs a 3.3-yr flood. For the post-dam period, 12,000 cfs becomes the 12-yr flood, and the probabilities for flows much greater than that become vanishingly small. How did they get these numbers? These estimates are based on the USACE determination

> ...that Howard Hanson Dam could only regulate flows to a 140-year flood. To evaluate safety issues at the dam, various reservoir inflow and regulation scenarios were simulated. One of these scenarios was adopted as the best available estimate of the 500-year flood and used for design of much of the lower Green River levee system upgrades to date. This scenario has a peak flow at the Auburn gage of 14,900 cubic feet per second (cfs). In November 2012, the Corps of Engineers released a report with new flood frequency estimates, including uncertainty bands, for the Green River (USACE, 2012). The new estimate of the 500-year flow is 18,800 cfs. King County determined that the project design had progressed too far to be changed at that point, so the Reddington levee design profile based on the older 500-year flow estimate of 14,900 cfs has been retained.(R-03)

The BoD's stated interpretation is a bit misleading. The new numbers are based on operations simulations for a set of flood events, from the 50% flood (2-yr recurrence interval) to the 0.2% flood (500-yr recurrence interval). Operations scenarios are based on a design discharge of 12,000 cfs for the Auburn levee. Their estimate of the 500-yr flood peak discharge is the median-probability (i.e., 50%) estimate of the peak flow at Auburn based on lower-bound, median, and upper-bound estimates of the 500-yr flood magnitude at the inflow to the reservoir impounded by Howard Hanson Dam (HHD), given a relatively complicated set of conditions and rules, including (a) the design discharge of 12,000 cfs, (b) the normal-pool maximum water surface elevation (WSE) of 1206 ft at HHD, (c) a starting-point WSE behind the dam, (d) a preference for gradually varying stage to avoid destabilizing the levees, and (e) initially passing inflows up to 10,000 cfs without storage. Their estimate of the 500-yr flood is *not* a proposed design flow. Rather, it is a statement of how badly the flood control system is likely to fail while trying to achieve a design flow of 12,000 cfs and making sure the dam does not fail. In general, their estimate of the 500-yr flood peak discharge would be different, and lower, if the design discharge were greater than 12,000 cfs (USACE, 2012). Now, USACE's design target of 12,000 cfs is based on the entire levee system, not just the levee at Reddington, and the USACE estimate may not be very sensitive to the value of the design flow of 12,000 cfs. Still, it is worth remembering that the USACE numbers represent the predicted magnitude of their failure to control flooding rather than a design prescription. Put another way, if we do consider it a design prescription and rebuild all levees accordingly, then it is likely that the prescribed design flow would be revised downward.

A final detail is worth noting: USACE's median estimate of the peak reservoir inflow rate during the 500-yr flood is 50,000 cfs, whereas the median estimate based on the pre-dam annual peak record *at Auburn* is 40,500 cfs (with 95% confidence interval of 30,800–62,000 cfs). Why the difference? First, they used a longer (78-yr) reconstructed record, and second, they considered different periods over which unusual volumes of rain would fall. The differences among the various estimates should emphasize that any prediction of unusual events comes with substantial error bars!

4. *Extend the levee system where no levee currently exists along roughly one-third mile of the river bank from just north of the River Mobile Estates to 43rd St. NE*

   Yes, done.

4.3.1. *Geomorphology.* [Stephen: Summarize findings for this site based on:

- Guiding questions, including adaptive management measures identified either through document review, site observations, or questions to King County Project Manager
- Consideration of the geomorphic consequences of the design and/or implementation that considers public safety, including but not limited to the interaction between flowing water and the placed wood (under projected flow regimes experienced during typical recreational seasons)]

Guiding Questions (General)

1. *What design elements (signage, ELJs, boulders, barbs, etc.) can be identified that were implemented with public safety as a primary consideration?*

   Arguably, the major motivator behind the whole project is increasing public safety by replacing an old levee that does not meet current standards with a new one that meets current standards and then some.

2. *In the EP members opinion, are there any noticeable changes (positive or negative) to the river immediately upstream or downstream as a possible/likely result of the project that impacts either the stated project goals or public safety?*

   I did not see the river up- or downstream, but I do not foresee there being a significant effect, much less a detrimental one.

3. *Can the EP members identify any unintended safety hazards (i.e., underwater strainers, entrapment of natural wood, etc.) that have developed as a result of the implemented projects?*

   None observed.

4. *Were adaptive management techniques applied at the site (such as reducing the number of unknowns, and better understanding to improve decision making), learning about management outcomes, and incorporating what was learned into ongoing management?*

   Among the sites reviewed, this one has the most monitoring data and reporting of adaptive management actions.

5. *What additional data (or data gaps) would be beneficial for King County to collect during ongoing monitoring measures (or as baseline data prior to construction) to evaluate the effectiveness at each project site relative to meeting project goals and objectives? Is there a range of conditions recommended for data to be collected?*

   See below.

6. *Has there been any loss or apparent degradation of features designed as public safety measures (i.e., emplaced wood, ELJs, bumper logs, barbs, geogrids for bank stabilization, signage, etc.) after the site has experienced a high flow or flood?*

None observed.

Guiding Questions (Site-specific)

1. *(CE, GM) Were there design and construction measures implemented that reduced the flood and channel migration hazards for the nearby residents? (no ref.)*

2. *(CE, GM, RS) Does the project as implemented provide an increase in flow capacity, as determined through available documents and field inspection? (no ref.)*

3. *(FB, GM, CE) Assuming an increase in flow capacity was created through the project, what ecological benefits can be observed (post-construction)? (no ref.)*

   Lacking data or modeling results that would provide quantitative answers, I can only speak qualitatively to this point. As built, the new levee had a larger design flood than the old levee, 14,900 cfs vs. 12,000 cfs.

   Changes since construction may also reduce flood risk, but that is far from certain. The levee setback allowed recent flooding in January 2015 to erode the bank by a substantial amount (although I don't have the means to estimate how much). Where erosion has occurred, flood conveyance should increase, although the overall amount of that increase will depend on where the eroded sediment has deposited. Some of it may have deposited within the project reach, where the gravel is smaller and the channel wider. That wider, shallower channel, at least to my eye, looks like better fish habitat than the deeper channel at the upstream end of the project reach (but of course that is not my area of expertise). However, it is possible that the same deposition could decrease flood conveyance. Given the substantial redistribution of sediment volume in the reach since construction, It would probably be a good idea to repeat the HEC-RAS modeling with updated topography and bathymetry.

4. *(CE, GM) Can the EP members identify any evidence that demonstrates that the designed/constructed project reduced vulnerability of the levee from fluvial scour, mass wasting, and channel migration? (no ref.)*

   Whereas the old levee would have constricted the flow at bankfull and higher discharges, so that the levee would have been subjected to attack by the main current, the setback of the levee should generally make it less prone to damage by swift currents. In addition to the distance from the channel, buried barbs will likely prevent lateral channel migration from threatening the levee.

5. *(CE, GM, RS) Is the design of the existing project conducive to reduce the long-term costs of flood hazard management? If so, to what extent is this measurable (and how)? (no ref.)*

6. *(CE, GM, RS) Are there other design recommendations that might further improve flood hazard management at this site? (no ref.)*

   Yes, but measurement of the likely reduction might be difficult. Perhaps they could draw inspiration from USACE, 2012 and explore the risks associated with flooding scenarios before and after. For example, one of the risks identified by USACE, 2012 is the potential need, in rare circumstances, to draw down the reservoir more quickly and, concomitantly, decrease flow more quickly than would be ideal for insuring the stability of the levee system. Is the new levee more stable relative to faster declines in stage?

7. *(CE, GM, FB) Does the project (as designed and constructed) allow the river to meander, scour, and develop a more complex ecosystem, which includes formation of rearing habitat for juvenile salmon? (ref. R-16)*

8. *(FB, GM) How can the ecological benefits as an outcome from the constructed project (construction, demolition, engineered erosion protection, and habitat protection) be determined/evaluated? (ref. R-02, R-16)*

   According to the monitoring report, the results of the project are generally good, and where there are outstanding issues, plans for addressing those issues have been implemented. The increase in "edge habitat" is particularly large, due mainly to the reconnected side channel, and juvenile salmonid counts are impressive. Problems such as invasive flora (canary grass and blackberry) and fauna (bullfrog) have been noted and measures to remedy the problems put into place.

9. *(CE, GM) Was the existing vegetation protected and the corridor restored with native vegetation to increase shoreline and channel shading? (R-16)*

   Shading was not addressed in the monitoring report; rather, the report addressed cover of different classes and survival rate of plantings. There is room for improvement in both, but remedies, including replanting to 100% of the design level, have been implemented.

10. (FB) If the existing vegetation and corridor were restored and there was an increase in channel shading, does it improve fish and wildlife habitat adjacent to and within the river channel? (ref. R-16)

Discipline-specific Procedures and Criteria Geomorphology: Use the criteria below as a guide in evaluating each site according to the members area of expertise, both through the field investigation and review of available documents.

- Condition of embankment (such as visible erosion, riprap, concrete, rebar, boulders), river substrate/bottom
- Seasonal flow rates, depths, and shifting channel conditions
- Flood hazard risk reduction, including erosion measures
- Adaptive management actions, respective to project effectiveness to meet stated goals

When considering the various aspects of flood control at this site, some things are so simple, others terribly complicated, and much of the trick is figuring out which is which.

High flows are simple for the most part. The U.S. Army Corps of Engineers ("the Corps") lets the smaller peaks, up to flows with 1.25-yr to 1.5-yr recurrence intervals (8000 to 10,000 cfs), through the dam with little interference. For greater flows, the Corps will stretch them out and, in nearly all occasions, keep the discharge at the Auburn gauge at or below 12,000 cfs, formerly the 2-yr flood. The dam operators at the Corps are good at what they do; the annual peak flow recorded at Auburn has been greater than 12,000 cfs three times since the dam closed in 1961, and the largest peak value among those was 12,400 cfs in February 1996.

This "cap" on discharge makes the question, what is the 100-yr flood? for example, difficult, so that the answer is either something along the lines of, "That's complicated," or just silly

and somewhat disingenuous. The simplest honest answer I could give to that question is that the 100-yr flood is about 30,000 cfs, maybe as high as 45,000 cfs or even greater, but that the Corps makes that not happen, so that something would have to go horribly wrong for Auburn to see a flow greater than 12,500 cfs, and that is only about a 2-yr flood, and the levees can typically deal with little floods like that.

