Meeting Summary

Kootenai River Habitat Restoration Program
Modeling Subgroup Meeting

March 5 and 6, 2014
Red Lion Hotel at the Park Spokane, WA

Meeting Attendance

Geum	Tom Parker
KTOI	Sue Ireland
Oakwood	Duncan Hay
RDG	Matt Daniels, Mitch Price, Chris Nelson
USACE	Karl Eriksen, Stanford Gibson
USGS	Ryan Fosness, Pete Elliot (day 1 only), Molly Wood, Rich McDonald, Jon Nelson,
Ziji	Alison Squier

Sean Welch with BPA was also invited to the meeting but was unable to attend.

Meeting Objectives

- Review and discuss USGS reach-scale monitoring efforts for the Braided Reaches
- Review model results for the Bonners Ferry Islands and Straight Reach Projects.
- Provide observations and conclusions related to project performance
- Identify additional modeling needs and follow up actions

March 5, 2014

1. Update on Kootenai River Habitat Restoration Program (KRHRP) (Presentation 1)

Matt Daniels reviewed the KRHRP projects that have been constructed and are planned for 2011 through 2016. Those include:

- 2011 – Phase 1A and Phase 1B
- 2012 – North Side Channels and Upper Meander
- 2013 – Middle Meander and 1A Extension
- 2014 – Meander Reach Substrate Enhancement Pilot Project (Shorty's Island and Myrtle Creek)
- 2015 and 2016 – Straight Reach and Bonners Ferry Islands

Figure 1 on the following page shows the location of the 2011 through 2016 projects (except the substrate enhancement pilot project.

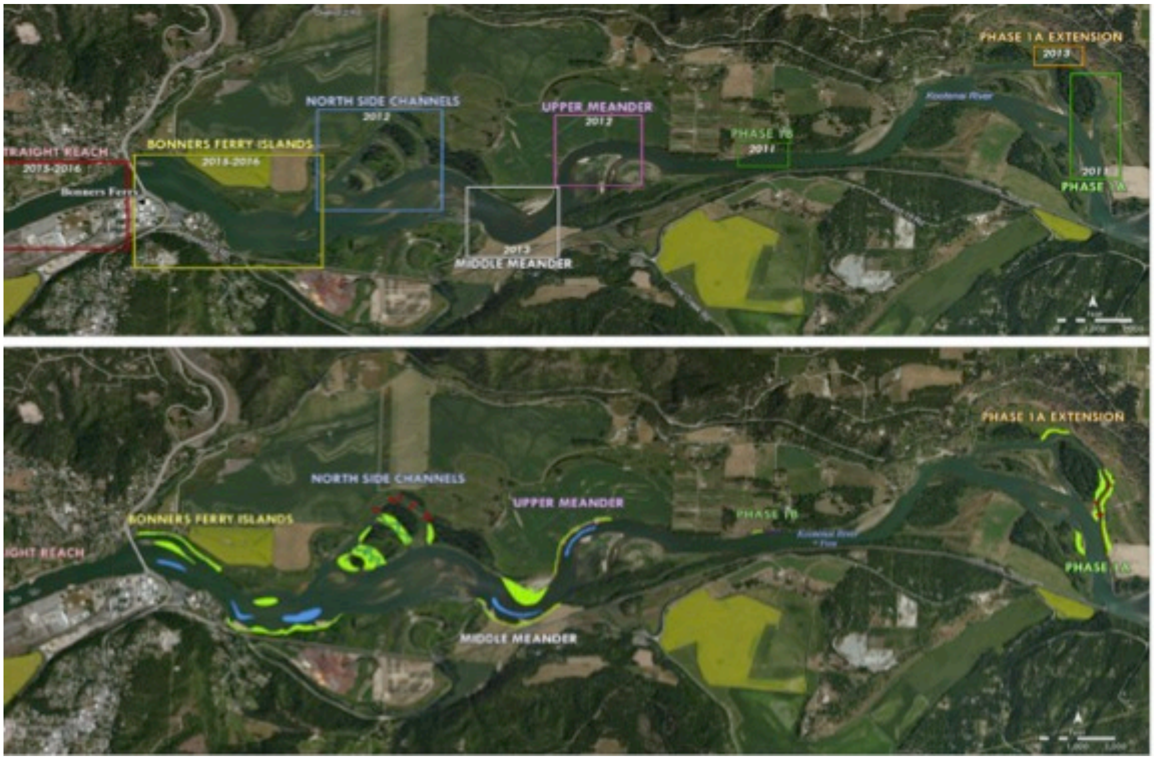

Figure 1. Location of 2011 through 2016 KRHRP projects (except substrate enhancement pilot project).

Matt reviewed the major types of treatment actions implemented through the KRHRP to date, which include:

1. Pool forming structures and pool creation or enhancement to encourage Kootenai sturgeon to migrate to upstream habitat & to provide holding habitat for sturgeon and other native fish.
2. In river and bank structures to create more diverse and complex habitats for sturgeon and other native fish.
3. Side channel reconnection and floodplain creation or enhancement to enhance the food web and provide habitat for juvenile Kootenai sturgeon and other native fish.
4. Riparian enhancement (and riparian buffer fencing) to enhance the food web and provide cover for native fish.

Sue and Matt reviewed the pool ladder concept that is being implemented in the straight and braided reaches. The BiOp includes depth and velocity attributes the pools and structures are helping to meet those attributes. Upstream of the Meander Reach, sturgeon spawning activity is currently located primarily below the bridge and around Ambush Rock. The Upper Meander, Middle Meander, and Bonners Ferry Islands projects all include pool components. The Lower Meander is a missing rung of the pool ladder. At this point no project has been designed for this area yet.

Bonners Ferry Islands Project

The Bonners Ferry Islands project area is located in the Kootenai River "Braided Reach", upstream of the city of Bonners Ferry between River Mile 153 and 154, and extends approximately one mile upstream of the U.S. Highway 95 Bridge. Several shallow gravel bars and mud flats are scattered throughout the project area, and the physical monitoring data collected since 2005 indicates bars are quasi-stable under the regulated flow regime.

Lateral migration has been a issue for shoreline landowners, and bank erosion has historically been addressed to mitigate local effects using a variety of techniques including riprap, concrete and car bodies, which have significantly reduced overall erosion rates. Flood control levees confine the reach vertically in order to keep flows from inundating agricultural areas as well as the city of Bonners Ferry.

The Kootenay Lake backwater has an influence on the area at flows greater than 10,000 to 15,000 cubic feet per second (cfs), depending on Kootenay Lake level. The Braided reach is used as a migratory corridor for fish, and aquatic habitat limiting factors include a lack of cover, complexity, and pools. Infrequent Kootenai River white sturgeon use has been documented in the Braided reach and no spawning locations have been identified.

Within the Braided reach, there are very limited areas where riparian vegetation is connected to the current Libby Dam-influenced Kootenai river hydrology. Multiple landowners are present in the project area and land use is mixed between agricultural, residential, commercial and industrial. Extensive utilities and infrastructure exist along the both river banks. The presence of constraints along the bank margins in the project area was an important consideration for electing to pursue a strategy of constructing islands in the middle of the river. By focusing on floodplain surfaces in the middle of the river, many of the features along the bank margins have been excluded from the project extents, and subsequently, potential conflicts with known constraints have been minimized.

The primary biological objectives of the Bonners Ferry Islands project are to:

- Increase the number of large deep pools to aid/encourage sturgeon to migrate upstream to higher quality spawning habitat of the Braided Reach and to support burbot foraging and migration.
- Increase the area of vegetated floodplain surfaces that provide food web support.

Matt reviewed that work that's been done to date which has included Identification of a suite of design configurations for each project (designed to maximize biological attributes and minimize risk), evaluation of design configurations using a 2-d depth averaged hydraulic model to determine which best met aquatic habitat objectives, and evaluation of design configurations based on technical risk. The design configurations for the project was reviewed with the project Peer Reviewer Advisory Team (PRAT) and Co-Manager / Agency Review Team (CMART) in October 2013. Based on input received at these meeting a refined hybrid design configuration for both the Bonners Ferry Island and Straight Reach projects was developed. The design has been refined to a 60% design. Matt also briefly reviewed the technical risk matrix that was developed for the Bonners Ferry Islands project as the framework for the subsequent discussions.

Straight Reach Project

The Straight Reach is located in the city of Bonners Ferry between River Mile 152 and 153, and extends 1.1 miles from the U.S. Highway 95 Bridge downstream to Ambush Rock. At base flow levels; the Kootenay Lake backwater is evident midway through the reach. As a result, the Straight Reach is a transitional reach between the gravel-bed Braided Reach and the sand-bed Meander Reach. The Straight Reach is predominantly a migratory corridor for fish. Kootenai River white sturgeon use is documented in the Straight Reach; however, most adult fish turn around for unknown reasons at the upper end of the reach and retreat downstream to spawn. There are essentially no functioning riparian areas or connected floodplain surfaces. Multiple landowners exist in the Straight Reach and land use is mixed between residential, commercial and industrial. Flood control levees exist along banks as well as extensive infrastructure and utilities.

The primary biological objectives for the projects are to:

- Increase distribution and abundance of holding and staging habitat to encourage sturgeon to migrate upstream to higher quality spawning habitat;

- Increase the amount of sturgeon spawning habitat (rocky substrate) to improve egg attachment and early life stage survival;
- Increase distribution and abundance of habitats to support burbot foraging and migration

The project was developed and refined using egg mat data collected by IDFG between 2007 and 2013, as well as data from USGS ADCP and bathymetry monitoring. Interestingly the coarsest existing substrate materials in the straight reach also correspond with the desirable sturgeon spawning velocities (greater than 3 feet/second) at less than 1 meter above the riverbed.

Rich noted that this is the same signal they're seeing at Shorty's and Myrtle Bend. He commented that depth appears to be secondary. Sue noted that the PRAT biologists (Mike Parsley and Larry Hildebrand) have been very clear in saying that they don't believe depth is a factor in spawning.

Rich and Jon noted that they visited with a scientist in Russia who said that sturgeon there spawn in high velocities at depths less than 1 meter. He also noted that they are spawning over clay.

Action:

- Jon to provide the Russian publication on sturgeon spawning over clay to Sue.

Bonners Ferry Island and Straight Reach Construction Phasing

Matt reviewed an illustration of the planned construction implementation (Figure 2). In 2015 Site 1 and Site 2 will be constructed. All work will be conducted from the north bank of the river. The earthwork is designed to balance. Constructing in this order would allow for completion of structures and earthwork prior to excavating pools. The 2016 work would include work on the south bank and the entirety of the Straight Reach project.

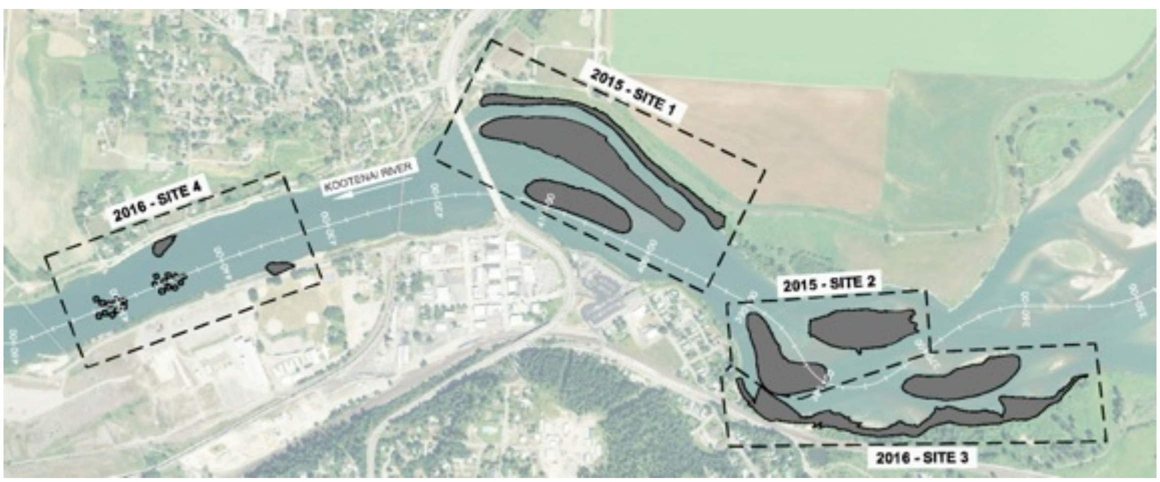

Figure 2. Proposed construction staging for Bonners Ferry Islands and Straight Reach projects.