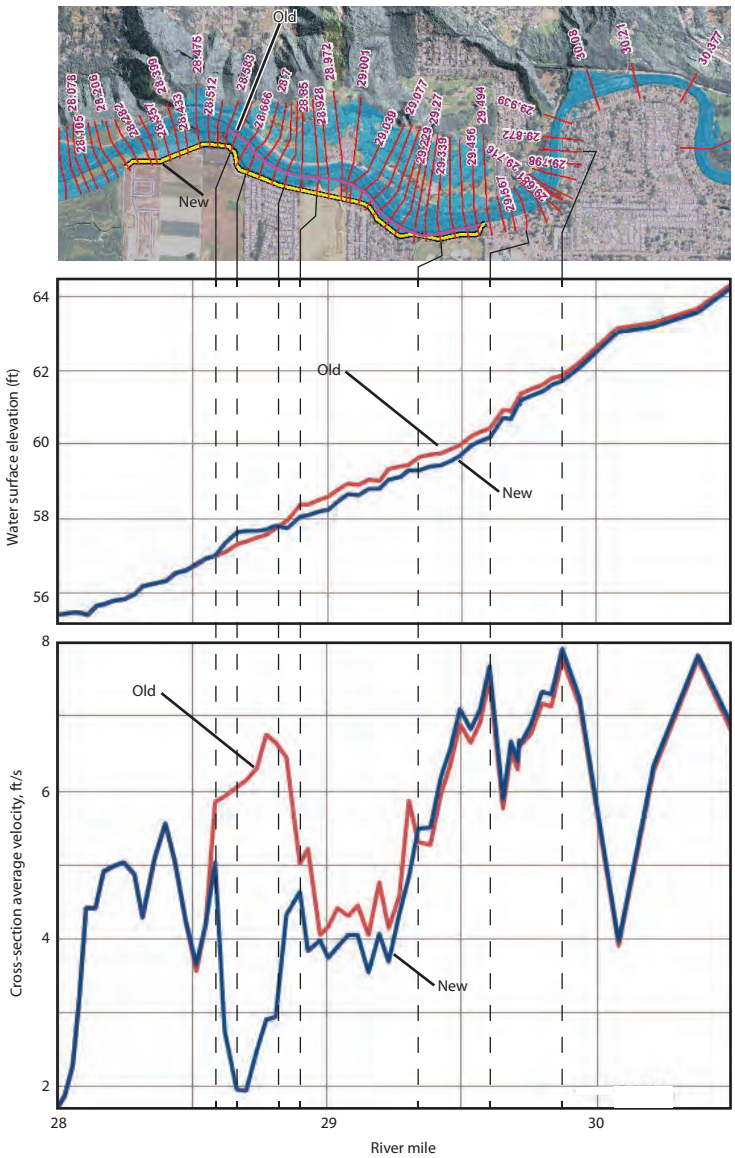


Figure 6. Results of HEC-RAS one-dimensional hydraulic modeling of scenarios before and after levee modification. Results shown are inundated area (top), water surface elevation vs. distance (middle), and cross-section average velocity vs. distance (bottom).

For projects like this levee setback, FEMA puts restrictions on the 100-yr flood level, so some number must be calculated. Pull out Bulletin 17B and get busy. In reviewing the requisite flood modeling presented in the Basis of Design (R-03), I nearly laughed out loud at the idea that the 100-yr flood is 12,500 cfs at Auburn. That answer simply ignores what the question really means when FEMA asks. What FEMA means is this: Draw the line on the ground, such that the line separates places where the probability of inundation by flood water is less than 1% per year on one side of the line and greater than 1% per year on the other. As far as I know (which may not be far), "probability of inundation" does not mean, "conditional probability of inundation given that nothing else, such as a levee failure, goes wrong." When the Corps was asked the 100-yr flood question, they really answered it:

> For the median and lower confidence limit scenarios project releases were made to target 12,000 cfs at Auburn. The pool was fully evacuated in the lower confidence limit scenario and partially evacuated at the end of the median confidence scenario. For the upper confidence

> limit scenario, releases were required per the DRS that resulted in a peak flow at Auburn of about 15,100 cfs. (USACE, 2012)

That answer might need some translation. That bit about "the pool" being only "partially evacuated at the end of the median confidence scenario" is not good, because the "scenario" was 15 days long, the peak in the reservoir inflow was at 1.5 days, and bets are off if another storm hits before they finish emptying the pool. That second storm might require consideration of some risky alternatives. For example, they could try to beat the storm by spilling faster, but one reason emptying the reservoir takes so long is that reducing stage more quickly than 1 ft/day risks destabilizing the levees. This is a serious concern: "In many of the smaller flood events, the desire to limit stage reductions at Auburn prevented Auburn flow from ever reaching 12,000 cfs" (USACE, 2012).

Along these same lines, I have been trying to decide whether the HEC-RAS modeling results are complicated or simple (Fig. 6. I tend to think it must be relatively simple, but I cannot make much sense of the explanations provided in the Basis of Design. In general, though, flow will accelerate where it widens and decelerate where it narrows; accelerate where the water surface steepens and decelerate where the water surface gradient becomes more gradual; over long distances, the water surface is parallel to the bed. Manipulating widths of large flows, especially introducing sudden constrictions and expansions, can lead to dramatic results, and it is possible that some of the sudden jogs taken by the new levee might lead to more erosive, and more depositional, flows than expected.

So we come back to the same old song: especially if there are places where 1-D modeling raises questions, then do some 2-D hydraulic modeling, even if it only targets smaller areas.

I have found a few things to pick at here, and I think they should be addressed, but overall I am impressed by the ambitious scope and diligent execution of this project. In particular, the monitoring so far has been thorough and data-rich. Moreover, I see no particular issues regarding public safety.

4.4. **Upper Carlson Floodplain Restoration, Snoqualmie River.** The geomorphic setting for this site is a relatively straight reach on a meandering river. Prior to the project, the channel in the project reach was narrower than adjacent reaches because the present-day main channel was a secondary channel at the time of levee construction and straightening in 1936, after which time the "improved" channel pirated the major part of the flow and deposition partially blocked the old, curved channel. Despite the increased flow, the improved channel remained narrow and therefore deepened via incision. Just downstream of the project, the sinuosity increases markedly, and consequently, the stream gradient decreases abruptly (Fig. 7). This break in slope may also be related to proximity to the mouth of the Raging River. Bed texture is dominated by gravel and coarser particles at the project site, which is approximately 3 km downstream of the Raging River confluence, whereas elsewhere the Snoqualmie is predominantly sand-bedded (C-079). The high sinuosity of the Snoqualmie River suggests a past dynamism that is absent in the present river; levees along nearly the entire length of the river below Snoqualmie Falls have effectively fixed the river in place since 1990, the date of the earliest photos shown in Google Earth. Rapid migration within a short reach upstream of Snoqualmie Falls hints at the river's potential dynamism (Figure 8). The relative steepness of the project reach will tend to promote both vertical

incision and bank erosion, but past incision has likely armored the bed, so additional incision is unlikely.

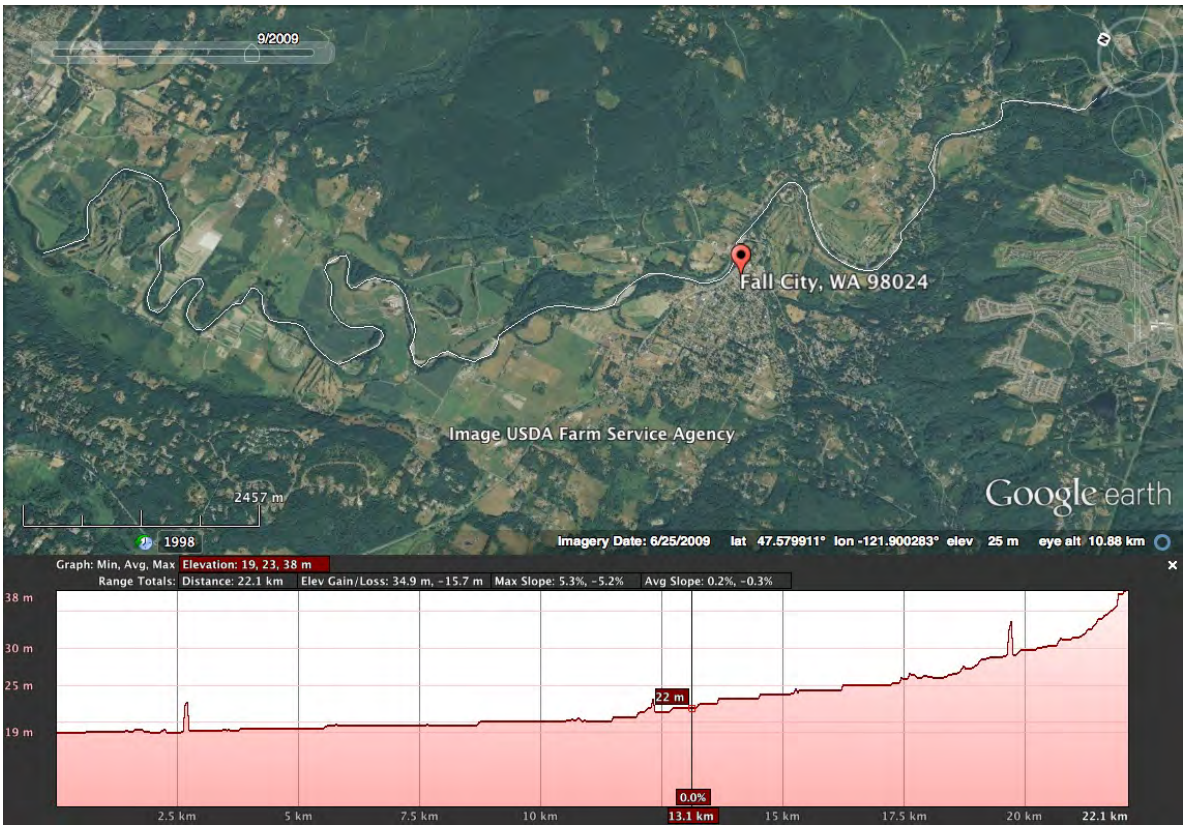


Figure 7. Aerial photograph (2009) of Snoqualmie River, with Upper Carlson site in the approximate center, and path (in white) tracing the river (top); and elevation profile along the path (bottom). Vertical line on profile marks middle of Upper Carlson reach.