BPA determined in November 2013 that an Environmental Assessment (EA) is required for the project. The scoping meeting to kick off that EA was February 26, 2014 and was well attended. The scoping period closes March 10. BPA will use the information collected during the scoping period to help guide the information to be included in the draft EA. BPA has indicated that the EA will be completed by February 2015.

Next steps include continued coordination with landowners, the City and County, completion of a Design Report in April, completion of the final designs in about April 2015. An important next step is also addressing flood risk. River Design Group (RDG) met with Joel Fenolio and Greg Hoffman from the USACE in December. They discussed the process that the USACE will use to evaluate flood risk. Karl Erickson drafted a memo clarifying what the process will be (see Attachment B). Flood risk was discussed in detail on the second day of the modeling meeting.

The risk template is provided in Attachment A.

Substrate Enhancement Pilot Project

Matt also briefly reviewed the substrate enhancement project in the Meander Reach. Starting from the information developed through the 1135 project, RDG worked with IDFG and USGS to refine the size and location of two substrate patches. One will be at Shorty's Island and one at Myrtle Creek. Each will be about 1-acre.

One change to the overall project is the identification of an alternate staging area at the Myrtle Creek bend. Use of that site would allow materials to be barged for a much shorter distance thus saving costs. Discussion of the physical monitoring plan for the substrate enhancement pilot took place the second day of the modeling meeting.

2. Bathymetric Monitoring

See Presentation 2.

Ryan Fosness gave an update on bathymetric monitoring including the 2013 and 2014 surveys, the status of the bathymetric survey data, and the USGS survey control network.

The 2013 and 2014 bathymetric surveys included three main study areas: the braided reach, supplemental surveys, and meander reach longitudinal provide and cross-section surveys. The braided reach work included 17 cross-sections from Ambush Rock to below the Moyie River. Surveys were done pre- and post- high spring flows. The current cross-sections have been surveyed since 2011, but some cross-sections have been surveyed going back to 2008.

Ryan overlaid the 2013 survey over the 2011 survey and subtracted the difference between the two surfaces based on a three-foot grid. In the river right side channel below the Phase 1A project site there's a distinct 5-foot aggraded elevation adjacent to a near vertical drop off. Mitch noted that they had scour chains in the area in the past and that bar had eroded and they lost entire chains. The downstream end of the island complex is aggrading just above where the channels convergence into a single thread. There's very little change at Crossport. There is not a lot of change in the braided reach area in general.

Supplemental bathymetric surveys in 2013 included the straight reach, the Upper Meander Project site, and the meander bend near the city water intake. The 2014 and 2015 supplemental surveys will include the Upper and Middle Meander projects. Asbuilt bathymetry for the substrate enhancement projects will be surveyed by the contractor. Post runoff surveys for the Bonners Ferry Islands and Straight Reach project sites will be postponed until 2016.

A pre-project survey of the substrate enhancement pilot project area was completed in November 2013 coincident with the fieldwork for the meander reach thalweg and cross sections. RDG or USGS (TBD) will complete an as-built survey in 2014. RDG also confirmed that they did receive the velocity data for this reach from Gary Barton. Ryan noted that there is more slope to the channel at the location where the substrate projects are going to be implemented.

Ryan summarized the USGS survey control network efforts. The network is quite old. It was established in 2002 (Idaho Transverse Mercator, NAVD88 (geoid99/03 mix)). 2011 used UTM (NAD83), NAVD88 (geoid 03/09/12). And in 2012 upgraded to UTM (NAD83CORS96), NAVD 88 (geoid 09), which is the same as RDG. Ryan said RDG has a really dense control network in the braided reach area and it goes to Porthill. As USGS moves forward with collecting new data sets and moves into meander reach, Ryan wants to ensure that there are no issues with datum sets.

Discussion:

- Rich – We used the bathymetry survey data for the Upper Meander project as-built as the base, then used Ryan's survey in June following construction and modeled that time period to see how well they could do with the channel change that has occurred. That will help determine the accuracy of the bed evolution modeling. It provides a good validation model. The key is the immediate post construction survey. In terms of 2014 surveys, would like to have the next run occur post-runoff.
- Rich – For many years everyone thought the meander reach spawning area was all sand. The identification of the clay shelves was a major finding.
- Ryan – Completion of the meander reach longitudinal profile was a missing gap. That was completed last November. There was a concern that some of the cross sections from 1D model were no good. GS re-surveyed 27 cross sections where Charles Berenbrock's survey was in 2002. The water was very low so survey was limited on edges, but the main concern was the deeper areas. Chris said he noticed an effect on the model outcome – the cross sections were about a half-foot higher.

Actions:

- A post meeting assignment is to identify a list of updated bathymetry needs to help clarify 2014 and 2015 monitoring. Help is requested from RDG and USGS in compiling this list.
- Need to identify specific substrate project bathymetry work and timing for 2014 and 2015 to update current and future SOW.

3. Sediment Data Collection and Gage Network

See Presentation 3.

Molly gave an update on the Kootenai River sediment monitoring work conducted under the Task 3 SOW. The goals of the work are to monitor sediment transport through the reach to support the KRHRP work. Data are used as boundary conditions for a quasi-unsteady 1D sediment transport model as well as USGS Task 4 bed evolution modeling to support design development. The study work includes evaluating acoustic surrogates for sediment as a way to get long term timeseries of sediment loads.

The three monitoring sites include the Tribal hatchery, Crossport and a site below the Moyie. The Moyie site monitors sediment coming out of the canyon reach. This is the upstream end of the white sturgeon critical habitat. The Crossport site is within the braided reach with KRHRP projects upstream and downstream. The Tribal hatchery is at the upstream end of meander reach. Most of the coarse sediment load comes from the tributaries (Fisher and Yaak). Most of the sand seems to be coming from mobilization of in-stream deposits and bank erosion.

WY 2013 activities included acoustic monitoring at three sites referenced above, five suspended sediment (EWI) samples at three sites, three bedload samples at Crossport, 10 autosamples at Below Moyie and Crossport, flow monitoring at Tribal hatchery and below Moyie, and stage monitoring at Crossport. Molly reviewed the timing of the sampling events (see presentation).

USGS installed ISCO 6712 autosamplers in the spring of 2012 at 2 sites (Crossport and below Moyie) to help capture events when they couldn't be there to sample. The autosamplers were triggered based on acoustic backscatter in cell 1 of the ADVM. They analyzed about 40 autosamples from each site. They developed a regression between EWI samples and forced grab samples from the ISCOs collected at the time of the EWI samples to estimate what the EWI concentration would be for each autosample collected.

They developed regressions between the concentrations in the ISCO "point" sample collected at the time of the EWI sample and the concentrations in the EWI sample. These regressions were then used to estimate what the EWI concentrations would have been whenever they collected a regular ISCO sample. They collected 8+5 ISCO "points" at the time of EWIs. Using these relations they were able to add 60 more estimated EWI samples at Crossport and below Moyie for development of the sediment surrogate models.

The ISCOs in general had higher overall sand concentrations that the EWIs. The ISCO intakes were attached to mounts a couple of feet off the bed at each site so they likely picked up a zone of higher sand transport than the overall cross-section average represented by the EWI.

Molly showed the range of suspended sediment concentrations sampled in WY2010-13. Most of total suspended sediment load in the samples is fine washload material. When concentrations are highest, the percent of fines are also highest (80 -90 %). In general, they saw a higher percentage of sands in samples collected during the late June high flows, although total concentrations were mid-range.

Molly showed boxplots for the EWI samples and point samples from the autosampler intake for each of the collection sites. There is an increase in the percentage of very fine and fine sands as you go downstream. Not much change in coarse sands but there's not much coarse sand overall. Energy is lower at the Tribal Hatchery site, particularly when in backwater, so they are seeing almost no medium sands in suspension at this point.

Bedload transport, on average, is about 6% of the total sediment transported at Crossport among the days that were sampled. Bedload is highly variable and episodic.

Molly reviewed the set up of the acoustic Doppler meters. They process backscatter data and process for acoustic signal loss and attenuation. They continuously monitor backscatter.

Spatial variability is one of the inherent limitations with sediment sampling. Distribution of sediment can change spatially, and although the acoustics handle this better than a point measurement, it still can miss the denser sediment moving lower in the water column if the instrument is not mounted in this area.

She showed the LOADEST and acoustic model results from a May 2013 event at the below Moyie site that was sampled using auto samples. It underestimates on the rising limb and overestimates on the falling limb. You see higher LOADEST loads because it consistently overestimates on the falling limb. It doesn't capture the peak on the rising limb.

Molly described the surrogate model development, and reviewed details of the acoustic model and LOADEST model evaluation. The question was if acoustic calculations give a better estimate that LOADEST. In general, because the LOADEST models are strongly dependent on flow, they tend to over predict sediment load on the falling limb of the hydrograph as well as during winter operations. (See presentation for specific comparisons.)

The sediment report will be published the third quarter of 2015 (Tribe is fine with this) in order to incorporate 2014 data and fit within Ryan's schedule so he can contribute.

Discussion:

- Matt – A question for the group is what would you expect bedload to be as percentage of load in an unregulated system? Response from the group was 5 to 15% (coincident with the range of observed data). Overall proportions not different but overall load is lower.
- Mitch – The general assessment is that the system is sediment starved relative to historical conditions. The measured annual average for the last three years is less than 500 tons per day of bed material load.
- Jon – The best thing is to look at is the size distribution within the load.

- Duncan – What I always want to know is where does the bedload transport stop? We know it is below Crossport and above the hatchery. Rich said it also depends on the stage and backwater. Duncan noted that the suspended load concentrations are pretty low. If you were presenting it to the public it would be helpful to show what it is for other similar systems; 6% is very low. Sue – That's a good point in terms of public perception. People are thinking about bank erosion but they don't understand low suspended load. Duncan suggested the best way is to do it is comparison to other systems, which helps explain why it's taking a lot longer to build floodplain.
- Matt – Larry H. always talks about how sturgeon have evolved in highly turbid systems and whether that is playing a role; turbidity was a place to hide. Sue noted that the Upper Columbia is a much more sediment-starved system.

Actions:

- Molly and Ryan will revisit the parameters being considered in the LOADEST calculation such as hysteresis (load characteristics of rising/falling limb of hydrograph). Now, the calculation is based on Kootenai flow and tributary flows.
- RDG will update the bedload and suspended load comparisons between the Kootenai River and other regional systems.
- Publish SIR in third quarter of 2015.

4. Bonners Ferry Island Project 2D Hydraulics

See Presentation 4.

Matt and Mitch reviewed the design process that was used to develop the 60% Bonners Ferry Islands and Straight Reach designs. Numerous design configurations were developed and graded and then simulated by the USGS (under Task 4) using 2D modeling. The purpose of this effort was to evaluate the range of technical risks associated with different design configurations. The results of the 2D modeling analysis and projected technical risk was presented to the Peer Reviewer Advisory Team (PRAT) and Co-Manager / Agency Review Team (CMART) at workshops in October 2013. The input from these groups was used to identify the final design configuration for each project.

The 60% Bonners Ferry Island configuration includes two large islands, three pools, and two pool-forming structures and proposed planting areas. The structures are intended to sustain the excavated pools. The configuration of the 60% Straight Reach project moved the structures farther downstream away from the bridge and current spawning area and incorporates limited addition of some coarse substrate materials (substrate enhancement) similar to the Meander Reach substrate enhancement project.

Matt reviewed the technical risk table and reiterated that one of the objectives of the modeling meeting was to get feedback from participants on what conclusions could be drawn from the modeling effort relative to the potential consequences and risk mitigation strategy.

The USGS used FASTMECH to look at pre-and post project conditions. The model domain extends from Crossport to Tribal hatchery. Nine flows were modeled, each over a range of downstream stage conditions. The model was calibrated to WY 2011 flows, (a very high water year). They looked at all previously constructed (2011-2013) and proposed projects with the exception of potential future work in the lower meander. Nine flows were evaluated (6, 10, 20, 25, 30, 35, 40, 50, 60 kcfs). The selected flows were based on evaluation of the last 10 years at the Tribal hatchery gage. Matt noted that the 6kcfs is valuable because it is representative of conditions during construction. In the future 15 kcfs would be helpful because it is a typical mid-summer flow. A range in the backwater was developed for each flow bin (i.e., min, med, max for the 10-year period).

Matt summarized the framework that was used to evaluate the model output (i.e., identification of polygons around potential risk zones or specific areas there detailed information is desired; use of box plots overlaid with histograms). They looked at the proposed scenarios and existing condition to see how much change in scalar magnitude is predicted.

The greatest change in the mobile particle size occurrs at low flow and low lake level. As lake levels increase, flow has less of an effect of particle mobility. At the highest flows you don't see much energy because of the backwater effect. The analysis was designed to bookend the most extreme scenarios to see what changes could be expected.

The major geomorphic questions RDG was trying to address with the analysis are (1) are the islands sustainable, and (2) are the pools sustainable, i.e., are they susceptible to filling in?

To support analysis of flood risk elevations, they looked at the change of water surface elevations for whole project area. There are localized areas where you're going to have some change in elevation, most notably at lower flows well below any flooding thresholds. The maximum rise you see at any point in the project area is at upper end. Mitch explained that when the USACE manages to 1,764 ft NGVD29 -- that is achieved by various combinations of flow and downstream stage. Most of the flood risk occurs at left hand range on chart (low flows). Most elevation change occurs in bulking up of water elevations that prior to construction would have been more spread out. But overall the change is relatively low. At lower flows it's about two-tenths of a foot, at higher flows it is about five hundred-tenths of a foot. This still falls below the 10 percent flood exceedance and is discussed in more detail in later presentations.

Island Stability Discussion:

- Matt – Questions we looked at were: what are the hydraulics going to be over top of islands, what do the islands need to be built of to be stable, and what is the likelihood of them aggrading and trapping sediment? The results show mobility of very fine gravel, which is what is currently going on out there now. The maximum mobile particle size is about 10 mm.
- Jon – Is it only for the wetted part of the polygon? Mitch – We have additional info that's not in the presentation that shows the percent of the wetted area. However, it is correct that the sample size is not the same on these plots in relationship to the wetted area.
- In response to a question about whether they will be bringing in materials from the outside or not, Matt said the plan is to use existing materials i.e., balance the cut and fill. However, if results show that those materials would not be stable they might have to bring in some additional materials. Plans include a contingency to import cobble to supplement island construction in higher stress zones such as the upstream nose of the islands and top surfaces of upstream side slopes.
- Jon asked about the results of the coring analyses? Matt explained the initial coring done by USGS years ago was just upstream of the Islands and included gravel, cobble and sand that coring effort went to 40-70 feet. Last year in order to look at what might be expected when the pools are excavated they did some additional core samples. Unfortunately the coring tube they used was only 2-inches in diameter so they hit refusal after about 10 feet, Matt didn't know if that was a limitation of the equipment or sand/gravel deposits. It is mostly uniform sand and gravel, no clay. They question is if these will be appropriate materials to build the islands out of. That will be determined by mobility. It is looking like the excavated material will be mostly sand, large gravel and small cobble material; if it were mostly sand then additional cobble materials would be imported.
- Duncan – You'll have to do some sorting during construction/placement and you'll likely lose a half-meter or so of material as it sorts out.

- Matt – There is high sand content, so there is a question as to how much sand is too much. Do we go ahead and plan on mixing in native coarse material or importing other materials and/or armoring the head of the islands?
- Duncan thought that intuitively if you penetrate into a riverbed you're going to get into course material based on pre-dam post-dam river conditions. Karl and Stanford weren't sure about that due to the lake backwater effect.
- Jon – When islands erode it would most likely not be by failure but by lateral erosion, therefore particle size isn't such a big deal. Even the biggest gravel can fail.
- Rich – Just looking at the polygon may not be enough to evaluate it; you may need to look at a larger scale area.
- Matt said that the current design incorporates side slope of 7:1, an upstream approach of 30:1, and the downstream backside of 20:1. Karl thought that 7:1 wasn't flat enough. He recommended 10:1 to 12:1 would be better. Matt agreed that flatter is better, but they are also trying to balance that with providing sufficient top surface area.
- Duncan – Bed evolution of what happens to the scour holes is probably more important. If the scour hole migrates downstream that could be a problem. There are two sides to the island. Having a steeper slope on the side channel side and a flatter slope on the main channel side.
- Duncan – Is having stable islands an appropriate objective? There is nothing wrong with having a little bit of motion and adjustment. A more appropriate objective and description is *dynamic stability*. You can make stable islands with concrete but that is not the objective. Jon commented that this same issue is going to come up over and over if we talk about certain features. The easiest way to ensure stability is to make sure that none of the materials will move. If you say some of it will move, then it is a lot harder to say how much of it should move. It is easier to design for complete stability.
- Matt clarified that the risk element we're talking about is catastrophic failure. Mitch suggested that what is necessary is a framework that is resistant to movement to minimize the rate of change.
- Duncan – There are certain things you can do in the lee of the islands. If it is in the mainstem you could put some large organic debris at the head of the islands.
- Matt – Knowing we could have a lot of subsurface variability, if we're into a batch of material where this could be mobile, then we have to have a contingency plan to mix or coarsen up that material to make sure that we're not seeing mass erosion? We don't want to be off by two grain size classes in terms of transport potential. It seems like the mobility is with the one-half to one-inch size gravel.
- Duncan – There are also options in terms of where you place material. If it is coarse put it in the nose and upstream.
- Karl – Will it be possible to sort material during construction? Matt said yes and they will also be able to add course material. For example, in the contract there could be a contingency for four-inch cobble, which could be, used it as needed.
- Tom – Are the models assuming a uniform surface in terms of roughness? Mitch said the roughness for the design development models was stamped in as constant roughness by reach. Tom noted that the constructed condition would have a lot more heterogeneity in the surface. Mitch noted that having spatial variability in roughness is preferred and acknowledged that it does have a subtle effect on the model output, especially when interpreting local effects.

- Jon – The larger scale stuff such as vegetation and stem densities could be mapped in. At the smaller scale they can treat for that, big stuff is okay too; it is that intermediate area that's harder to look at.

Conclusions and Recommendations Regarding Islands Stability Risk and Mitigation:

- Duncan – A consideration is boat wake, which can do far more damage than anything else. The slope of sides is important. Safety factors are also a consideration. If the number is 10 mm, what do we add to that to factor for safety or ignorance? That's an engineering discussion. But the way to mitigate risk is to address the areas where your greatest exposures are i.e., the mainstem and nose, don't put silt layers in, and watch for water seeping. Don't think you would loose an island in this location (i.e., catastrophic failure). There are lots of other islands already in the area. Concern is with the potential for migration of the scour holes. If they migrate downstream they'll undermine the toe of the island. Duncan reiterated the importance of establishing appropriate expectations i.e., dynamic stability rather than simply stability.
- Molly – Has RDG calibrated the model in area where you have a well-formed island and looked at how it migrated and changed? Mitch said they had looked some air photo analysis but other than that, no. An example is Box Elder Island, which is actively eroding. It is formed primarily of silt and was formed by being cleaved off from the mainland. Molly – Suggest contingency plan to be able to make some post-construction changes to island if needed. Matt and Mitch noted that this allowance is incorporated into the operations and maintenance plan and budget.
- Ryan – Is there any concern about upstream changes with respect to scour upstream e.g., channel shifts and a resulting change in the angle of attack? Mitch said they hoped to address that through the bed evolution and scour modeling. There is uncertainty about a very large episodic upstream event. Matt explained that the nose of the islands are totally round, they can sustain flow from a lot of angles.
- Ryan – The big elephant in the room is winter power peaking and the damage that does with repeated wetting and drying. Karl suggested that if you construct a very flat side slope it would give you soft armor that can deal with those types of changes. Low and high Lake levels will extend that slope. That approach would also handle power peaking. You can lose gravel at fast rates on steep slopes; it just disappears.
- Jon – The primary risk of failure for the islands would be lateral erosion moving through. You can deal with that by having hardened and intentionally erodible or adaptable cover. That would include a coarse core on the upper end mantle with stuff that may move. Even completely erodible core should not be sized in such a way that if the thalweg changes it can't erode. If you build a stable nose and core and match that with material that can move, with the flattest slopes you can get away with, it should be okay. The ability of vegetation to survive is going to dictate what the height it has to be. Then you work from there to get the side slopes as flat as possible.
- Duncan suggested also putting some coarse materials at the entrance to the side channel and tying that into the nose.
- Jon – There's criteria for higher flows i.e., what size of material can move anywhere.
- Ryan noted that there is quite a bit of bedload in this area during a small window in the spring.
- Stanford – Agree with Jon that the dominant failure mode would be lateral migration. A disproportionate amount of analysis was going into lower failure modes. The 2D or 3D model can't get at the risk of lateral failure. Simple bank evolution models and velocity vector models would allow you to pretty simply quantify some numbers. He suggests doing that and trying quantify the dominant failure mode. You've currently got great modeling of secondary failure

modes. He likes this current 60% configuration a lot better than the ones that were shown to the PRAT in October. If you compare the current design configuration that to what's there now, how does it affect the angle of attack? The railroad and community on south area of the bend is potentially vulnerable. By shifting the flow lines into that south bank that is exacerbating an already problematic area. RDG has got the numbers to figure that out, so they should look at that. You've taken an island that created a shadow out, and replaced that with an island that concentrates; it's an area of vulnerability.

- Karl reiterated what he has said previously about size load. He suggested considering a few barbs along the mainstem face to deflect flow on the island on the south side, or several small ones. Matt commented that the vector modeling shows a little bit of eddy formation. Rich confirmed that there's an eddy in that pool.
- Rich – Along the lines of what Duncan said about the potential of pools to migrate: a big unknown is still what the transport of bedload through that reach is. If the pools were to start evolving that could change the angle of attack on the islands. Duncan added that typically you'd fill in the head of the pool and then the downstream sides would fill in.

Action:

- For final design, RDG will modify island side slopes adjacent to the river to be at least 10:1 and consider modifying island side slopes to less than 7:1 on the lower stress side channel/bankline side of the island. In addition, the design will include a contingency for adding cobble to the upstream end of the islands.
- USGS and RDG will attempt to quantify risk of lateral migration of pool as an island failure mode using the bed evolution modeling tools. This will support final engineering of the island side slopes.
- Mitch will follow-up with Stanford and Rich to do the suggested additional analysis regarding the potential vulnerability of the south bank and Railroad.