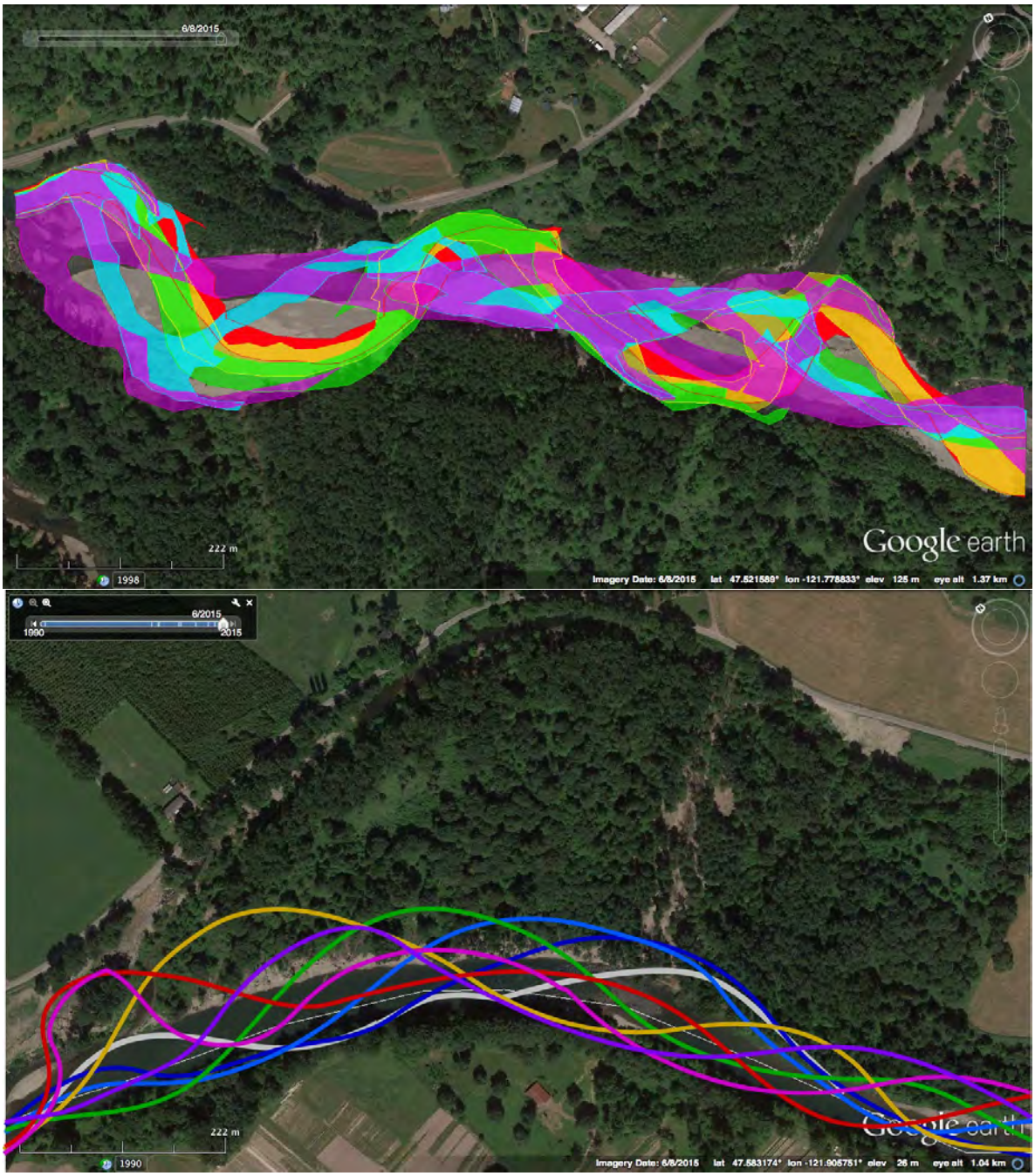


Figure 8. Top: Aerial photograph taken in 2015 of the Middle Fork Snoqualmie River at the North Fork confluence, with past low-water channels superimposed in different colors: red = 1998, yellow = 2006, green = 2009, cyan = 2011, and magenta = 2014. Bottom: Drawings, on 2015 aerial photograph of Upper Carlson site at the same scale as above, to illustrate the potential for initiation and migration of several bends within the project reach. Gray line is pieced together from traces of nearby bends downstream of the project, and colored lines are speculative predictions of the evolution of that initial channel at later times, given the constraints imposed by remaining levees and the "catcher's mitt" at the downstream end of the project.

Shortly after the project construction, in January 2015, discharge peaked at 50,000 cfs, which exceeds the 5-year recurrence flood (i.e., the probability of the annual peak discharge equalling or exceeding 50,000 cfs is between 0.1 and 0.2; Fig. 9). This flood resulted in right-bank erosion and concomitant increase in channel width, as well as deposition of a new gravel bar on river left near the upstream end of the project. Prior to project construction, the hydraulic width at "ordinary high water" (OHW) was nearly uniform at 140 ft. and 150 ft. at low flow. According to the as-built drawings, upon project completion the distance from the TFP ("tree felling and placement") line to right-bank edge of water at low flow and was 65 ft, or 60 ft. to OHW edge of water, and 57 ft. to the top of the bank. As of January 15, 2015, that distance to OHW edge of water was only one-third of the original distance, i.e., 20 ft., so that the OHW hydraulic width increased to 180 ft. As of the time of the site visit on August 24, 2015, similar to the time of the sheriff's jet-boat inspection on April 24, 2015, woody debris had fallen into the channel at only 2 locations, so the bank remained relatively smooth.

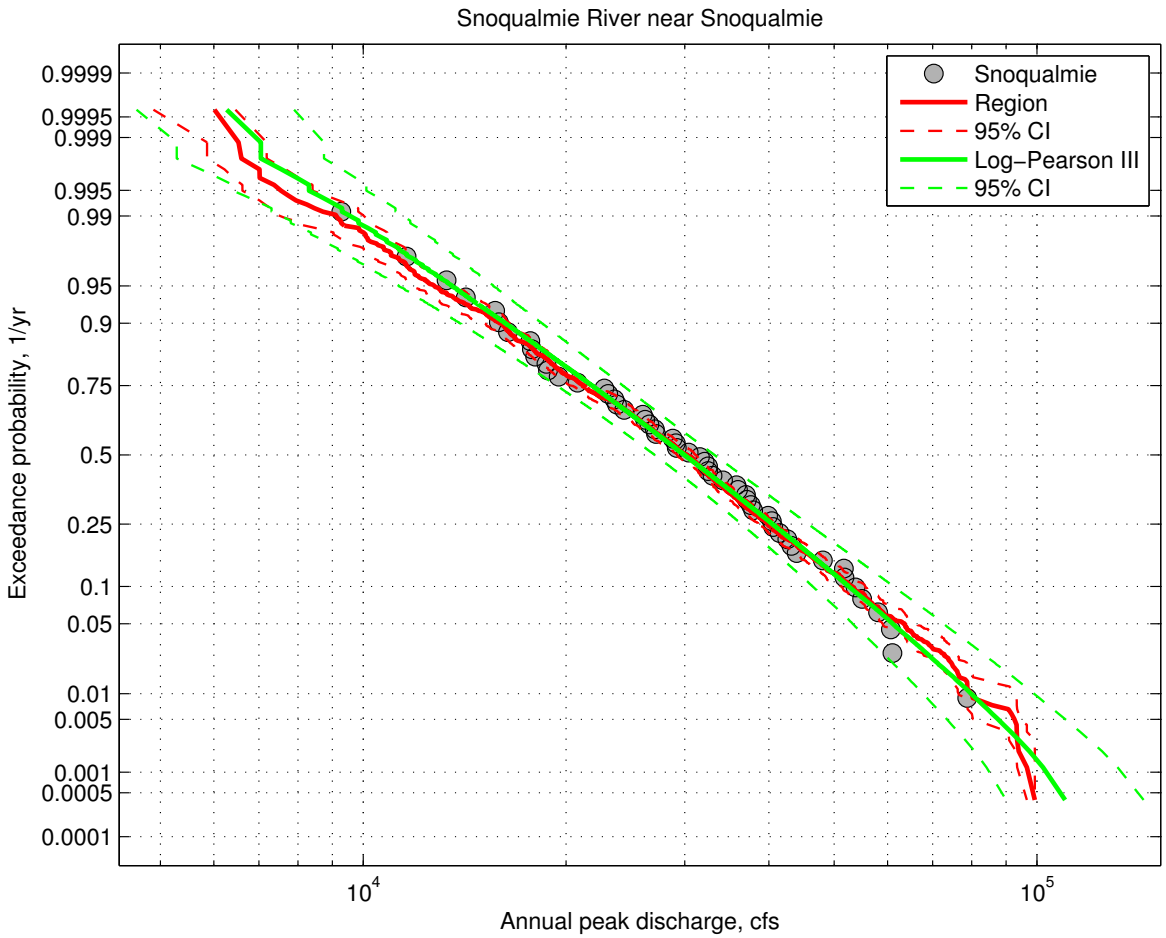


Figure 9. Flood frequency distribution for the Snoqualmie River near Snoqualmie, Washington (USGS 12144500), log-Pearson Type III fit to the Snoqualmie data (*Interagency Advisory Committee on Water Data*, 1982; *Burkey*, 2009), and regional distribution combining 1287 annual peaks from 27 gauges in the Puget Lowlands, with 95% confidence limits for the fit and, via bootstrapping, the regional distribution. For the regional distribution, mean annual flood discharge is used for normalization; for nearby gauges on the same stream, redundant values are not included; and neither are values affected by regulation or diversion. For graphical purposes, plotting positions are determined according to a log-normal distribution. The inverse of exceedance probability is the average recurrence interval.

This channel enlargement and its effect on shear stress may explain, in part, why bank erosion during the January 2015 flood stopped short of the TFP line. The hydraulic modeling of the 1.25-year recurrence flow for both pre- and post-project cases implied that water surface gradient and, therefore, boundary shear stress in the upstream part of the project reach would decrease slightly, by 10% (Table 1). However, the increased cross-sectional area of flow associated with post-project bank erosion implies a greater flow velocity reduction than predicted by the hydraulic modeling of the as-built case and, hence, a larger, $> 50\%$, reduction in boundary shear stress (Table 1).

Table 1. Esitmated hydraulic changes, 1.25-year recurrence flow, Snoqualmie River.

Parameter	Pre-project value	Post-project value
Water surface gradient, S	9.4×10^{-4}	8.6×10^{-4}
Average flow depth, H, m	7.3	7.3
Average boundary shear stress, $\tau = \rho g H S$, Pa	67	62
Hydraulic width, B, m	43	55
Cross-sectional area of flow, A_{cs}, m^2	320	400
Flow velocity, U, m/s	1.8	1.2
Average boundary shear stress, $\tau = \rho C_f U^2$, Pa	67	29

Public Safety Considerations – Design and Implementation Phases. [Identify the ways in which public safety was taken into consideration during the design, implementation, and/or adaptive management measures (i.e., public meetings, revisions to the design at/after 30%, other safety considerations, in-river signage during construction, etc.)]

Managers and planners considered public safety in every decision, and they found that the project poses a small and manageable risk to public safety. Recreational use surveys provided usage rates and skill levels, and King County personnel sought, received, and substantively addressed public input. County personnel gave public presentations, wrote detailed responses to questions and concerns (e.g., letters of Nov. 19, 2013), and modified plans to address some potential hazards. A key finding is that the project reach is rarely used by recreational floaters, especially since a successful private business in Fall City is designed around floaters leaving the river just upstream of the project site, and floaters are directed by large signage to use that take-out point.

Some aspects of the project may pose hazards in the future, but I believe that the immediate effects actually reduce risks. As detailed above, bank erosion occurring as a direct result of the project has widened the channel, so that flows will be slower. Consultants also predicted the deposition of bed material as a result of channel widening, and indeed a new (gravel) point bar has formed at the upstream end. Widening, then, is also making the channel shallower. Whereas the pre-project river was narrow, deep, and swift, the restored river is wider, shallower, and slower, and the new bar provides a potential beaching point for floaters that overshoot their take-out point.

Site-specific Project Goals and Objectives. [Were these achieved while minimizing risk to (or not impacting) public safety?]

Goals

1. Promote more natural rates and frequency of channel and floodplain processes (such as channel migration, overbank flooding, and wood recruitment) to improve salmon spawning and rearing habitat with the primary focus on restoring mainstem edge and off-channel rearing habitat, specifically for ESA-listed juvenile Chinook salmon and steelhead trout.

   In the first year, a flood (with peak flow of 50,000 cfs) corresponding to an annual maximum flow with a 5- to 10-yr average recurrence interval (Fig. 9) caused substantial bank erosion, but not yet to the point of much wood input to channel. Given 1) the

relatively narrow pre-project channel, 2) the nearly uniform bank erosion through the project reach, and 3) the typically shorter wavelengths of meanders in adjacent reaches (Figs. 7, 8), I infer that the recent bank erosion represents channel enlargement rather than migration *per se*. That said, the new point bar at the upstream end of the reach suggests that channel migration will follow, because point bars are necessary for channel migration that is typical of meandering, i.e., coherent bends that, when relatively small, rapidly migrate downstream. However, remaining constraints, including the left-bank levee, levees on adjacent reaches, and the set-back levee at the downstream end of the reach (the catcher's mitt), will likely inhibit the development of large-amplitude bends at the Upper Carlson site. Small meander bends migrate downstream; as the bends lengthen, the locus of larger bank shear stress remains "tied" to the upstream cross-over, i.e., the point of zero curvature between one bend and the next, and the transverse component of migration increases. The abandoned meander bend next to Neal Road had to originally migrate to its present position from upstream. That downstream sense of migration is evident in the 1936 aerial photograph from the wide unvegetated area indicative of downstream migration of the upstream bend. At that time, it appears that migration was already inhibited on the right by efforts to protect Neal Road and on the left by a levee.

2. Maintain or improve current levels of flood hazard protection of private property and public infrastructure.

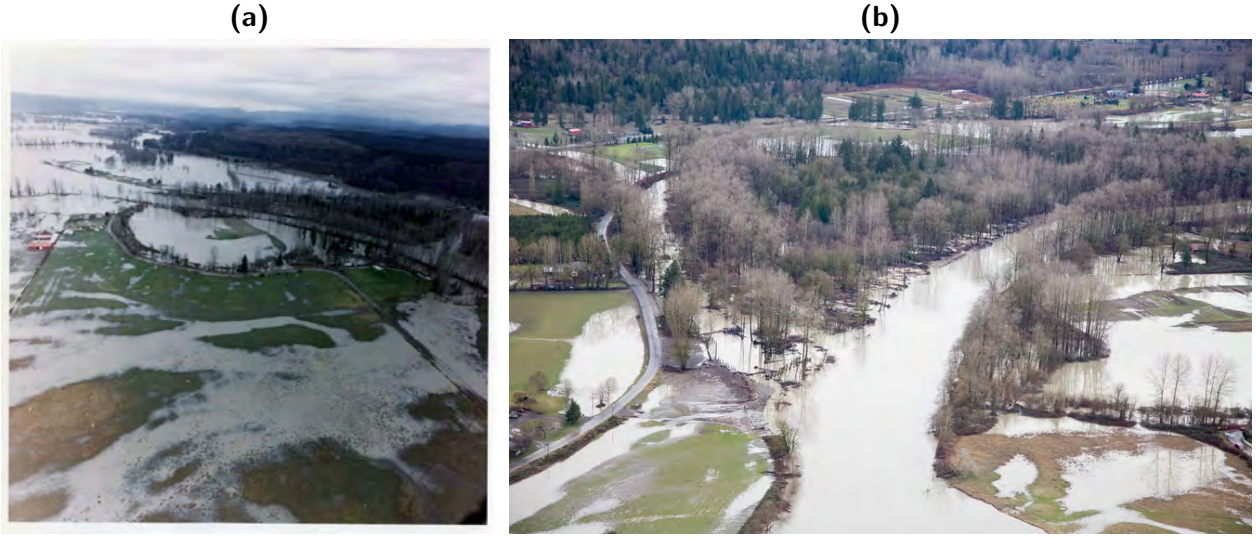


Figure 10. Oblique aerial photographs of the 1990 (a) and 2015 (b) flood events on the Snoqualmie River at the upper Carlson site. The 1990 photo was taken on November 24, the same day that the Snoqualmie gauge recorded the peak flow of record, 78,800 cfs. The 2015 photo was taken on January 5, the day the Snoqualmie gauge recorded a peak flow of 50,100 cfs. According to the flood frequency distribution shown in Fig. 9, the 1990 and 2015 peak discharges have average recurrence intervals of 68 yr and 8 yr, respectively. The 1990 photo shows all of the project reach, where the flow is noticeably constricted relative to the reaches up- and downstream. The levees in the 1990 photo are visible as dark, unbroken lines separating channel from floodplain. The 2015 photo shows the project reach from downstream and, in the distance, a bit of the upstream reach. Note that the transition, so apparent in the 1990 photo, is difficult to pinpoint in the 2015 photo; at the time of the photo, rapid bank erosion had already widened the channel, and water is flowing between channel and floodplain via numerous small channels. The bottleneck formed by the end of the Aldair levee and the upper part of the lower Carlson levee is visible in the foreground.

Two-dimensional hydraulic modeling predicts that changes in water surface elevation (WSE) during high flows are mainly small and/or negative, but flood levels might increase by a few tenths of a foot in some places (C-079). Note, however, that the hydraulic modeling could not account for the channel enlargement that has already taken place. In the upstream part of the site, predicted decreases in flood WSE are consistent with enlarging the bottleneck represented by the former narrow, leveed channel (Fig. 10). As the narrowest part of that bottleneck was moved downstream by removal of the levee, WSEs backed up behind that bottleneck have also moved downstream. Recent bank erosion and channel enlargement seem likely to increase this tendency: The bottleneck is effectively gone from the upstream end of the reach, and the bottleneck formed by the lower Carlson revetment and the downstream end of the Aldair levee catcher's mitt on the right side and the Aldair levee on the left remains. I would expect accelerating flow and steepened water surfaces during flooding to be particularly steep at, and immediately downstream of, that bottleneck. The problem existed prior to project construction, as evidenced by the eroding bank at the Richmond property, but the removal of the upstream bottleneck will likely worsen the problematic patterns of scour and deposition downstream of the Aldair levee. It might therefore be appropriate to apply adaptive management funds to

slight setback and extension of the Aldair levee. Setting it back to parallel the upstream part of the lower Carlson revetment would ease the bottleneck somewhat, and extension would protect land currently threatened by bank erosion. Alternatively, or in addition, creative in-channel use of an excavator to remove some willows from the Carlson side and transplantation of willows on the Richmond side might lead the thalweg to switch sides and allow a bar to develop adjacent to the left bank.

3. Address potential impacts on recreational boater safety.

I largely addressed this goal above. Continued monitoring and inspection by the sheriff, as planned, will allow adaptive management to mitigate any risks posed by large wood entering the channel as it meanders.

4. Enhance and maintain the native riparian vegetation community

Ongoing monitoring catalogs invasive species at the site, and that monitoring has recorded that knotweed infestation is ongoing. The project has ample reserve funds to address this issue. Of course, the stated goal is to "enhance and maintain" natives rather than eradicate invasives. The barren bank should be monitored so that native riparian species are able to colonize the bank as it evolves. I don't see this as an area of concern for public safety.

Objectives

1. Remove approximately 1,600 feet of existing levee and allow the river to expand, migrate, and reconnect with former channels within this reach
2. Construct approximately 1,200 feet of setback revetment to protect Neal Road and the adjacent Carlson property
3. Incorporate input from the local recreational boating community into the Design Plans and the Site Management Plan and implement this plan to manage risk to recreational boaters at the site and in the reach
4. Re-vegetate areas disturbed during construction and areas where invasive plants have been treated with herbicide; continue to manage invasive plants and promote native communities

These objectives were achieved or represent activities ongoing without significant risk to public safety.

4.4.1. *Geomorphology.* [Stephen: Summarize findings for this site based on:

- Guiding questions, including adaptive management measures identified either through document review, site observations, or questions to King County Project Manager
- Consideration of the geomorphic consequences of the design and/or implementation that considers public safety, including but not limited to the interaction between flowing water and the placed wood (under projected flow regimes experienced during typical recreational seasons)]

Guiding Questions (General)

1. *What design elements (signage, ELJs, boulders, barbs, etc.) can be identified that were implemented with public safety as a primary consideration?*

   The largest and most noticeable features of the project are the nearly complete absence of large wood outboard of the TFP line, where rapid bank erosion was expected to occur, and the felling and placement of many whole trees among standing trees on the floodplain, where those standing trees are likely to provide natural anchors and largely keep the wood in place without use of anchor chains or the like. Had the felled trees remained in their original locations, wood input would have been immediate and rapid, as noted by project personnel (C-101).

   The other large noticeable feature of the project is the catcher's mitt, which catches floating logs and uses that wood to help protect the upstream end of the lower Carlson revetment, and this feature was modified to mitigate risk. Specifically, it was shortened to protrude less into the flow and redesigned to employ ballasted wood and rock to block flow under and through the engineered and growing jam.

   Design revisions modified locations and orientations of buried logs to mitigate risk to the public. Buried logs are now angled downstream or perpendicular to the bank to provide a softer landing for wayward floaters. Logs were buried at shallower depths to reduce interaction with the flow at lower stages, when floaters are more commonly on the river. Most logs were buried farther from the channel, and those buried close to the channel were located in the downstream third (approximately) of the site reach. Indeed, bank erosion during the January 2015 flood has exposed some of these logs, and they are easily seen from a distance of several hundred feet.

2. *In the EP members opinion, are there any noticeable changes (positive or negative) to the river immediately upstream or downstream as a possible/likely result of the project that impacts either the stated project goals or public safety?*

   No such changes were observed.

3. *Can the EP members identify any unintended safety hazards (i.e., underwater strainers, entrapment of natural wood, etc.) that have developed as a result of the implemented projects?*

   None were observed. Those logs that did protrude from the bank were noteworthy for their modest interaction with the flow in August 2015.

4. *Were adaptive management techniques applied at the site (such as reducing the number of unknowns, and better understanding to improve decision making), learning about management outcomes, and incorporating what was learned into ongoing management?*

   King County personnel appear actively engaged with the project. As such, our "tour guide" did not appear surprised by, or unfamiliar with, recent developments at the site. Moreover, the rather dramatic amount of bank erosion was expected. The quantity and quality of prior study at this site is truly impressive. The 400-page "Basis of Design" report by Herrera and King County brought impressive levels of human and technology resources to the task (C-079). King County is well equipped to move forward.

5. *What additional data (or data gaps) would be beneficial for King County to collect during ongoing monitoring measures (or as baseline data prior to construction) to evaluate the effectiveness at each project site relative to meeting project goals and objectives? Is there a range of conditions recommended for data to be collected?*

   The Basis of Design mentions contrasts in bed material grain sizes within a few miles downstream of the Raging River confluence: whereas the Raging River supplies gravel and cobbles, and the bed is predominantly composed of gravel and larger particles, in this part of the Snoqualmie, most of the Snoqualmie is sand-bedded. So, there is mention of existing grain size data, but other than mentioning the 2 mm sand-gravel threshold, none of those sizes are included in the report, or anywhere else that I can find.

   The sediment budget is important for this project. Designing the right bank so that it would erode was a major design feature. They recognized that initiation of lateral migration required a gravel bar to form, which they predicted, and which happened. The lack of sediment storage in the project reach prior to construction and the ongoing deposition and gravel bar growth past the downstream end of the project reach were recognized as contributing to the bank erosion problem at the Richmond property. Still, we have no grain size data. Such data, especially given the extensive hydraulic modeling done here, would allow calculations addressing the issue of, say, the frequency of flows that fully mobilize the bed. For example, given my own calculations of shear stress and flood frequency above, grain size data would allow assessment of the effective reduction in bedload transport rate. Specifically, gravel transport rate is typically very sensitive to changes in shear stress for values that typically occur during bankfull discharge. That sensitivity to shear stress is also realized through sensitivity to grain size. With grain size numbers, calculations could provide some indication of the range of discharges that promote high transport rates, how often such discharges occur, and how that range may have shifted following enlargement of the channel. Finally, pebble counts are not difficult. Yes, they are tedious; yes, their feasibility is limited to relatively shallow water; but the information they provide is valuable in the hands of someone armed with a state-of-the-art bedload transport formula (e.g., *Parker*, 1990; *Wilcock and Crowe*, 2003), for which free, useable tools are available (e.g., *Parker*, 2004).

6. *Has there been any loss or apparent degradation of features designed as public safety measures (i.e., emplaced wood, ELJs, bumper logs, barbs, geogrids for bank stabilization, signage, etc.) after the site has experienced a high flow or flood?*

   None that I observed.

Guiding Questions (Site-specific)

1. *(GM) Does there appear to be restored connectivity with the natural floodplain, or does the river appear to be migrating back to the natural floodplain (right bank) as a potential result of this project? (ref. C-094)*

   As predicted and mentioned above, right-bank erosion has been dramatic in the first year. During the flood that caused that erosion, video documentation shows water spilling from the channel into the old channel and over the banks to the floodplain. I cannot address the question quantitatively, however, because I have no monitoring data other than photographs and video clips, e.g., from monitoring records of water level. The 2D

hydraulic modeling indicates that parts of the floodplain will become inundated during the 1.25-yr recurrence flow and greater, and the pathway for that inundation is now relatively unobstructed.