Infrastructure Risk and Mitigation Discussion:

- Matt explained that the RDG analysis has also focused on potential effects on bridges. Specifically, looking at how the project would change sediment transport under the bridges.
- Duncan suggested that RDG should look at each pier individually in terms of how the velocity is approaching the bridge. If he were reviewing this he would want to know what the changes would be on the velocity of approach and degree of attack. The bridge region should include a circle around each pier.
- Stanford suggested also doing the standard federal highway bridge scour analysis as per HEC-18. It will take about a day to complete and should be in final report. The 1D approach won't show much but is still due diligence.
- Mitch noted that the local pier scour equations can be sensitive to grain size and attack angle and for that reason is a little leery of presenting the scour analysis without appropriate context. We know that the bridge piers don't scour, don't want to show a scour just because of the model sensitivity when we know it isn't the case. Would rather present the relative change pre and post project if that's sufficient. Stanford thought that would be fine. He still suggested doing it internally and if they ask for it then you have it and you can explain the sensitivity and concerns with the output.

- Jon – Would be very leery of drawing broad conclusions about erosion/deposition only based on maximum grain size mobility; this approach is fraught with error. Just looking at maximum grain size mobility is likely to give the wrong answer -- or at least is no more likely to give the right one. Instead it is important to look at the spatial differences in transport. Ultimately it's about water rise. The plots of change in grain mobility are okay as a screening tool, but use caution in terms of looking at local scour and fill. He recommended instead talking about the difference between it becoming more of less active and then draw that line in terms of activity.
- Stanford said in general he feels better about it in this reach because it is a fairly sediment starved reach.
- Duncan – There could be a change in where the spawning occurs right now downstream of the pier on the right bank. He suspects the distributional flow is going to change downstream from the second pier. Matt said they had looked at that and it doesn't show much of a change through that spawning area. Rich added that most of the velocity is coming along the left bank. The project doesn't really change that.

Action:

- RDG will complete a traditional federal highway bridge scour analysis as per HEC-18 using the HEC-RAS model.
- RDG will use alternate methods to evaluate erosion effects including use of the BSTEM bank erosion model
- USGS can provide support for evaluation of the spatial differences in transport using bed evolution modeling tools.

5. Bed Evolution Modeling

See Presentation 5.

Rich gave an overview of the bed evolution monitoring work that he and Jon have done. They used the Upper Meander project post construction bed evolution monitoring to determine how well the model is working. They looked at post construction change from October 31, 2012 through June the following year using FaSTMECH. The modeled the entire WY 2012 hydrograph and looked at changes in the distribution of shear stress at the bed and channel change. They ran 30-day simulations of channel change at the 15th percentile lake level, fine-sediment simulations with respect to Bonners Ferry Islands pool scour and fill, and also developed some observations of hydraulic process in natural pools in the meander reach. Rich noted that when you coarsen the grain size distribution up you get a much smaller response. Rich also reviewed the change in bed topography following construction of the Upper Meander project.

- Mitch noted that the upper and middle meander area is where the backwater cyclically moves in and out for higher flows of 30+ kcfs. So you do see a big change in transportation potential depending on the flow and lake level.
- Rich – We did run the whole set of boundary conditions. This run is for 60 days. Knowing what I know now would have run it for the whole thing because low flows are really important. I think that the answer is between these two distributions. Also think that during construction a lot of disturbance occurred, e.g., putting in pads for pilings which may not be represented in the bathymetry.
- Jon noted that he thinks the adjustments in the pool side slopes are a result of gravitational failure.

- Rich – There is some fine grain re-suspension that's occurring in the lower right model. These are always really sensitive to grain size. Used parker transport model that actually calculates the fining and grain size distribution.
- Jon – The model predicted some deposition.
- Rich – Jon had pointed out that we might create some local backwatering upstream that would lead to more flow being redirected down through secondary channel left of the structures; noted that this may have potential to run away. Mitch acknowledged that there are scour chains installed at the head of that channel so that can be monitored.

Rich reviewed the modeled bed evolution and grain-size sorting. He explained that each panel shows the change in gradation of the surface. They used the same grain size distribution for incoming load, upstream equilibrium flux. Stanford noted that it is probably too large and too coarse.

The 2009 measurements of grain size were from video surveys plotted down through the reach and projected onto thalweg line. They looked at D16 and model predictions of D16 in that reach. The model predictions of D16, D50 and D84 fall within that measured data as correct.

- Jon commented on the gradations derived from the video pebble counts. There was a change in sampling technique. Is the fact that WY2009 samples are generally coarser a sampling issue?
- Mitch responded that sampling methodology may be account for some of the observed difference between WY2009 and the WY2011/2012 video pebble counts. For the WY2009 samples, Gary's sampling technique utilized a variable height and thus some videos were represented a larger spatial area greater than one square meter and potentially more coarse material. For the last two years, Gary's setup switched to a camera mounted on the Helley-Smith bedload sampler and was a fixed height relatively close to the bed that sampled less than a quarter square meter.
- Ryan – the sampling size is different too. Wolman pebble counts there were over 100 counts across the section, and that earlier data set was never sampled. But the thalweg couldn't be sampled.
- Jon – But the difference between the 2009 sampling and 2011-2012 sampling is far greater than the assumed particle size we used in the model.
- Mitch – We're seeing similar issues in how the video pebble count data influences the HEC-RAS routing model. It gets into what is the envelope for bed gradation and is it representative/ believable. Tempering the video pebble count with what is sampled on the ground. We think the substrate videography effort has collected some interesting information but we're not continuing that effort because there is still a lot of variability and it is expensive/time consuming relative to the output.
- Jon – The effort where you set the camera on the bed is accurate but you're sampling a much smaller spatial area which needs to be offset by increasing the sample size to remove bias.
- Mitch – I generally consider the WY2009 data sampling effort as being more robust relative to representing a reasonable range of bed gradations.

In summary of the Upper Meander bed evolution modeling, Rich said that the conclusion from the modeling is that we get a lot of basic response. The model captures salient features we get development of point bars and channel scour, but it is really sensitive to grain size distribution. So that should color later discussions about any of the mobile bed load calculations. Some features not captured by the model may be the result of sediment load during construction. Or the post construction survey (cross-sections) may not have captured bed topography sufficiently. Also, the USGS post-freshet survey did not capture higher elevations on the point bar topography sufficiently for the model. It is a pretty big range i.e., three grain size classes. There ought to be a graduation of the grain size distribution as you move downstream. In spite of all the data collected it is a bit of unknown. It gets down to where the comfort level lies with bookends.

For flow, boundary shear stress, and channel evolution they used the WY 2012 hydrograph. It provides insight into change of sediment mobility potential through the year.

To evaluate the Bonners Ferry Island project, they modeled the entire Upper Meander, Middle Meander, Bonners Ferry Island and Straight Reach project areas using Nays2D. In general, the model is not predicting coarse sediment mobility below the middle meander site. At lower flows you get relatively high sheer stress at the North Side Channels project area at low summer and winter flows. There's some erosion and deposition happening at each of the pools with the first rise of the freshet. It helps to explain why the reach looks the way it does downstream of the middle meander.

- Matt – We learned at a public meeting that the lower meander point-bar is the place where they took most of the gravel out of the river when they had the gravel mining operation going. They said it was perfect for making concrete i.e., one-inch or less size gravel. Note: significant gravel mining also took place on the middle meander point bar on the north side of the river.
- Rich – Hadn't realized how effective low winter and low summer flows are at moving 2-8mm (VFG to MG) particles through to Bonners Ferry Islands and Straight Reach areas.
- Mitch – Does it make sense given the uncertainty of the videography grain sizes to use a predicted bed gradation from the bed evolution model for the reach scale routing model? Then you could adjust it slightly finer or coarser as a sensitivity analysis in lieu of video pebble counts. Maybe start with that as future condition.
- Stanford – We'll be able to have an answer in about six months when we take the second run of bathymetry from that bend. Then that will increase your confidence in predicting the downstream pools by one or two orders of magnitude.
- Ryan – I will map that in June and get it to RDG in about August [2014].

Rich reviewed the simulation of channel change following WY 2012. There are similar patterns of scour outbound from the spur dikes, and deposition on the downstream point bar. It is eroding the nose of the point bar and depositing a little in the pool. The exit of the mega pool is getting reconfigured. There are also very small changes at the tops of the pools. But we used the same grain size distribution as with the Upper Meander. Using a finer grain size distribution they would expect to see a greater change. Jon noted that the pools consistently show flattening out at the upstream end of pools until they collect enough water. Rich added that there is an initial response to the change in topography that adjusts the upstream side of the pools i.e., scour at the upstream end, deposition at the upstream end of pool, but then the rate of change decreases over time. The pool is not migrating downstream here.

Conclusions on the simulated channel change were that the grain size distribution is probably too coarse for the reach below the Middle Meander and so may under predict transport potential. There are dramatic decreases in transport potential based on boundary shear stress predictions below the downstream end of the Middle Meander. There are relatively higher stresses downstream of the Middle Meander during late summer and winter periods. These periods may be important for routing fine gravel and sand deposited in back water conditions through the reach. Generally sediment less than 8mm (medium gravel) is not mobile below the Middle Meander, except at low flow greater than 10 kcfs between winter operations and spring high flows (a relatively long duration). Pre-dam flows had more extended periods of flow greater than 10 kcfs. The upstream and middle pools are generally in very low boundary shear stress over most flows. Pools are bounded by regions of relatively higher boundary shear stress. Based on a simple mass-balance box placed over the pools, with relatively high shear stress upstream of the pool and low shear stress through the pool, the pools are expected to fill over time. The rate of filling is essentially a function of the sediment load and gradation.

Rich reviewed the mobile bed calculations for selected index flows with Kootenay Lake level at the 15th percentile elevation. These include plots of elevation change, maximum mobile grain size (bedload), and maximum suspended sediment size. He highlighted the gradients in transport potential surrounding the Bonner Ferry Island pools and noted that the transport potential is generally lower in pools than the area surrounding the pools (see presentation).

At low flows there is some erosion and deposition in the upper two pools. What's important is the spatial distribution. A pattern of relatively high upstream mobility is true under almost all flow conditions. The question is, what's the supply, and that's what we don't know. Rich stated that the question is what is the appropriate grain size distribution in this reach?

- Jon – The key is that you'd have to have a continuous supply. But it looks like once you adjust the entrance to the pool it adjusts to equilibrium it and stops.
- Matt – We saw that during construction.
- Jon – The good thing is that on bedload side, it doesn't seem like it's an issue.
- Rich – It is with these two lowest flows that you even see any action down in the Bonners Ferry Island reach. Above those flows there's nothing happening in terms of mobility.
- Jon – So we're looking at 30 days of very rare flows.
- Rich – Ryan's observation that he's seen lots of sediment in that reach for a short time is a potential concern.
- Jon – But the model is showing high transport mobility in that location for a short time.
- Rich – Maximum suspended grain size throughout reach is between .15 mm and .25 mm (VFS to MS).
- Mitch – How well represented is the sand fraction in the bedload portion of the mobile bed?
- Rich – It is not at all here.
- Mitch – Perhaps consider adding some suspended sand load into the model and see how they propagate.
- Jon – We separated bedload and sand because gives you a better framework.

Rich described the fine sediment transport modeling using the Nays2D. Modeled scenarios included:

(1) 10mm (MG) sediment everywhere plus 200% incoming equilibrium load.

(2) 2m of sediment deposition in pools plus 0% incoming load.

For conditions they modeled 280 cms and 760 cms, 0.15 mm and 0.25 mm (FS to MS). The scenarios represent extreme bookend events designed to look at the basic response of pools to sediment load (filling) and scour (see presentation). Jon added that the model represents suspended sediment using an advection/diffusion algorithm; you can source sediment and place it. Rich explained that they wanted to evaluate if you had a bunch of sediment in suspension, where would it end up.

- Jon – All that really happen is the same basic pattern occurs, it is just slower.
- Duncan – So I've got a pool that's deeper than the rest of the bed, if I have a concentration of suspended sediment in the pool, then downstream the concentration should be less? I'm not

seeing any scour downstream from the pool. Rich explained there's a continuous supply coming into the reach because it was modeled as 200% of equilibrium load.