2. *(CE, GM) Does the available data from Water Year 2015 (flood magnitude and duration) indicate that the channel migration and overbank flooding occurred as potential result of this project? (no ref.)*

   The bank could not have eroded as it did without removal of the rock that was armoring the bank prior to the project. And, while the floodplain may have gotten wet before, levee removal has provided a direct pathway for water spilling from the channel onto the floodplain.

3. *(CE, GM) Has there been a reduction in flood flow velocities and channel migration rates as a result of moving approximately 70% of the large and small diameter trees (creating large log clusters) into the floodplain during the single post-construction water year? (no ref.)*

   As detailed above, I expect that flood flow velocities in the channel have been reduced. And, with the quantity of wood now lying on the floodplain, overbank flow velocities must be reduced, although I have no way to quantify such a statement.

4. *(FB) Has there been an increase or improvement in salmon spawning and rearing habitat in the mainstem edge, side channels, or off channels as a likely result of this project? (C-098)*

5. *(FB) What has been the impact on habitat for ESA-listed juvenile Chinook salmon and steelhead trout? (no ref.)*

6. *(GM, CE) Has there been an increase in wood recruitment, logjam formation, and other habitat-forming natural processes as result of setting back the levee and revetment in the Snoqualmie River? (ref. C-006, C-095, C-098)*

   By design, only a small amount of wood placed on or buried within the floodplain interacts with the flow at stages lower than bankfull. The lion's share of that wood will be recruited gradually over the coming years.

7. *(GM) Has there been a reduction in channel migration along the left bank as a result of reinforcing the downstream 40 feet of the Aldair Levee and bolstering the levee with large angular rock 175 feet upstream of the levee (Adaptive Management Item No.1)? (no ref.)*

8. *(CE) Has the reinforcement and extension of the Aldair Levee maintained the existing left-bank configuration and pre-project flow orientation? (C-095)*

   Not applicable. There has not (yet) been any work done on the Aldair levee, nor has other work addressed the left-bank erosion. Comments above address potential remedies.

9. *(CE, GM) Does the project improve levels of flood hazard protection (erosion and flooding), both to private and public property? (ref. C-006)*

   This is addressed above.

10. *(CE, GM) Relative to a threshold or a single wet year cycle, is there any evidence of reduced flooding of adjacent property, and if so - what? (no ref.)*

    No.

11. *(RS) Were there recreational safety signs or other means of public notification regarding work at the site as a means to improve the overall recreational safety along this reach of the river? (ref. C-139, C-144, C-147)*

12. *(RS) What has been the frequency in emergency calls or reported incidents from local whitewater clubs or public agencies from recreational users (boaters, floaters, and anglers)? Is there an increase (or decrease) to the number of calls compared to pre-construction? (no ref.)*

13. *(RS) Is there an increased risk to river recreational safety as a result of removing the levee, leaving approximately 91 large wood (¿ 18-inch diameter) and 157 smaller diameter trees in the floodplain; or as a result of setting back the levee? (C-006, C-095)*

14. *(GM, FB) To what extent has the native riparian vegetation community been enhanced as a likely result of this project? (C-098)*

    It is still too soon to say. The area that was, by design, left barren largely remains so. It will be up to King County personnel to monitor the riparian community and see that native vegetation takes hold in the riparian zone.

Discipline-specific Procedures and Criteria *Geomorphology: Use the criteria below as a guide in evaluating each site according to the members area of expertise, both through the field investigation and review of available documents.*

- *Condition of embankment (such as visible erosion, riprap, concrete, rebar, boulders), river substrate/bottom*
- *Seasonal flow rates, depths, and shifting channel conditions*
- *Flood hazard risk reduction, including erosion measures*
- *Adaptive management actions, respective to project effectiveness to meet stated goals*

I believe these have been adequately addressed above.

5. Recommendations

6. Summary and Conclusions

7. References

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Draft – Do not cite 10/8/2015

Ecological/Habitat Benefits

Prepared by Kelly M. Burnett, PhD
as requested for King County, WA

Summarize fisheries biologist's findings for this site relative to stated project goals and any adaptive management efforts that might have the potential to impact the habitat

Upper Carlson Floodplain Restoration Project

(p7)

2. *In the EP members' opinion, are there any noticeable changes (positive or negative) to the river immediately upstream or downstream as a possible/likely result of the project that impacts either the stated project goals or public safety?*

   No changes to ecological/habitat conditions were obvious immediately upstream or downstream of the project.

4. *Were adaptive management techniques applied at the site (such as reducing the number of unknowns, and better understanding to improve decision making), learning about management outcomes, and incorporating what was learned into ongoing management?*

   Project planning proposed three adaptive management components, one of which was subsequently implemented during project construction. The two major adaptive management actions that remain to be implemented and the progressive strategy for adaptive management, which is well detailed in the Upper Carlson Floodplain Restoration Project Site Management Plan (King County 2015a), are intended to address public safety issues while mitigating risks with the least invasive solutions and thus unlikely to have negative consequences for ecological/habitat benefits. One of the major adaptive management actions, adding another engineered log jam with floodplain roughening along Neal Road, may increase the ecological/habitat benefits of the overall project if implemented.

   In addition, the adaptation of project design [60% Instream Project Checklist (Appendix L) (King County 2014)] to direct distribution of felled trees in the floodplain beyond the "rapid channel adjustment zone" for a more "natural release rate of logs" was consistent with ecological and public safety concerns, however it is unclear that trees placed in the floodplain will be available to function during the life of the project. Although log decomposition was acknowledged in the 60% Instream Project Checklist (Appendix L) (King County 2014), the assumption that felled trees will maintain enough structural integrity for delivery via bank migration and for fulfilling stated floodplain and channel functions is presented without discussing the implications of decomposition over 50 years. Decomposition rates vary by log moisture content, size, and species (Harmon et al. 1986). Logs decay faster when on land than submerged in water, of smaller than larger diameters, and of deciduous than conifer species (years to decades versus decades to centuries). Thus, relatively fast decay rates are reasonably expected for most project placed logs because log clusters were assembled on the floodplain primarily from small diameter ($\leq$17" dbh) deciduous species (e.g., black cottonwood [*Populus balsamifera*] and red alder [*Alnus rubra*]). If the placed logs rapidly lose structural integrity, then fewer logs will effectively function as intended to "increase surface roughness on the floodplain and improve the quality of mainstem edge habitat along the

banks as the river migrates … and recruits them into the river, thereby reducing flow velocities and moderating channel migration rates."

5. *What additional data (or data gaps) would be beneficial for King County to collect during ongoing monitoring measures (or as baseline data prior to construction) to evaluate the effectiveness at each project site relative to meeting project goals and objectives? Is there a range of conditions recommended for data to be collected?*

The Upper Carlson Floodplain Project Monitoring and Management Plan (King County 2015b) is commendable in detailing indicators, methods, and a schedule for monitoring project effectiveness over 10 years. A 10-year plan should adequately address the public accountability and short-term adaptive management functions for monitoring. This period is likely too short, however, to offer data for validating many of the assumptions underlying the Upper Carlson Floodplain Restoration Project (e.g., pattern of bank retreat or rate of log decomposition) that are essential for longer-term adaptive management or designing future such restoration projects.

The plan distinguishes some indicators as "required" and others as "discretionary," raising questions about whether indicators in both groups will be monitored. Monitoring is "required" (e.g., by permit conditions, law, or regulation) for indicators to assess effectiveness of invasive plant treatments and native cover restoration. In contrast, monitoring is identified as "discretionary" for indicators (edge and cover habitat, large wood abundance, bank retreat, channel plan and cross-sectional form, engineered log jam function, and fish use) intended to assess effectiveness for all other project goals.

If "discretionary" monitoring is conducted, then adding indicators to those specified could provide a more comprehensive understanding of project effectiveness. For example, a broader view of "fish use" would emerge from monitoring "salmonid spawning" in addition to "density of juvenile salmonids in edge habitats during April and June." Salmonid spawning could be quantified either indirectly by area of habitat available for spawning or directly by counting adults or spawning nests (redds). An indicator could be included also for the detailed project goal to "Reconnect right bank floodplain with river at lower flows." Adding an indicator of wood decay class could assist in validating the assumption that placed logs will retain structural integrity adequate to function as intended during the life of the project.

A more thorough explanation is needed for the intended use of the derived indicator "habitat preferences." Habitat preference, often expressed by a selection index or by a less biased resource selection function (Manly et al. 1993), describes whether organisms are using a habitat type in proportion to its availability. The Upper Carlson Floodplain Project Monitoring and Management Plan (King County 2015b) proposes an index "Jacob's D" (Jacobs 1974) (though not referenced as this) to quantify selection by juvenile salmonids for the four edge habitat types (bar, bank, backwater, and side channel). It is unclear whether the values will be compared between the project and reference reaches and for what purpose, and if differences are expected in habitat preference between the two reaches and/or to change over time.

In contrast to hydrologic and geomorphic conditions, pre-project data are lacking sufficient for a valid statistical evaluation of effectiveness regarding salmonid use. The Final Basis of Design presents high quality pre-project base-line data for the project reach against which to evaluate effectiveness relative to hydrologic and geomorphic goals. However, base-line data on fish use

documenting the "as-built" project condition (draft summary J. Latterell) are available and provide a basis for monitoring trends. Future monitoring of salmonid habitat and/or use in the project reach and the downstream reference reach should yield data to infer some aspects of project effectiveness.

(p11)

4. *Has there been an increase or improvement in salmon spawning and rearing habitat in the mainstem edge, side channels, or off channels as a likely result of this project?*

   Geomorphic measurements supplied by King County for channel widening and bank migration as well as field observations from August 2015 indicate that since project implementation: 1) approximately 1.5 acres of new mainstem aquatic habit have developed, 2) the few trees recruited from upstream are starting to increase the amount and complexity of low-velocity rearing habitat along the right bank, 3) the expanding left-bank gravel bar includes well-sorted gravels of appropriate size for salmonid spawning 4) the black cottonwood, willow, and red alder plantings have established, grown, and likely functioned to slow flood flows and trap debris as evidenced especially on the downstream right-bank, and 5) $\pm$ 300 logs, many with rootwads intact, placed in the right bank floodplain (174 trees $\leq$ 17" dbh; 90 trees 18 – 47" dbh; 10 trees 48 – 60" dbh) have potential to create habitat complexity during flood flows.

5. *What has been the impact on habitat for ESA-listed juvenile Chinook salmon and steelhead trout?*

   Despite observed geomorphic and vegetative changes that imply a trajectory toward achieving goals, the Upper Carlson Floodplain Restoration Project was implemented too recently (2014 and riparian planting during winter of 2015) for a reliable field review of site-level trends in producing desired effects on habitat for ESA-listed juvenile Chinook salmon and steelhead.

14. *To what extent has the native riparian vegetation community been enhanced as a likely result of this project?*

    The several thousand native deciduous and conifer trees planted on the floodplain to help restore sediment and hydrologic processes and increase future salmonid habitat complexity generally appear healthy during this first of three years for scheduled maintenance. Invasive plants are scarce in the 20 acres of treated floodplain.