- Stanford – The anthropogenic pools don't necessarily have natural processes to keep them clear. What does your model do to a naturally formed pool? Jon said it stays clean. In all cases you have a flux in naturally formed pools out of the pool. In these cases the only places you see that in these constructed pools is in the lower pool.
- Duncan – But again this is all really sensitive to the grain sizes chosen for the boundary condition.
- Rich – The only grain size modeled so far is the 0.25mm (medium sand).
- Stanford – 0.25mm would be less. It is decreasing deposition by half. The pools fill to a larger extent with the finer material than with the coarser material because more of the coarse material is dropping sooner.
- Mitch – We probably need to run these to represent a longer time period, there's no clear answer for a short simulation. Anticipate that you would see some cyclical scour and deposition in the pools.
- Duncan – There are two things going on with the pools. Excavation and the dynamic associated with the spur, morphology and change in structure.
- Rich – What I haven't seen is those proposed spurs on the BFI left bank doing much of anything. They are sort of in a hydraulic shadow to begin with. They don't seem to be adding any energy to the pools. The velocity core is coming through; you don't see a lot of high velocity along the bank. The high velocity isn't seeing the downstream spur.
- Stanford – In line with what you said that spur is in shadow. It looks like the pool might be in a shadow. It is recruiting more sediment in that shadow and doesn't seem to erode as efficiently either.
- Jon – I'm concerned that there's any conclusion from this. One of things we wanted to emphasize is uncertainty with different grain sizes. We have to come up with frameworks to treat this kind of uncertainty. The pools that fill easily also can be evacuated relatively easily. So it seems plausible that you'll get filling and emptying on a somewhat regular basis depending on flows. It can be moved out of there. From the standpoint of fine material, you have to have that in mind in the design. Coarse material doesn't seem like that big of an issue.
- Rich – We still have a question of what the finest fraction is in that reach. But the basic result is fill and empty. But over a lot of years…
- Duncan – In the braided reach we're seeing movement. So if upstream from that I've excavated a pool in a place where I'm seeing movement of fine gravel and sediment. Why wouldn't you expect to see pool infill? My experience of dredging on rivers is to see infill at the upstream end and a flattening of the slope at the downstream end. I'm trying to understand why that wouldn't happen here.
- Jon – These designed pools are much flatter than in the dredging that occurs in rivers. The pools don't have sharp margins.
- Matt – Pools have 5:1 side slopes and the entrance and exits are 7s and 9s. The other limiting factor is the excavator equipment. Can't remember if we did 10:1 or 20:1. Clarification: design side slopes are 5:1 for all sides including the pool entrance and exit slopes.

- Mitch – One thought I have from this is maybe recommendations for how we could adjust those slopes. Matt said he didn't think that would make a difference relative to constructability.
- Matt – I don't disagree that tendency is for pools to fill. What we can't answer is at what rate, how long and when will they reach equilibrium.
- Jon – We could make a prediction, but I think it is more important to understand what the uncertainties are.
- Rich – The excavation rate is much slower than the infill rate. Duncan asked if that was in total volume or depth? Rich said they could model it in terms of volume.

In conclusion it appears that if there is significant sediment supply of less than 0.25 mm particles (MS) the pool will fill. If there is no sediment supply the pools largely remain empty, except some local supply may slowly end up in the pools. If there are alternating periods of high supply (typically at higher flows and lake levels) and low supply (typically at intermediate flows and lower lake levels) the pools could fill and empty on a seasonal basis.

Pool Sustainability Risk and Mitigation Conclusions and Recommendations:

- Jon – Now that framework is complete and we know the uncertainties we'll go back and do what is the closest to reality. I think we'll come out kind of in the middle on the bedload stuff. We'll be able to say that for this year's hydrograph we'll be able to predict that the pool will be able to empty or fill with this temporal pattern, and then to explain that this is the remaining level of uncertainty. We've always known that one of the big uncertainties in this project is the upstream supply. We need to go with the load and then at least double it to see what the uncertainties are. It isn't a very active system and these uncertainties are much less than we're seeing in other systems. It's a pretty stable system.
  - Molly – Do you feel like we need to revisit looking at the substrate and quantifying it in a consistent way for future projects?
  - Jon – In one season don't think we can do a lot better.
- Duncan – I would be nervous about saying the excavated pools won't fill in. There are two aspects to this, one is the hydraulics associated with spurs, and trying to generate quasi-hydraulic pools. In terms of the pools that are being excavated for fill and the sturgeon ladder concept, I'm not so sure about them. The issue isn't with the design, but about how you manage people's expectations. The modeling is great but you can only push the modeling so far. If I think in terms of the physics and I have a mobile bed and I dig a hole – I don't expect it to fill in. If I have a bed with a sand/silt component and the gravel doesn't move I'd expect some sand/silt to fill in. But if you have a mobile bed where some gravel is moving that's more of a concern. A person is hard pressed to say I'm going to dig a hole and it's not going to fill in, because we know the gravel won't come out. The real question is how much is going to fill in? What would really help is a sensitivity analysis to do some modeling to bracket how it would fill in. That doesn't make it any easier on the decision. There is some good information with the LOADEST and you have a rating. So bring that physical information into the model. One of the advantages of having to two pools already excavated is that you could monitor those and see what's happening upstream and downstream. It would be a great asset to have one or two years of modeling first, additional data would add confidence to the design.
  - Matt – That's what Ryan showed, we'll have two years of data at the Upper Meander project and one year at the Middle Meander, but you have different hydraulic conditions.

- Duncan – The last point with the downstream pool is to have some confidence that it's not going to migrate downstream.
- Matt – Something Rich and I talked about is looking at existing pools and how much we can tease out of that. There's a deep thread near the upper pool that could maybe tell us something.

- Karl – There will be a lot of concern from our water managers especially as regards the lower pool. Pool #2 seems a little disconnected – reconfigure to work more with the barbs. I wonder if the hole up by the barbs couldn't be brought up by the barbs to maintain that pool. Would recommend comparing the excavation volume to the transport loads measured by Molly to get a time of reference relative to pool filling.
  - Jon – They would be order of magnitude issues or larger if you could make that one feature instead of two. I think that that feature may cause current across.
- Stanford – From the USACE perspective the potential loss of flood stage benefits as the pools fill elevates the risk. When I first saw the plan I thought it was clever and was excited because of the spur dikes. The pools would give the spur dikes a 10-year head start and then maintain the pools. I do think there's a result from the modeling, it is to tell us they're not self-sustaining pools, they are temporary features. So, can we do them better even if they're not self sustaining? Maybe the alignment of pool two isn't optimal. Is there a better way to do this if we divorce it from the spur dikes? I live and breathe sediment models, they have to be calibrated. That first slide with the two vastly different results: we can zero in on that by looking into the repeats for the upstream pools. I think that will tell us these pools aren't that dynamic and that they might last 10 to 20 years. I keep thinking about the peak annual load of 500 tons. I think we can get to some level of confidence short of a multi-dimensional level. I'm sad the spur dikes aren't making these permanent features but I think the pools might be saved by the lack of sediment in the system. Jon – just following on 500 tons – that is 20 years for the pools. That's 20 years of the entire load going into the pools to fill in. The upstream pools would fill in the most. It is 100,000 cubic yards per pool that is being excavated. I think that's good news. You could think about aligning them some they don't intercept bedload as much. We want them as parallel to the thalweg as possible. **Clarification to above discussion: 500 tons is not the average annual load, but rather the peak daily load.**
  - Matt pointed out that the spurs would provide bank protection, that's their primary purpose.
  - Duncan – With the rating curve you could run 10 years for each hydrograph.
  - Jon – Don't want to build anything out there that when filled creates risk. Think it's trying to come up with a good rationale to explain why they are quasi-stable and when they fill why they don't create a risk.
  - Chris – Aligning the pools with the thalweg might improve the flood risk.
  - Stanford – It might now show up in the model. Sometimes you get inappropriate credit.
- Molly – The grain size distribution information we're getting from the auto intake might be helpful. We have full grain size on the sand fraction.
  - Rich – What we're using is in the ballpark of what you have there.
  - ***Action:***
    - Molly will run numbers on the bedload to give Rich and Jon more accurate numbers.

- Ryan – So when you run the model you can get it to vary the supply? Jon said yes, it does vary it and you can also compare it. Ryan – I'm trying to get at what the surrogates are predicting and then could compare that. There's a lot of time when there's just clear water scouring.

Actions:

- USGS and RDG will attempt to quantify risk of lateral migration of pool as an island failure mode using the bed evolution modeling tools. This will support final engineering of the island side slopes (Repeat from above).
- USGS can provide support for evaluation of the spatial differences in transport using bed evolution modeling tools (Repeat from above).
- RDG will re-align the middle pool to improve hydraulics and interaction with the bank structure.

6. Sediment Routing Model

See Presentation 6.

Mitch presented the 1D sediment transport model work and results. The sediment model is designed to answer reach scale questions. Questions of interest on the Kootenai include:

- What are the reach scale observed trends for erosion and depositions over a "typical year" and for the two distinct hydroperiods i.e., winter operations and spring freshet?
- What is the longitudinal transport potential by size class over the steepest energy grade-line?
- What is the reach scale stability condition considering a large change in load, or gradation?
- Considering the reach is quasi-stable, at what sediment load or gradation change does stability change?
- What is the long-term sustainability of transport and conveyance capacity by size class?

Mitch described the modeling framework and provided an overview of the RAS 4.2 routing model. He explained that they are using the reach scale sediment transport model to help answer mass balance questions and to look at system dynamics. The model is not suitable for evaluating local sediment dynamic, but it can predict floodplain response in simple systems. He reviewed the model assumptions and limitations (see presentation for details).

Mitch summarized that sediment in transport exchanges only with sediment in the active layer. If size fraction is not represented in the active layer then it will not be present in transport. Bed is divided into multiple layers depending on whether net erosion or net deposition had previously occurred. The active layer is assumed to be well mixed by the exchange process so that it has no vertical structure. Substrate does have a vertical structure and is assumed to have no interaction with the sediment in transport. Substrate and active layer can exchange material as the bed aggrades or degrades. Particle size distribution is assumed to exhibit a discontinuity at the layer between the surface layer and the substrate.

The data inputs for geometry included: cross-sections, movable bed limits, roughness; for sediment bed material gradation, inflowing load; and for hydrology flow record, rating curves, and temperature. The schematic was adapted from USACE CRT model (Libby Dam to Kootenay Lake) and then cropped (below Moyie to Tribal Hatchery) and existing geometry (2009 braided reach bathymetry, 2010 overbank LiDar, 2010 straight and meander reach bathymetry, 2011+ various as-built and patch surveys). Hydrology inputs incorporated index flows (10-70kcfs), measured hydrographs (WY 2002-2013) and synthetic flows. Sediment load inputs were based on three plus years of USGS data collection (sampled bedload by fraction, suspended load with silt/sand break, acoustic surrogate with silt/sand break, LOADEST with silt/sand break, and time series discretized by 16 size classes.

- Mitch noted that if you look at the drainage area in square miles versus bedload you could really see that we're very sediment limited.
- Karl commented that he was surprised that it falls within the band when it comes to suspended sediment.
- Matt said they were too -- it may be that historically the sediment load was a lot higher than in other systems.
- Ryan suggested it would be interesting to put the Fisher and the Yaak in the comparison on their own.

Next Mitch reviewed the model inputs for transport functions. Inputs included excess shear, stream power, and dual functions. He noted that what is interesting is that you have the early freshet when the peaks run off but have four months of high volume low sediment water. In Rich's modeling it would be interesting to run these loads rather than just equilibrium.

The model calibration approach incorporated fixed bed hydraulics, for mobile bed – hydraulics and sediment (Steady State and Quasi-Unsteady). Mitch reviewed the sediment model calibration metrics. USGS calibrated over a range of Steady State flows early one, then made adjustments and did robustness tests. He hasn't started tweaking the inflow bed information yet and is now running the quasi-unsteady. Chris has dialed in the water elevation information. Sediment concentration includes the washload. The bed load fraction is hard to dial in. The scour chains provided good data. In the Bonners Ferry Area we see net deposition on the scour chains relative to scour.