Draft – Do not cite 10/15/2015

Ecological/Habitat Benefits

Prepared by Kelly M. Burnett, PhD
as requested for King County, WA

Summarize fisheries biologist's findings for this site relative to stated project goals and any adaptive management efforts that might have the potential to impact the habitat

Belmondo Revetment Enhancement Project

(p7)

2. *In the EP members' opinion, are there any noticeable changes (positive or negative) to the river immediately upstream or downstream as a possible/likely result of the project that impacts either the stated project goals or public safety?*

   No changes to ecological/habitat conditions were obvious immediately upstream or downstream of the project based on the field review.

4. *Were adaptive management techniques applied at the site (such as reducing the number of unknowns, and better understanding to improve decision making), learning about management outcomes, and incorporating what was learned into ongoing management?*

   Responding to public comment, several pre-construction changes to the design were implemented in the Belmondo Revetment Enhancement Project for reducing risks to recreational users. These design modifications are apparently documented in the Basis of Design Report (60% March 2012), but the document was unavailable at the time of this review. Information contained in that report may have helped assess whether adaptive techniques were applied and answer the key questions if design changes compromised attainment of other project objectives? If so, how? And, what information would be necessary to achieve a better balance among objectives in the future?

5. *What additional data (or data gaps) would be beneficial for King County to collect during ongoing monitoring measures (or as baseline data prior to construction) to evaluate the effectiveness at each project site relative to meeting project goals and objectives?*

   The memorandum "Belmondo Revetment Enhancement – Safety Review and Design Modifications," dated April 11, 2012, lists several useful monitoring measures in the section *Discussion and Feedback*. It is clear that data have been collected to address some of these monitoring measures but not others. For example, the area of low-velocity habitats was quantified pre- and post-construction and summarized in the draft "Belmondo Revetment Enhancement Fish and Aquatic Habitat Monitoring Report" (April 2015). In contrast, no evidence was provided to determine whether or not a "monitoring and wood management plan" was developed and implemented "to address future changes on the site" as called for in the memorandum. Despite the draft monitoring report referencing ongoing effectiveness monitoring of flood protection and habitat restoration projects in the lower Cedar River, no plan was provided that describes these efforts.

Although a key objective of the Belmondo project was to "promote lateral channel migration and connectivity with the right-bank flood plain," the channel has not yet reconnected to its floodplain. If the connection can be re-established, this should facilitate development of low-velocity habitats that benefit salmonids. Monitoring rates of channel migration as well as development and fish use of low-velocity habitats in the floodplain will aid in evaluating project effectiveness.

According to comments on the draft "Belmondo Revetment Enhancement Fish and Aquatic Habitat Monitoring Report" (April 2015), it is unclear whether the riprap along the Herzman Levee is the current control site for monitoring effectiveness of the Belmondo project. If so and the "Herzman Levee Setback and Floodplain Reconnection Project" proceeds as scheduled in 2018, then identifying another control site for the Belmondo project will be necessary.

(p8)

5. *Was there an overall benefit (quality and quantity of aquatic habitat) to the implementation of the project design challenges, including increased deflection angle of ELJs, root wads on ELJs, elimination of voids and strainer effect, increased size and boulder space, and no exposed chains or cables?*

   Given the available information, it is not feasible to evaluate whether the quality and quantity of aquatic habitat benefited overall from the implemented design challenges. Juvenile and adult salmonids of various species were seen, however, using the site during the August 2015 field review. Fish were observed from above the water surface at the downstream end of the side channel along the left bank and in the large deep, complex scour pool associated with the upstream engineered log jam. The juvenile fish exhibited feeding behaviors, darting in and out of available cover provided by large wood. The adult fish were closer to the substrate (a mix of bedrock and gravel) and appeared inactive. Though none of these fish were positively identified to species, several native salmonid populations have been previously documented in the Cedar River at the location of the Belmondo Revetment Enhancement Project. Of utmost concern are the populations of Cedar River fall Chinook salmon (*Oncorhynchus tshawytscha*) and winter steelhead (*O. mykiss*). Both spawn/rear in the reach, and both are ESA-listed as Threatened. Also documented in the reach were bull trout (*Salvelinus confluentus*), coho salmon (*O. kisutch*), sockeye salmon (*O. nerka*), and coastal cutthroat trout (*O. clarkii*) (http://apps.wdfw.wa.gov/salmonscape).

6. *Were the vegetated geogrids effective in establishing riparian shade and cover for the replaced 2009 emergency riprap repair above the ordinary high water mark?*

   Vegetative geogrids appear to be providing shade and cover for the 2009 emergency riprap repair and stabilizing the bank above the ordinary high water mark at the Belmondo Revetment Enhancement Project site. In general, the riparian plantings have established and are growing. However, areas with drip irrigation seemed more robust than areas without this supplemental watering. The Cedar River is too wide at the project location for the newly planted riparian vegetation to effectively shade the channel.

7. *Were the mitigation requirements for WDFW (impacts on aquatic habitat associated with log jam removals) met at Cedar Rapids (2011, RM 7.4)?*

   The WFDW mitigation requirements for the Cedar Rapids Levee Setback Repair project were unavailable, thus the question cannot be answered at this time. However, the Belmondo Revetment Enhancement Project did incorporate numerous conifer logs along the left bank. This included several logs associated with the large engineered log jams and "roughness" trees (eleven large conifer logs with root wads each anchored to at least two of sixteen Leyland Cypress trees with root wads). In addition during the August 2015 field review, the mid-channel bar contained large wood that appeared to have been newly recruited from upstream.

8. *Were fish refuges created through the reduction of local velocities and shear, and increased sediment deposits created through the construction of two complexes of roughness logs?*

   Evidence provided in the draft "Belmondo Revetment Enhancement Fish and Aquatic Habitat Monitoring Report" (April 2015) supports that the area of low-velocity (< 1.5 ft/sec) habitats was increased by the project and that juvenile salmonids are using these habitats. A pre- and post-construction comparison during spring and early summer months of low-velocity habitats, categorized as gravel bar, bank, backwater, side channel, or engineered log jam, showed an unequivocal increase associated with only the area of engineered log jams. A better understanding about the contribution of roughness logs to increasing amounts of other low-velocity habitat types may emerge if monitoring continues. The complexes of roughness logs were not interacting with the wetted channel during the August 2015 field review. Although no pre-construction fish data were collected for the Belmondo project site, post-construction comparisons of fish counts, densities, and preferences among habitat types confirm use of engineered log jams by juvenile coho salmon, juvenile Chinook salmon, and multiple age classes of trout. Densities of juvenile coho salmon were greater in engineered log jams at the Belmondo site than in riprap at the downstream control site.

Ecological/Habitat Benefits: Herzman Levee Repair Project

(p7)

2. *In the EP members' opinion, are there any noticeable changes (positive or negative) to the river immediately upstream or downstream as a possible/likely result of the project that impacts either the stated project goals or public safety?*

   No changes to ecological/habitat conditions were obvious immediately upstream or downstream of the project based on the field review.

4. *Were adaptive management techniques applied at the site (such as reducing the number of unknowns, and better understanding to improve decision making), learning about management outcomes, and incorporating what was learned into ongoing management?*

   Given the limited scope, duration, and objectives of the Herzman Levee Repair Project, application of adaptive management techniques would be unexpected. Despite this, project design was modified to reduce risks to recreational uses. Though not provided, documents listed in the Herzman Levee Repair Project Charter may discuss adaptive management. The memorandum on Lessons Learned (July 26, 2010) from Wes Kamada, the project manager, provided insights intended to help improve design, planning, and implementation of future projects.

5. *What additional data (or data gaps) would be beneficial for King County to collect during ongoing monitoring measures (or as baseline data prior to construction) to evaluate the effectiveness at each project site relative to meeting project goals and objectives?*

   If the Herzman site is the control for the Belmondo project as indicated in the draft "Belmondo Revetment Enhancement Fish and Aquatic Habitat Monitoring Report" (April 2015), then any monitoring data collected previously or in the future at the Herzman site can be taken advantage of in characterizing conditions of fish and habitat for: 1) the Herzman Levee Repair Project; and 2) prior to construction of the planned Herzman Levee Setback and Floodplain Re-connection Project. Consistent with the objectives of the Herzman Levee Repair project, post-project monitoring covered the status of the levee repairs, large wood, geogrids, and riparian vegetation (Project/Property Maintenance and Monitoring Inspection reports from 2010 and 2011).

(p9)

2. *Based on available documents and field investigation, have the vegetated geogrids been effective in establishing habitat conservation measures since installation in 2010, including re-establishment of willow canopy and riparian shade and cover?*

   Recent photos and observations during the August 2015 field review suggest that the vegetated geogrids have been effective in re-establishing a willow canopy as well as shade and cover along the embankment since completion of the Herzman Levee Repair Project. However, data on riparian vegetation prior to construction were not available as a quantitative basis for comparison. The willow plantings do appear healthy and to have grown substantially since 2010. These will likely contribute more to creating low-velocity habitat when stream flows are higher than during the field review but will unlikely ever be tall enough to shade much of the channel. No tree species were planted on the upper bank (Project/Property Maintenance and Monitoring Inspection report dated November 10, 2010) that might eventually provide channel shading.

3. *Has fish habitat (refuges) been created as a result of the levee repair features (repairs to 270 linear feet of eroded facility with geogrids, rock, and six large wood placements)? If so, to what extent is the panel member able to determine if additional habitat was created?*

   Except for the Instream Project Checklist (May 27, 2010), indicating two pieces of large wood at the Herzman Levee Repair Project site, pre-construction data were not presented to determine if additional habitat was created. If the Herzman site is the control for the Belmondo project as suggested in the draft "Belmondo Revetment Enhancement Fish and Aquatic Habitat Monitoring Report" (April 2015), then post-construction data on low-velocity habitats at the Herzman site may exist. However, such data were not apparent in the draft report. The Project/Property Maintenance and Monitoring Inspection report (October 5, 2011) indicated that large pools were forming in the site downstream of root wads - except at the furthest downstream piece of wood. During the August 2015 field review, rootwads of the placed logs were in contact with the wetted channel but contributing only marginally to habitat complexity. More of the large wood and bumper logs should be in the wetted channel at higher stream flows, increasing the potential to contribute cover and low-velocity habitats.

4. *Is there evidence (either through available documents or field verification) of juvenile salmonids post-project construction?*

   Although not referenced in material regarding the Herzman Levee Repair Project, the WDFW Salmonscape website (http://apps.wdfw.wa.gov/salmonscape) affirms use by populations of Cedar River fall Chinook salmon (*Oncorhynchus tshawytscha*), winter steelhead (*O. mykiss*), bull trout (*Salvelinus confluentus*), coho salmon (*O. kisutch*), sockeye salmon (*O. nerka*), and coastal cutthroat trout (*O. clarkii*). If the Herzman Levee is the control for the Belmondo project as indicated in the draft "Belmondo Revetment Enhancement Fish and Aquatic Habitat Monitoring Report" (April 2015), then salmonids were documented at the Herzman site during the spring of 2014. Juvenile coho salmon and juvenile chinook salmon were found in riprap, bar, side channel, and backwater habitats. During the summer 2015 field review, available fish habitat was confined to the main channel with little complexity provided by the willows planted or large wood placed as part of the Herzman project. No fish were seen in the site during the field review.

10. *Where the repairs all accomplished during the Cedar River fish window?*

    The Cedar River Fish window was July 1, 2010 to September 30, 2010 as described in the Hydraulic Project Approval issued by WDFW. Repairs occurred in July 2010 as inferred from the Initial Schedule Estimate in the "Herzman Levee Repair Project Charter" and from the memorandum by the project manager addressing Lessons Learned (July 26, 2010).

1. BELMONDO REVETMENT ENHANCEMENT

The intentions of the Cedar River Belmondo Project were to protect the infrastructure (Cedar River Trail, fiber optic cable, and SR 164) and encourage lateral river migration into the floodplain areas off of river right. River impact design elements included the installation of rock, Engineered Log Jams (ELJs}, and root wads for fish habitat.

The Belmondo project utilized several public input opportunities during the design phase to facilitate the protection and enhance the safety of the recreational community. An initial SEPA process included a comment period (December 2nd, 2011) an Open House held at Lake Wilderness Lodge (November 15th, 2011), and a project website was created, published, and available through the KingCounty.gov webpage. Public input and recommendations could be posted for the project design team and project manager to review.

The Belmondo project was also reviewed by Chris Johnason of WaveTrek, Inc. Chris is a Rescue 3 International Instructor and preceptor. Rescue 3 International is the international *'Gold Standard'* for Water Rescue training and instruction. Her comments and evaluations resulted in the addition of low water level bumper logs, and angulation of the ELJs to deflect swimmers from potential entrapment. The project design and construction required inclusion of void filling rocks to further eliminate entrapment possibilities for the recreational user.

In reference to the two fundamental questions at the center of the independent evaluation: I would agree the Belmondo project development and design process included measures which demonstrated public safety was of primary consideration in the design and implementation of the project; this included flood risk reduction measures as well as river recreational safety. I also agree the other stated site-specific project goals and objectives were achieved at Belmondo and were successful in their intent to minimize the risk to public safety.

Belmondo Project site as viewed from upstream on 07/25/15 – laminar flow visible moving to river left and bumper logs visible at initial ELJ

On the afternoon of July 25th, the panel and Parametrix coordinating personnel visited the Belmondo project site. I was impressed with the design features undertaken to improve the safety of the recreational public on the Cedar River. Signage was present and the design features mentioned above were apparent. The main laminar flow of the river channel flowed around the right hand turn of the Cedar River and moved to river left as designed above the Belmondo reach. The laminar flow migration to the left side of the available channel is a normal effect present in moving water in a right hand turn. Once the laminar flow encountered the upstream ELJ of the project, the current was forced by channel blockage (ELJ) and returned back towards the right side of the available channel and the available flood plain.

I noted, with some concern as I had not noted them in the design elements for the project, two root wads were engineered into the ELJ and extended into the main or laminar flow of the channel on the upstream or current impact side of the ELJ. The depth of the root wads below the surface of the river was negligible, resulting in a significant risk of foot, clothing, or body entrapment to the recreational user (inner tuber, rafter, swimmer) who would be carried downstream in the current to the left side of the river channel while transiting the Belmondo Reach. The 2013 King County River Recreational Survey indicates a significant number or recreational users utilize this section of the Cedar River on hot summer days. There were statistically different findings in two studies separated by a couple of years, but the studies dismissed the differences while citing a temporary closure of the reach during the construction phase. This may have caused the disparity, or it could be attributed to the closure of a common launch beach upstream from the Belmondo Reach. Recreational use in this area, per the studies, could be as high as 1900 total users between May and September of any given year. Generally, our region's hot summer weather is most common in mid to late August. River flows this late in the summer are traditionally significantly lower, exposing rafters and inner tubers to entanglement, entrapment, and potential drowning if caught up in the root wads present on the upstream side of entrance ELJ at Belmondo Reach. The root wads were not visible at the angle or view elevation where a recreational user would encounter the hazards; the user would simply be swept unawares into the root wads where a shoe lace, heel enclosed sandal, loose piece of clothing, or lower extremity (foot, ankle, leg) would entrap the user and anchor them in the current. The result of such a chain of events would in all likelihood be fatal.

Belmondo upstream ELJ with laminar flow impacting off of river left and into underwater strainers – 2 strainer root wads visible from elevated view

I took several photos of the site depicting the location of the underwater strainers/root wads obscured in the laminar current and their relation in the flow into the upper ELJ. I later met with representatives from the regional response agencies having jurisdiction/responsibilities at this project site (King County Sheriff Marine Services Unit and Maple Valley Fire and Life Safety). The consensus of the respective responders was consistent with my assessment: the inclusion of the below surface root wads on the upstream side of the ELJ at an insufficient depth to allow tubers or swimmers to pass unhindered during low water flows created a significant hazard to recreational user who floated or swam on river left on the upstream side of the Belmondo ELJ. Members of the King County Sheriff's Marine Services Unit actually visited the site after completion and reviewed the features for potential hazards.
According to MSU Deputy Chris Becker, the usual summer- time flows of the Cedar River (high volume recreational use periods) are in the 300-400 Cubic Feet Per Second (CFS) range. Due to the low winter snow pack, summer 2015 flows have been in the range of 160 CFS. When the KCSO Deputies visited the site following completion and actually swam the project reach, they found the root wads in question were not a hazard during the normal summer flow volumes. In reviewing the site during my inquiries, Deputy Becker confirmed the root wads below the bumper logs would expose a swimmer to a possible entrapment hazard. However, while the assessment by Deputy Becker was consistent with the evaluation by Maple Valley Fire and Life Safety and my conclusions, he advised the probability of an incident was very low. The low CFS values resulted in a slow current vector and the ELJ would be easily avoidable by a swimmer or tuber/rafter, with or without paddles.

According to the facts and observations published in the 2013 King County Recreational River Survey - the vast majority of the users in this area did not wear safety equipment (personal flotation devices – PFDs) nor did they

have a means of propulsion, so it would be highly probable for recreational users to be swept to river left and into this portion of the Belmondo Project site. Despite these observations from the respective emergency response personnel, there were no reported rescues, searches, or recoveries as a result of a call for service in the Belmondo reach since the project was completed in 2013.

My further observations at the site did not generate any significant issues. Per the project historical data provided to the panel, warning signage was posted upstream of the project site during the construction phase. On our inspection at the site July 26th, 2015, recreational user warning signs were still in place upstream from the project. The signage warned recreational floaters of hazards ahead and advised users to move to river right, encouraging users to avoid the potential associated logjam hazards in the project site. Although the signage was present, there were no apparent permanent mounting systems. The sign was simply placed on a leaning metal bracket commonly utilized for temporary road signs. The temporary nature of the signage would require site monitoring by local authorities to ensure the sign remained in place during high recreational user periods.

Belmondo project site warning sign posted immediately upstream river right from the site

Finally, I noted the remains of a safety cable fence on top of the initial or upstream ELJ on river right. Some effort was made to build the safety fence on top of the upstream ELJ, most likely in an attempt to prevent falls by visitors scrambling around the project site. The posts and cable fence had been vandalized, as the cable was disconnected from an anchor at one end and one of the galvanized steel posts was broken off of the top of the ELJ. The cable and posts were at one point considered critical for public safety but had obviously not been maintained. I could not determine the specific requirement for the safety cable fence and recommend it either be repaired if it's still needed or, if not, removed in an expedient manner.

Broken Cable fence on top of Belmondo ELJ

2. HERZMAN LEVEE REPAIR

Public Safety Considerations – Design and Implementation Phases

The Herzman Levee Repair project was relatively small in comparison to the others selected for review by the panel. The first stated goal of the project was to balance the permit required mitigation for construction and reduce any impact on recreational user safety. Recreational use in the Herzman Reach includes fishing, floating, and inner tubing. The highest recreational use in the project area is during warm weather months. This project site is also in close proximity to the Cavanaugh Pond Recreational area, a public site managed by the City of Seattle Public Utilities. The 2013 King County River Recreational Survey indicates a significant number or recreational users utilize this section of the Cedar River on hot summer days.

Signage at entrance to Herzman Project area/Cavanaugh Pond

Close up of warning sign for the river recreational users

During the design phase of the Herzman project, the design team and project manager sought public input during two community meetings held on May 26th, 2010; the first at Bellevue City Hall and, later in

the day, at the Mercer Island Community Center. The project manager's contact information was published at these meetings for follow-up contact.

Upon design review at the public meetings, garnished input concerns focused on the hazards to the recreational public caused by the inclusion of wood products in the levee face. Recommendations were made by the public to ensure the large wood was placed in a location less likely to cause entrapment. The result of the meetings and community input resulted in the ELJs being placed at the tail end of the project site as well as the placement of bumper logs in front of the ELJs that would deflect unwary recreational users away from the associated hazards of the root wads.

The finished project design did include the placement of 6 large pieces of wood into the levee repair. The log placement for fish habitat was mitigated for recreational user safety by the inclusion of braced bumper logs in front of the ELJs and inclusion of large void filling rock within the areas of the large wood.

Upon inspection of the site by the panel, I eventually noted a warning sign at the entrance to Cavanaugh Pond from the parking area. The warning sign addressed the issue of the danger of the river. I was concerned, as the sign was posted away from the gate access and not immediately noticeable. None of the panel noted the presence of the sign when we arrived at the site and walked down to the river. The parking area was secluded from the trail and river access by a locked gate.

Cavanagh Pond signage at gate near parking lot.

Warning sign posted at the gate on a nearby tree

At the river, I could clearly see the design features as described in the project data and information. The two ELJs were present at the far downstream end of the project and they had the requisite planned bumper logs in place. In addition, the voids immediately adjacent to the bumper logs and ELJs were filled with large rock, eliminating foot and body entrapment possibilities within the project zone for general recreational users. Although the laminar flow of the Cedar pushes directly up along river left, the portion of the river levee involved in the project, the bumper logs appear to be very capable of pushing a recreational user (tuber, rafter) away from any hazards that would be associated with the ELJs. The usual summer time flow rate for the Cedar in this area is 300-400 CFS. During our inspection, however, the flows were in the range of 160 CFS. At the observed rate of flow, the project ELJs were not engaged in contact with the active channel. The rock toe of the levee, located upstream, effectively redirected the laminar flow of the current away from the ELJs.

Herzmann ELJ and bumper log (braced) visible on river left, photographed at approximately 160 CFS. The ELJ is placed at the downstream terminus of the project reach. Bumper log and rock filled voids clearly visible.

I contacted rescue personnel from the regional response agencies (Maple Valley Fire and Life Safety and the King County Sheriff's Office Marine Services Unit) and both reported there were no calls for rescue within the reach of the Herzman Project during the construction phase or since completion. Both agencies were also part of the planning and review process prior to the implementation of the project. Agency representatives advised they had been provided with a key to the Cavanaugh Pond Gate for quick site access if there was to be an emergency response to the project reach.

Herzman Levee Repair Project, view from river right at approximately 300-400 CFS

In conclusion, it is very obvious the processes and engineering utilized by WLRD demonstrated public safety was a primary consideration during all phases of the project. Community meetings were publicized and conducted with constructive recommendations received and implemented. Project data indicated there was signage placed upstream warning recreational users of the hazards ahead. While necessary

during the construction phase of the project, warning signage is no longer needed nor utilized within the project reach. The bumper logs were braced in place and appear they would be effective in diverting unwary recreational users away from the hazards associated with the root wads extending out into the river at the foot of the levee.

The project appears to be functioning well and was obviously completed as designed. I observed no discrepancies in design/published data compared to the observed completed and functioning repaired levee.

3. REDDINGTON LEVEE SETBACK AND EXTENSION

The Reddington Levee Setback and Extension project is a long range project with several elements. The project was designed to provide setbacks of existing levees for allowing river migration. In addition, the project provided for the removal of existing narrow river channeling levees, added engineered erosion protections to the levees, and included mitigations for fish habitat. The project also involved the relocation of public utilities within the urban core area of the reach. While not addressed as a specific project goal or objective, the Reddington Project by design included flood protection measures, which in itself does provide for the safety of the surrounding residential areas. There was no mention in the project's published goals and objectives addressing the safety of the recreational public.