Mitch reviewed the long-term monitoring cross-sections (see slides).

Finally he reviewed the sediment profile plots.

Mitch noted that last year the group had a heated debate about mass balance. Looking at the cumulative longitudinal bed change, Mitch noted that what is represented is the differences 2011 versus 2005 with the area below Bonners Ferry showing slightly net erosion.

In wrapping up, Mitch said that in general the provisional model is predicting the same trends as before. There are erosional and depositional trends by size class with the tipping point between the braided 1 and braided 2 reaches. Fine sand transport is extending further downstream. However at some point because of the backwater you see it shift by size class. Initially they thought that was because they had too fine a gradation in the model. They coarsened it up by as much as two grain size glasses and were still seeing that same erosion/deposition signature. What the model is showing now is that regardless of the transport equation or parameters used it is the backwater that's driving the hydraulics. The Task 3 sediment surrogate load timeseries are currently being used for the model. The question is, from a sensitivity standpoint, at what load threshold does this tipping point become an issue? If we know we're in this depositional environment how do we design for that? Mitch would like to get the model wrapped up and calibrated so that they can rely on it in the future.

Discussion:

- Jon – Why are you seeing that long plateau? Mitch said it was because it stops changing. It's the delta. It deposited out and it is gone.
- Karl – What are the bedload transport loads you're getting? Mitch said plus or minus 5 tons a day. Stanford clarified that this is tons per computation increment i.e., tons per hour not day.
- Stanford – It looks like we're computing high. Mitch thought with the 2D stuff on the Nays model, you could load it up with sediment using Molly's data and maybe that would give a margin of safety. Then sequentially increase the load until we see the tipping point.
- Matt – Looking at this, does it look realistic? Is it plausible?

- Duncan – What sort of depth change are you seeing? Mitch said generally plus or minus a foot but added that the 1D hydraulics cannot model pools such as ambush rock.
- Duncan – That's pretty stable.
- Stanford – recommend switching from Exner7 to with Exner5 sorting which should be more stable. Ambush Rock needs to be set as pass through.
- Mitch – In general the modeling that Rich has been doing is a better perspective of local project effects. Rich asked if they saw any cyclical scour and deposition of fine material in the backwater region between backwater conditions? Mitch said yes, you do.
- Stanford – My suspicion is that as the water level raises and drops that is something you're going to capture. We can get to it from the cumulative time series.

Actions:

- Ryan to provide older ADCP data to Mitch to integrate into model.
- RDG will update the bedload and suspended load comparisons between the Kootenai River and other regional systems.

March 5, 2014

1. Recap Discussion from Day 1

To follow-up on the previous day's discussion, Matt requested participants provide any additional input on: 1) tweaking pool geometry/pool alignment and structures, 2) anything else RDG can do to address uncertainty in the models, and 3) how to best frame up the observations in the design report e.g., how to appropriately convey expectations for project performance and risk.

- Jon – In terms of the pool and island stability, we'll go back and do our best guess scenarios with the best inputs from various collaborators. We'll pass that around and try to come up with a list of potential tweaks. Within the spread of uncertainty we have to be realistic about what we can really do. We can improve some things e.g., lower slopes at upstream ends of pools, etc.
- Karl – Try to make the pools work a little more with the barbs you're building on the bend. They seem a little disconnected and maybe could work better. Compare the volume of excavation to volume of transport. Get some kind of time reference. Compare bedload transport. What do the numbers come out to be?
- Duncan – Jon summarized where I am. You can only push the modeling so far. There are some reality checks; one is the bedload contribution. If bedload goes in the hole it's going to stay there. The challenge is the fraction of suspended sands. That's the tough part to model because models are so sensitive to grain size. See if you can use any information from the existing pools regarding infill, i.e., what's on the bottom. The 1D modeling is really nicely presented. I'm still trying to understand what the conclusions were from that. What is it really saying? From a practical side, I don't see a problem if there is some movement or adjustment of the islands. It is really presumptuous to think that you're going to get a configuration that is "right". To the degree you can manage that expectation that's good. Pools will be dynamic. There will be some changes. This reach is not very active but it is also not static.
- Stanford – Reflecting on Rich's presentation, it looks like sand can be removed with clear water flow. Bedload puts a 20-year cap on what it is. The 2D modeling suggests there's a level of self-

sustainability here; that makes the hydraulics more critical. I think the modeling shows that pool #2 can be improved. Look for ways to optimize the hydraulics.

- Molly – Will provide Jon and Rich with grain size distribution from the autosampler. She has 2 years of autosampler records. For bedload she has 4 years of data. Mitch noted there is also the older stuff that Gary did for bedload.
- Chris – It was good to see in the bed evolution model that the pools didn't migrate downstream towards the bridge. Matt – that question hasn't really come up yet but it could. Typically people looking at bridge hydraulics. If an engineer asks about pools or islands migrating into the right of way it sounds like we have the ability to address that with the bed evolution model.
- Mitch – Which is more appropriate on bed evolution - long flow models or running actual time series with the load? My thought is running three months of load would be useful. Since we're dancing around these questions, one bookend gives one answer and the other bookend gives us another answer. Jon thought the best approach is probably to pick one high and one low energy annual hydrograph and see how much filling we get.
- Matt noted that another consideration related to sediment load is that we've been collecting data throughout the time period we've been constructing these projects. Through the KRHRP projects that have been constructed in 2011-2013, we've essentially cut off 80-90% of the local sediment supply from the banks in this reach. We could see a reduction in some of the fines from these bank projects.

2. BFI vegetation analysis

See Presentation 7.

Tom reviewed the list of plant species you might see growing together in the Bonners Ferry Islands area plant community. He reviewed the differences in how different plants respond to different treatments. From physical modeling point of view, he explained, if you're trying to come up with criteria for vegetation there's a lot of literature. But the numbers in terms of how long a specific plant can withstand being inundated are different for different systems.

He reviewed the functional guilds in plant communities and the relationship to flows. For example, cottonwoods put out a lot of seeds and a relatively small percentage of those survive. Once they hit the ground they have a very short window of time for the roots to get going if they are to survive. Once they get to certain size (trees) they are hardy although there are some disturbances e.g., ice, that they may not be able to withstand.

Reed canarygrass is another challenge. Reed canarygrass colonization is a risk to getting cottonwoods to establish. Reed canarygrass also puts out a lot of seeds, but they're highly viable. They can persist for a long time in the soil. If you disturb an area there's probably already seed there. When reed canarygrass starts being flooded it send out roots. When flooded it shifts to a tussock form and puts energy into vertical growth. It can withstand turbulence and shear and has one of the widest ranges of plant tolerance. Reed canarygrass is good at growing fast. NRCS promoted it to farmers as a good crop for hay. If you had a small piece of land you could grow enough forage for cows. As grass adds roughness on point bar it will start to trap sediments and build soil that creates better environment for reed canarygrass. Reed canarygrass invasions happen in wetlands near sediment sources. Sediment flows into wetlands and makes it more homogeneous and provides a better environment for reed canarygrass.

Alder is fall seeder; seeds mature in late summer. It starts as a catkin but ends up being woody cone. Alder drops seed in early fall. Some are viable and some are dormant. It is a dual strategy. Some seeds need to overwinter and then can respond to spring freshet. It can modify its environment; is a nitrogen fixer. We tend to see it in areas with a more stable water table. The roots are closer to the surface. Different plants are using different aspects of the hydrograph.

Cottonwoods are also good at colonizing. But the seeds are really tiny and they don't have any energy reserve. Cottonwoods are not a good competitor with other species. If you have a dewatered system you tend to see a shift in balanced ratio of cottonwood males to females. There are boy and girl cottonwoods. Females tend to die off in a dewatered system. A lot of older cottonwoods are stranded on a higher surface. If they're producing cottonwood fluff they're girls. If you've got more males than females that could mean we have fewer seeds available. A lot of cottonwoods we have in the Kootenai River watershed are plains cottonwoods. Tom didn't know if the male and female thing was true for them or not. You see cottonwoods colonizing fine sands, coarser gravels, etc. even though literature says they just like just coarser gravel. Stewart Rood is doing research looking at areas below dams, looking at soil saturation and the impact on cottonwoods.

If cottonwoods establish too high relative to river stage they'll die, if they establish too low they'll scour off. We are looking for that sweet spot on the Kootenai River. Norm Merz with the Tribe observed young cottonwoods laying on surface of point bars with their roots on surface. He hypothesized that you have ice freezing around the roots, then with winter operations the ice melts and refreezes pushing them out. Reed canary grass tends to outcompete the cottonwoods as it switches to the more rhizonomous zones.

Cottonwoods need more sediment available each year. You get successful cottonwood recruitment even about every 10 or 12 years. There are clear elevation bands where cottonwoods are establishing. When you get off the river into more of a backwater zone that elevation niches is colonized by reed canarygrass.

Assembly theory is a model some ecologist use to understand how plant communities develop over time. The idea is if you develop a filter that will dictate what can't grow there. Tom reviewed the ecologically significant elevation, i.e., the elevation at about 20-30 kcfs, where cottonwoods are establishing on the floodplain and showed those locations on a map.

Cottonwoods group at approximately one-inch per day. That is the water falling rate; it is a conceptual estimate. Cottonwoods seeds need to hit the ground when it is wetted to survive. If they it have a week to extend their root system down that will be enough to get started.

With the North Side Channels project, one objective was to increase the amount of bare ground at that ecologically significant design elevation for cottonwoods. The Kootenai River used to be a hugely depositional reach with large areas of floodplain. The hypotheses in the North Side Channels project was that if you built these surfaces at this elevation you'd get cottonwood recruitment. They are seeing lots of recruitment at that site now.

Last summer Tom went out and mapped vegetation communities on the islands. He stuck to the Islands because that reflects the elevations that we'd be looking at on the Kootenai River. The 1758-1762 elevation that we picked for the islands looks about right. Anything below 1758 probably will not support perennial vegetation.

One question is if we can find the highest energy condition that you could see on that river and figure out what it is so that we can identify a flow when you'd have the highest energy gradient and figure out a threshold condition for vegetation. Is there some relationship between mobile particle size and mobile plant size i.e., ability of plants to stay put. Can we use shear stress as part of the design criteria? Colonization is also dictated by what seed got there first. There are other challenges too, for example, geese have overgrazed Box elder Island. That is a potential problem on the Bonners Ferry Islands too.

A challenge is how to quantify risk of cottonwoods establishing or not establishing. Tom reviewed the Bayesian conditional probability tables, essentially cause and effect pathways, which he has developed for the vegetation component of the KRHRP.