The project solicited public comments through two community meetings held May 9th and 12th, 2012. The first meeting was provided to the Homeowners Association for the River Mobile Estates and focused on how the project would displace 16 residences and provided assistance information to those displaced residents. The project data stated a second community meeting was held as an open house to provide information to the public and to make them aware of what to expect during the project construction. No indication was provided as to whether public input was utilized to modify the project in consideration of the recreational community.

According to the 2013 King County River Recreational Survey, the Green River remote cameras located at or near Isaac Evans Park, RM 29.1, and within the reach of the Reddington Project, captured recreational users that averaged 7 per day over the survey period (June 22nd-September 17th – 5 camera locations covering a combined total 376 days and 2,626 persons – per table 7 in the report). Though this report was commissioned in 2013, it was not available during the planning phase for the Reddington project. The 2013 study did reference an earlier King County commissioned study – the 2009 McIlroy survey. The McIlroy study findings indicated "ambient air temperatures affect the level of use by swimmers, inner tubers, and recreational floaters, and is the primary reason the highest recreational use occurs during summer months"

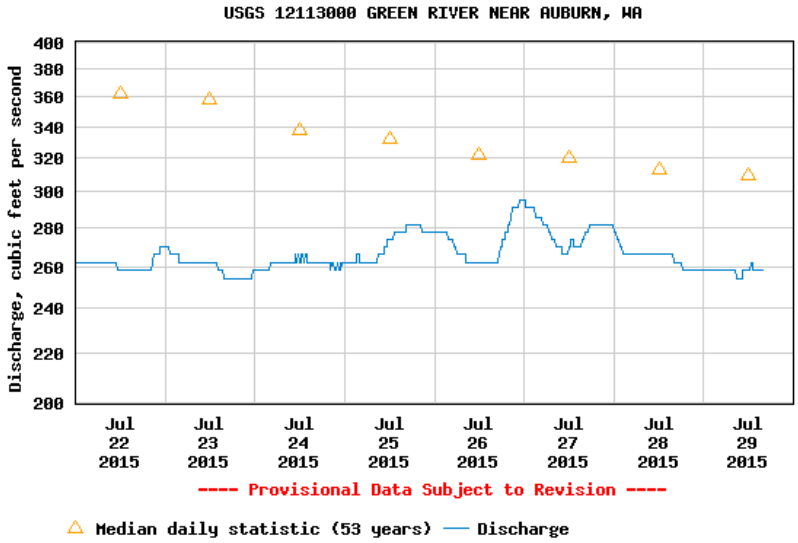
According to the work plan, and as discussed on the panel's site tour with the Project Manager, there was great effort to involve the public and stakeholders on this project. The project setting is heavily urbanized and within the limits of the City of Auburn. Besides the considerable numbers of land and governmental stakeholders, the project manager advised consideration in design was also given to the potential recreational users in the project area. The initial estimates for the recreational users in the project reach was grossly underestimated, a shortfall identified by the Project Manager and stated during the panel's tour of the site. Pre-construction site inspections failed to recognize a high use recreational beach off of river right, directly across the river from several rock barbs included in this project's design and construction phases.

This project's long range potential impact for river migration is impressive. Although most of the project is buried and will not come into play or be exposed by river migration until there are several significant river flows, the project design appears it will achieve the goals and objectives as stated during the publishing of the project during the planning process.

The main and only recreational boater safety consideration I read in the data involved stand alone ELJs, which were considered and eliminated from utilization in this project due to their danger to the recreational public. As a consequence, all ELJs were limited to being placed between or behind rock

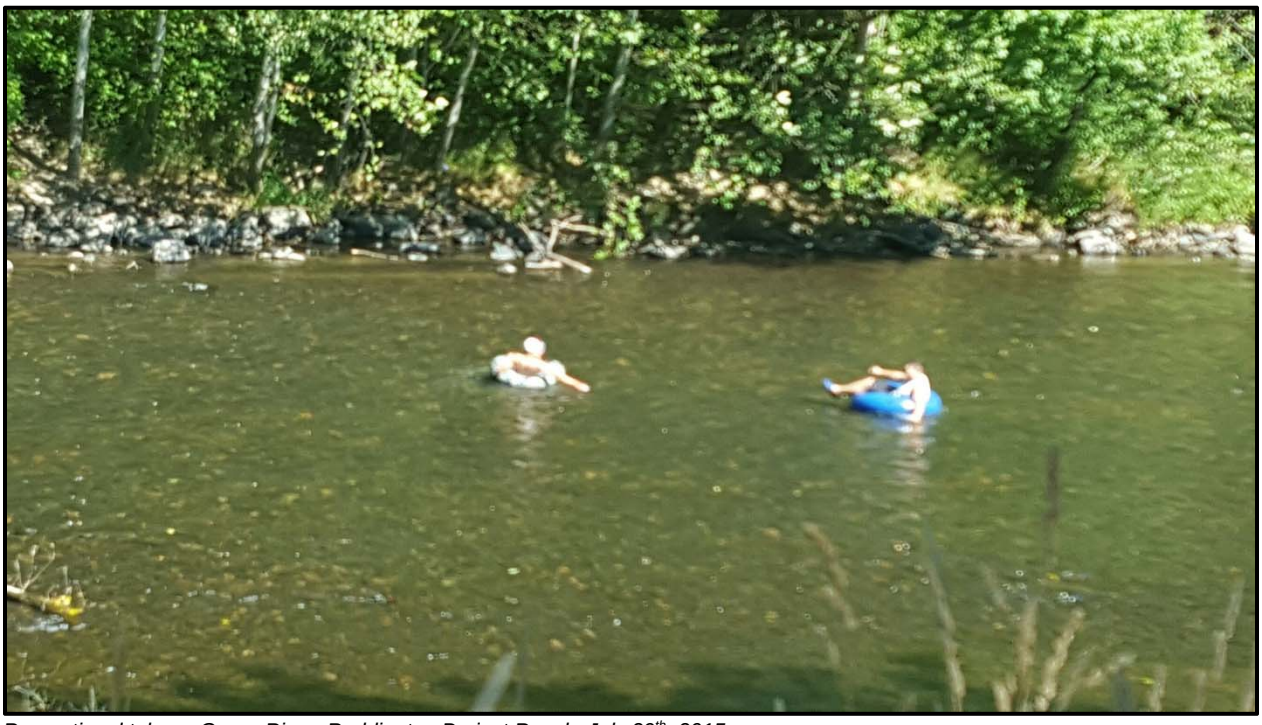
barbs. The inclusion of rock barbs deflect the main current as well as recreational users away from the eddy or pool areas behind the barbs where the ELJs are located.

I toured this site on two occasions (July 29th, August 24th),the second tour completed with the project manager and the panel members. I observed recreational users in action during my visit on July 29th (hot summer day). As reported by the USGS Green River monitoring station near the project site, the normal flow for July 29th is generally 310 CFS and the flow during the observations on July 29th was 260 CFS, approximately 16% below the historical average for the date.



There were several rafting/tubing groups as well as unaided swimmers/waders off of river right at the local Golf Course Park beach. I counted approximately 25 swimmers near the park, on the beach opposite of the project. The laminar flow of the river in this area is in the center of the channel, which would push the park waders and swimmers from the park away from the project rock barbs on river left. The tubers were not utilizing paddles, however they had no issues negotiating past the exposed rock barbs.

Reddington Project Reach, Recreational users accessing the river from the Golf Course Park beach across the Cedar River from the Project site (July 29th, 2015)



Recreational tubers, Green River, Reddington Project Reach, July 29th, 2015

By what I could determine from the project design and implementation, the project will have a low incidence of issues and cause little impact with the recreational users in this region. The project changes to the reach are not engaged with the river channel at present. Much of the project is buried and out of

current influence on the existing river channel and, as a result, should not impact the recreational public.

I contacted the regional emergency response organizations to gather data on this site. I spoke with Valley Regional Fire Authority Battalion Chief Perry Bogaard and he advised the fire agency had no calls or rescues as a result of, or associated with, the project since its completion in 2014. His impression of the project was consistent with mine; the project was effective in protecting the recreational user and should cause no negative impacts in the foreseeable future.

4. UPPER CARLSON FLOODPLAIN RESTORATION

This project effort was impressive, both with it's long range planning models and its goals for channel migration, as well as integration of large wood into the project zone. I noted the sheer size of this project and potential impacts with any recreational users, farm lands, and public roadways.

Consideration was given during the planning phase of this project to the recreational community. Public involvement and input was received through regional organizations and agencies, including Fall City Fire, The River Safety Council, design consultation with Wave Trek, and the King County Sheriff's Office Marine Services Unit.

The 4th listed goal of the project was to address potential impacts to recreational boater safety. This project was designed to encourage river migration and create large wood containment and recruitment in and about the channel. This has the potential to be inherently dangerous to recreational users. In-river signage was placed during the construction phase warning potential recreational users of the project activity. Current signage, a separate effort not associated with the project, continues to advise unwary recreational users of the exit location, which prevents rafters from wandering further downstream past the normal take out location.

The project, by design, is going to place a significant amount of large wood into the river channel. During the panel's visit to the site, the project manager pointed out the formation of a new gravel bar on river left of the upper portion of the project. He identified the gravel bar as new, but as an expected outcome of the Upper Carlson plan. River migration to river right would encourage gravel deposits on river left and, by design, provide for a safe passage for the recreational users in the project reach.

In review of the 2013 King County Recreational River Survey on the Snoqualmie River, I believe the common recreational users in this reach of the Upper Carlson Project were underrepresented in the collected data. My opinion is this reach of the Snoqualmie River would be more likely used by recreational fishermen than any other type of user, and the dates and seasons of the completed surveys were not consistent with seasons associated with this user group.

My professional impression of the average large-river fisherman is they are better prepared for navigation in and around the associated hazards of moving water and are more highly capable than the common rafter/tube user. The area upstream from this project is a tuber/rafter high use reach of the Snoqualmie River, but these users generally exit out river right, upstream from the project zone. Signage has been placed on the river identifying the exit for these types of users and, without fail, it appears to have been effective.

Additionally, a significant effort of the project involved the protection of infrastructure and adjoining farm lands from inundation caused by the changes of the Upper Carlson Reach. Significant engineered revetment and bank deflectors constructed of ELJs were placed in an effort to protect Neal Road, a county road located on river right along the reach of the project. This area has been subjected to past flooding during large water events. The placement of these ELJs would assist in redirecting high water flows away from the public roadway, as well as adjacent residential areas and farmlands.

Snoqualmie River exit trail sign posted in Fall City just downstream of the SR202 Highway Bridge, located approximately ½ mile above the Upper Carlson Project Reach

Additional Recreational User signage preventing trespass issues on private lands along Snoqualmie River

A small business entrepreneur has established a tubing business and shuttle service upstream from the project and his influence on the recreational community has increased recreational user safety. He has provided signage on the river identifying the exit, he requires the use of, and provides his tube renters with, a USCG approved Type III Personal Flotation Device. He encourages in-river users to exit at the Fall City Bridge by providing a safe parking area. Additionally, he operates upstream shuttles for recreational users who have their own equipment. A USCG approved Type III PFD would be the preferred and recommended type PFD for this type of recreational activity.

Fall City float parking and business promoting safe recreational use on the Snoqualmie River (*In cooperation with King County parks)*

Fall City Floating sales office and pricing

Although this project has significant impacts on the river with the placement of large wood that will eventually be involved in the river, and this zone will have significant strainers and sweepers, possibly in the main channel of the river, my opinion is the potential impact on the recreational community will be limited to a small user group who are more highly capable, prepared, and aware of the potential hazards associated with such issues.