Discussion of vegetation analysis and risk mitigation:

- Rich – If we want to use shear stress as design criteria we may need some other models. What you're missing is the evolution of that island. After the island gets established the flow also gets reduced. Stanford wondered if the variance might be more instructive. Tom wondered if maybe rather than taking the whole polygon you could tighten the area up. Mitch noted the resolution is already getting pretty small relative to the vegetation polygons. At some point with FASTMECH you can't zoom in too much. There's a window between a really low shear stress and something slightly higher. There's a narrow energy band that we're trying to bracket. The hypotheses is you need some amount of energy long enough to establish desirable plants but not too much energy that will strip them off.
- Rich – It seems like a really critical part of the vegetation work is the sediments being deposited plus the hydraulic conditions. All those conditions you've shown so far are point bars. In the restoration work you're basically stopping the development of point bars so you're stopping that regime of disturbance that creates those conditions.
- Mitch – The conditional probability tables provide a useful framework that we can feed information back into and a way to quantify risk.
- Matt – It seems like we're scratching our head over the shear stress numbers, it's a tight range of numbers. I wonder if it's maybe not the right criteria. I wonder if we need to just be looking at the bars. Maybe think of disturbance as an evolving surface. I don't know if deposition has an effect on reed canary grass, but it seems like deposition of sediment is helping get cottonwoods to year three or so. Tom – They can't be buried too deep but they can survive being buried to some extent.
- Tom – Can we design for that process of continued aggradation? That's what these plant communities are evolved to. Mitch – That's one intent of the microtopography. Matt – I don't think we can design it.
- Jon – If you use models that are coupled for vegetation growth "rules" about what goes on you could model it. The hard part is the feedback loop. In the same way we use the computational flow model, we've used that and bed evolution and growth "rules" to predict where things will grow. You can just step through time over the years and end up with a prediction of what you think will happen. It is even worse then sediment transport due to the uncertainties. But it is something. Andrew Wilcox has done simple work using FASTMECH. We've written plans to do a very generic set of rules to make that apply to other species.
- Rich – Hiroshi has done that in Japan and Italy. Blair has done work for seasonal macrophytes.
- Jon – we've looked a little at stresses to move a certain type of vegetation. It is really simple in single species applications. Hiroshi has done more complicated work. If you don't have the roughness field its hard to speculate the answer. I think if there were a simple enough sets of rules or elevations or sedimentation rates for certain species it would not be that hard to run the model over time.
- Mitch – The Bayesian process could help build the rules, but it takes some time to build that data set.
    - Jon – It is iterative, you do flow, then sediment transport, and then you can add probabilities. You can have all sorts of different relationships or probabilities.
    - Mitch – Even if they weren't accurate but just quantitatively representative that might indicate a trend.

    - Jon – Need to keep it simple.

- Duncan – How important is sediment deposition once cottonwoods are established? Tom – It's the early life stage that requires the substrate and sediment. Duncan – One way to reduce the risk of failure is to use seedlings? Can you plan cottonwood seedlings? Tom said yes, that was something that was under consideration.
- Rich – Wondering if you know what the age of the different vegetation communities is and if you related it to the history of flow you could get some sense of what was unique about the time. Then we could run those models over a long period of time. Sue asked if Stewart Rood had done that with the cottonwood recruitment after the sturgeon flows started? Tom said he had done some of that.
- Tom – Think the challenge is that as we get into the Bonners Ferry Islands area we don't see much vegetation that we want there. The more we get into the backwater area in this confined reach there's just nothing happening.
- Duncan – again planting seedlings there may be the best mitigation approach in this location. Duncan also asked about using alders. Tom is looking at alder, dogwood, and three or four species of willows. There is existing willow and dogwood in that reach. He is envisioning the vegetation on the islands as being largely composed of bushes and shrubs.
- Molly – Has anyone looked at the groundwater data to look at if there's variability in terms of how the islands respond to the river? Tom said they did look at that. The wells close to the river very closely follow the river stage. If you're close to the river the groundwater is going to closely follow the river stage. It's when you get within the levees away from the river that there's a difference.

3. Flood Risk Modeling

See Presentation 8.

Chris presented the RDG flood risk analysis. He explained that the objectives were to review the 1D flood model results and get input regarding acceptable risk tolerances. That input will be integrated into the flood risk analysis for the final designs for Bonners Ferry Islands and the Straight Reach.

The overall goal is to maintain the current risk tolerances for flooding in Bonners Ferry, which included evaluating the effects of the habitat project on Libby Dam operations. RDG met twice with the USACE to identify and refine an approach. The first meeting was in May 2012 to define the modeling approach. The second meeting was in December 2013 with Joel. Fenolio and Greg Hoffman to look at initial results and refine the approval process. The final step will be to confirm that the USACE approval of identified flood risks and management operations will also satisfy FEMA and meet other regulatory requirements.

Karl Erickson produced a memo in February 2014 (Attachment B) that indicated that according to initial model results the USACE could manage to current flood levels, and confirmed their concurrence with the agreed upon approach pending completion of the final design and model input. In short, the memo stated that the proposed KRHRP actions are not likely to have a measureable impact on Bonners Ferry flood elevations. That there were no changes in water management recommended for Libby Dam based on current designs. And that USACE would re-analyze impacts of any future design iterations. RDG will provide USACE with the final HEC-RAS models for use in conducting a quality review.

The meetings were helpful in providing a framework for taking the 1D results and turning them into understandable metrics, and translating that into implications for reservoir operations. The current flood management thresholds in Bonners Ferry are based on 0.5%, 1% and 10% exceedance thresholds. The current flood threshold in Bonners Ferry is 1,764 ft NGVD29 (~1767.86 ft NAVD88). The modeling bracketed extremes including high lake/low flow conditions and a really high lake level with high flows. What has actually been observed in Bonners Ferry falls somewhere in the middle. Matt noted that they've been able to calibrate some of the higher flows with the recent 2011 high flows.

Chris explained that what they are looking at is how the median line shifts. How does it represent the confidence intervals? How does the shift in this line translate into flows? Various combinations of lake elevation and flow can produce flooding in the areas protected by levees between Bonners Ferry and Porthill, ID. As a result, stage-based regulation targets have been adopted.

Chris reviewed the FEMA maps for Bonners Ferry (see presentation). Zone A10 is the area of 100-year flood with base flood elevations determined. It is the area right in town. FEMA has published flood elevations for this portion of the data. The map is 1980s era and a little outdated. Mitch noted that FEMA isn't up to date with any of the longer-term work that the USACE has done. In FEMA's Zone A most of the rest of the County, there are no flood elevations determined. Up to this point none of the KRHRP projects have been in the Zone A10 – they've been upstream in Zone A.

In 2005 the USACE completed a flood study looking at flood damage exceedance thresholds throughout the Kootenai River that was translated into damage assessment information. Chris reviewed the 1D modeling efforts to date:

- 2005 COE Bonners Ferry Flood Level Study Report Model
- 2005 - 2010 USGS Model
  - HEC-RAS Steady flow / quasi-unsteady
  - Downstream boundary = stage at Porthill, ID
- 2012 Columbia River Treaty Model (CRT)
  - HEC-RAS Un-steady flow
  - Upstream boundary = Kootenai River discharge from Libby Dam
  - Downstream boundary = Kootenay Lake stage at Kuskonook, Canada
- 2013 Kootenai River Habitat Project Flood Compliance Model (FCM)
  - HEC-RAS un-steady flow calibration / validation models
  - HEC-RAS steady flow 'index' model
  - Upstream boundary = Kootenai River flow at Leonia, ID
  - Downstream boundary = Kootenay Lake stage at Kuskonook, Canada

In 2013 RDG started working on a flood compliance model which is a derivative of the USACE and USGS models, but which incorporates enough resolution to show the effects of proposed KRHRP projects. Chris explained that RDG had originally planned to use the CRT model to evaluate the KRHRP projects. However, they found some cross-sections in the braided reach that are skewed to the current flow regime and didn't incorporate recent bathymetric data. Also the reach lengths in some areas didn't match cross sections. In the meander reach downstream of Porthill they found one cross-section that appeared to be stretched and overestimated the flow area. However, none of those were major issues. The biggest issue was the density of cross sections in CRT model, which wasn't sufficient to allow RDG to represent the KRHRP project geometry. It is a difficult situation with the backwater effects. Using Kootenay Lake as downstream boundary, with changes in fluctuations in the lake levels, it is difficult to find a single set of calibrated flow dependent roughness values.

RDG made a number of improvements to the base CRT model. In the braided reach they corrected skewed cross sections and downstream reach lengths, added cross-sections to represent pre- and post-project conditions, adjusted ineffective flow areas for side channels, used additional gages and stage recorder data for calibration, and vertically varied roughness using calibrated flow roughness factors. In the meander reach they corrected stretched cross sections, added cross sections to enable representation of pre- and post-project conditions, used 2012 and 2013 multibeam bathymetry, and vertically varied roughness using calibrated flow roughness factors. They now have an average of roughly 200 cross-sections spaced throughout project area.

Chris reviewed the pre-project existing ground for the Bonners Ferry Island project area and then showed the proposed design surfaces, which incorporated the currently proposed pools and islands. He reviewed the USGS Kootenai River and Kootenay Lake gages that were used to calibrate the model. The biggest challenge for them has been the datum issue for the downstream boundary condition. Canada is working on a sea level datum that's been updated over time with the most recently published version in 2013. They can use that with their GPS reference. But it doesn't correlate to the NGVD29 and NAVD88, which is where all of the RDG and USGS cross-section and stage data is. He ended up using a common datum at Porthill and found a conversion factor that could be applied from there. There are still some questions regarding the best way to correct the Canadian datum. One of suggestions from folks in Canada and RDG is to go out and set up base stations and set up actual GPS data. However, with the current corrections instead of a discrepancy of plus or minus 4 feet it is now plus or minus about 1 foot.

Chris reviewed the calibration data and calibration issues noting that the Klockman gage was only available for WY 2007-2011, so they used those years to calibrate the model.

Another challenge was how to account for tributary flow inputs in the meander reach. In CRT model they took tributary inflows between Libby dam and Leonia and averaged those over their calibration period and inputted that at a single location, or distributed it at a number of cross sections. That allowed them to calibrate the model to peak stage plus or minus a foot. But the lower flow stage calibrations were a little more variable. RDG ended up taking the actual difference in flow from below Moyie to the Tribal hatchery and distributing that over the reach, and taking the difference in flow from the Tribal hatchery to Porthill and distributing that over the reach. They took about 30% of flow from the Deep Creek watershed and put that at the Deep Creek confluence. Smith creek accounted for about 30% and they put that at Porthill. The remaining input was distributed through the reach. That allowed them to match stage and flow more precisely i.e., within less then one-tenth of a percent.

For the meander reach bathymetry, they compared the 2013 multibeam data from USGS with the older data. Adding the 2013 multibeam data had a noticeable effect on the model. Using the 2013 cross sections caused an increase in water surface elevation of about three quarters of a foot. It has a noticeable effect on the overall water surface elevation.

Chris walked through the model calibration. Base Manning n values were horizontally varied using generalized polygons. Low roughness factors were applied by reach (6 – 60 kcfs). The unsteady model was calibrated using WY 2008-2012 and validated with WY 2006. Chris showed comparisons of the CRT model at Porthill and Bonners Ferry. The results were much improved when you used actual flow rather than averaged flow (see slides for calibration results).

Chris reviewed the FCM simulations. The results of the unsteady model allows comparison with observed data over time. Steady flow 'Index' model depicts a steady-state snapshot in time. The three-way lookup tables: rating curve shows pre- and post-project WSEL, rating curve shift shows difference in stage-exceedance curve, delta flow shows difference in flow corresponding to rating curve shift (see slide in presentation for results).

Mitch took two curves and for each one-tenth difference in stage plotted a curve that's the difference in flow as a function of stage. The question was what is the difference in flow to offset that difference in stage? Karl validated that the modeling is in line with the USACE three-way lookup table. This is data that was presented to USACE in December. The next steps are to translate this into the difference in flood exceedance probability by hand fitting some curves. However, everyone was really interested in seeing what happened when you fill pools in so Chris went ahead and ran that. They looked at the difference with from one to three pools filled back in. For WY 2006, the maximum increase was 0.07 feet based on maximum stage plot. There is a noticeable difference at lower flows with and without pools. At higher flows it is drowned out by backwatering.

Nest steps include:

- Survey Kootenay Lake gage benchmarks at Kuskonook and Queens Bay to determine accurate conversion factors
- Survey additional cross sections at meander reach high points and pinch points
- Consider adding stage recorders in meander reach for calibration/validation
- Append CRT model geometry from Leonia to Libby Dam
- Run synthetic flows provided by USACE
- Evaluate project impacts
  - Reduction in flow required at Libby Dam
  - Duration of flow reduction
  - Cumulative volume of flow reduction
  - Change in flood frequency at Bonners Ferry
- Document modeling and analysis in report to USACE

Discussion of flood risk analysis:

- Duncan – This simulation doesn't reflect any changes in bathymetry after the islands are built. That is a concern. It is a neat result, the fact that the impact on the stages is so low. It would be interesting to look at the change in conveyance of the flow area. We're building the island in an area that's already pretty high so there can't be much change in conveyance capacity.
- Jon – It is all backwater so it doesn't matter. It would be shocking if there were any significant impact. Matt – That's why we pulled back on the idea of creating all these complex surfaces.
- Duncan – So even if we did get scour at low lake levels it wouldn't make any difference when the lake levels are high.
- Matt – We thought is really important for everyone to hear how these models were developed. It has been Chris' life for some time now.
- Jon – It looks good!
- Rich – Looks really good!
- Karl – What was helpful in the presentation to us was the difference from the 2012 flood. That is something that the public has fresh in their minds. It will be helpful in communicating to people.
- Matt – Are we overlooking anything with FEMA? Hopefully we won't get into a technicality with them on no rise, but will it really come down to the USACE being able to say it doesn't change their ability to manage to the current risk tolerances that relate to the base flow. Karl – It will depend on who your FEMA representative currently is. Matt – I think if it is a no rise the

County can say okay. Karl – FEMA may let the county decide even if there is a rise. Mitch noted that at the 1% level it is actually no net rise.

- Molly noted that the new Idaho state floodplain coordinator is Keri Sigman

Action:

- Sue to follow up with Sean Welch and Ted Gresh about what information they would like to have from the team to include in the EA.

4. Physical Monitoring for Meander Reach Substrate Project

See Presentation 9.

Matt provided an update on the substrate enhancement pilot project scheduled for implementation in 2014 and explained that as part of the modeling meeting the Tribe wanted to get input from the modeling subgroup on how to best accomplish physical monitoring of the pilot project. The Tribe has been coordinating with IDFG on development of a biological monitoring plan.

The meander reach substrate pilot project will include sites (Shorty's and Myrtle) with a one-acre substrate patch at each site. Each one-acre site will include approximately 3,500 cubic yards of substrate materials. Barges will be used to transport and place rock. GPS and sonar will be used to achieve accurate placement below the water. The Tribe is currently reviewing alternative staging sites and finalizing the construction approach details.

Sue and Alison explained that IDFG developed a study plan to monitor egg deposition and larval survival at the site. A draft of that plan was reviewed by some of the PRAT members, and IDFG also coordinated with Jason McLellan and Larry Hildebrand who have a track record of success in capturing larvae, in order to get ideas about how to modify gear and approaches. IDFG revised their study plan based on this input. A second review was recently completed although IDFG has not received the results of that second review yet. They will begin pre-project baseline monitoring this summer.

Matt explained that the team would like to get the modeling subgroup's thoughts on how to conduct the physical monitoring for the project. The primary questions are (1) whether the surface remains clear of sand or fine sediment during the spawning season and, (2) whether the interstitial spaces remain clear to D90. Matt explained that there is no widely accepted method for measuring substrate embeddedness. There is also the challenge of how to do physical monitoring under 20 or 30 feet of water.

Discussion of approaches to monitoring surface sand/sediment deposition:

- Group discussed possible use of a diver. However there are significant challenges associated with safety and velocities during the spawning season. It might be possible to send a diver down to check embeddedness at lower flows and to take pictures. Matt talked about possible ways to set up a descent line and a longitudinal line that the diver could follow. Sue said that in the past a graduate student had tried diving in the area and found the velocities really difficult. Ryan agreed that it would be challenging, especially during the spawning season when flows are high.
- Ryan – We've put a video camera down there before and that gives you a good surface view. A vertical camera gives you good spatial location. Ryan offered to dig up old videos of the area to see what is available. Rich noted that he and Gary Barton took video in 2002 and there was no problem seeing the ground.
- Mitch – Recommend using a better camera than the one the USGS has previously used. The resolution on the USGS camera isn't that good and there's a fish eye effect. A high end GoPro

might be more cost effective. However, the vertical arm on the USGS set up works really well and USGS has experience working with it.

- The group also discussed mounting a camera underwater. You could plug a cable into the camera and set it up to view using Lab View on a laptop.
- Jon – Suggest having fixed cameras or a Didson camera. With Didson you could look at the bed and see if it's embedded.
- Mitch – Also talked about having Ryan do another surface multibeam over the site to see if there's a veneer over it. The group also talked about the need for an as-built multibeam. This would either be included in the USGS 2014 SOW or specific details would be written into the contractors SOW.

Discussion of approaches to monitoring embeddedness:

- Matt clarified the approach being used to place materials and modifications to material composition. The plan is to place the big rocks first and then put down the smaller stuff. The original gradation that was identified during the 1135 process has been modified slightly to eliminate the 2.5-inch and smaller component.
- Stanford – What are they doing on the Trinity? They're doing a lot of work on embeddedness. Is there some sort of slide geophysics you could do? You could talk with a subaqueous geophysicist to see if there's something you could drag down to see if it is bridging or percolating. As soon as you fill those interstitial spaces you'll see it. Jon thought it would be too small a scale for that to work.
- Duncan – if you had a probe or tube with some hydraulic pressure and you put that tube down 6 inches qualitatively you'd see any fines. You could qualitatively capture how much fines is in there. If you had a camera and a probe and a shot of pressure. Jon – not sure how to use that information.
- Rich – If all were talking about is fine sediment getting into the interstitial spaces and filling up, maybe the immediate issue is really just how clean it is during spawning season, and is it still there after the peak. Mitch – So that monitoring would occur after the two distinct hydro periods in March and August. Then after a few years you would look at the interstitial spaces. Rich – I think it won't be an issue for the first few seasons. Mitch – You are saying that the measurement of the embeddedness may not be triggered until you've seen it on the surface. Duncan – You could possibly make that D90 assessment by saying no we see gravel between the interstitial spaces.
- Duncan – I wonder if you would see any embeddedness that would hamper successful spawning by just photographing the surface.
- Jon – We all know that the deep interstitials will fill somewhat. It is just a question of how long it will take. A depth of D90 was what Boyd said was sufficient to still allow larval hiding. You can concentrate the effort at different periods of the year to give you exactly what you want to know.
- Stanford – We've done a bunch of flume flushing; you get relatively clean if there's enough difference between the substrate and fill materials. You will get surfaces underneath that will be clean if there's enough shear.
- The group discussed the idea of burying a cylinder that could be retrieved. They identified challenges with retrieving it, although there was some agreement that if you could figure out how to make it work it would provide valuable information. It would be inexpensive to place it; it is just the retrieval that is challenging.

- Molly brought up the idea of possibly installing a pressure plate. But others thought it would be to difficult to get the data and that the scale would be an issue.
- Matt – We will be able to see enough into the interstitial space to see if a D90 is available with the camera. The material we will be uses is a range of about 2.5 to 20-inches.

Discussion of timing of monitoring:

- Recommendations that were discussed included: during spawning and egg incubation, post freshet, and post-winter operations. Jon recommended continual monitoring over the whole time period if funding allowed. Stanford recommended post freshet and pre-spawning to take biological interference off the table. Sue commented that monitoring pre-spawning is not of any value since you wont know if conditions have changed when spawning begins.
- Matt – The highest sediment load comes when the tributaries empty out. The fish are going to spawn on the descending limb post-freshet. It helps to think about it in terms of the expected sediment load.
- Jon – Suggest that we really cover it well for the first year, less the second year and after that maybe just once a year.

Recommendations for physical monitoring of substrate enhancement pilot project:

- The group reached agreement that surface videography is sufficient at this time to monitor the surface. They also agreed that it would be possible to tell from the surface images if the interstitial spaces were beginning to fill in. All agreed that in the near term the filling of the interstitial spaces was not a concern. At this time having USGS do the videography makes the most sense since they've got the equipment on their boat to mount the camera and have experience operating it. The group recommended upgrading the camera to an upper end GoPro. Ryan also suggested using the old camera to help guide the new GoPro since it has real time feedback.
- There was also agreement on the need for a good as-built multibeam surface either from contractor or from USGS. The Tribe will determine if that will be included in the USGS SOW or in the construction contractor's SOW. **Clarification: Per the construction drawings, the construction contractor will be responsible for completing an as-built survey using multi-beam sonar.**
- The agreement on timing of monitoring was to complete videography of the pilot project in during spawning, post-freshet and post-winter ops (i.e., approximately March, August and somewhere in between in May/June).
- Molly also suggested getting some ADCP measurements while you're doing the spawn time videography. Chris thought there would there be value in an upward looking ADVM that would measure velocity over the course of the freshet. Participants agreed that collecting additional ADCP measurements would be valuable.

Actions:

- Rich and Mitch both asked for a copy of the latest version of the IDFG biological study design. Alison will send it.
- Determine if as-built multibeam survey will be conducted by USGS under the 2014 SOW or written in with detailed specs into the construction contractor SOW.
- Stanford will send a paper he has on embeddedness from the Danube.

5. Concluding Comments and Wrap Up

Meeting participants offered the following closing thoughts on risk and risk mitigation:

- Duncan reviewed the risk matrix item by item.
    - Flooding: The work done on the model is very rigorous. Flooding doesn't seem to be much of a risk and is very manageable.
    - Sediment transport: Sediment transport is now catching up with the project. The risk appears to be in the interpretation of the 2D models. There's a certain element of faith in any modeling. There are probably not a lot of holes in the sediment transport analysis except how that information is used in the interpretation. You can minimize your risk by not claiming that anything is going to be stable, it is a dynamic system and you should expect dynamic stability in the constructed pools and islands.
    - Bank erosion: Only concern would be if there was anything being done that causes bank erosion on private property or if there is other bank erosion that you're exposed to.
    - Subsurface conditions: Given that you didn't encounter sand or silt in the coring samples, the risk is small.
    - Levees: The risk is small.
    - Bridges and utilities: The risk is small.
    - Vegetation establishment: A question to Tom was: would it be deemed a lack of success if you don't get natural cottonwood recruitment? Or is the idea of the island simple to have vegetation development, in which case you could install plants plant. If natural recruitment is the goal it will be difficult. But you'll be able to vegetate the islands. Matt also noted that part of the project actions also includes planting the banks.
- Rich – I'm really encouraged by the result that Chris gave related to flood risk i.e., if the pools were to fill in at some point there's no flood risk associated with that.
- Karl – Risk areas have been well addressed.
- Stanford – Substantial steps have been taken to reduce uncertainty since I last saw this. The designs are engineered optimally and uncertainty reduced as much as it can be. I have short list of HEC-RAS model suggestions that I will send to RDG.
- Molly – A general comment is thinking about to communicate risk effectively to the public. It is a dynamic system and there will be changes. How to you convey that and not send the public running?
- Jon – Have already covered Islands and Pools in previous discussions. The risk of having substrate in the substrate enhancement project permanently covered with sand is very low.
- Mitch – Regarding the stability of Bonners Ferry Islands there is a range of category of risks. Some are more important than others and the scale of the risk is important to consider. It may be helpful to rank the different risk categories appropriately.

Next meeting and other follow-ups:

- Ryan – I learned a lot from the meeting. There are some changes we need to make in terms of upcoming bathymetry. Mitch and Alison will coordinate with Ryan in next four weeks or so to identify changes.

- Alison – Future modeling meetings might be focused in part on looking at monitoring results, maintenance needs in addition to other future projects.
- Sue – Also recommendations for management of these projects for the long-long term.
- Chris – Talked with Rich briefly about the meander reach and the survival model, i.e., whether it is feasible to couple the larval drift model. That's something we might consider in the future.
- Ryan – Is taking over the velocity depth mapping that is part of the BiOp compliance. He is going to summarize all of that data going back to 2008. He would like to run this by this group.
- Molly would like to have some one-on-one time with RDG to go over the data.
- Alison – Also need to schedule a spring meeting with USGS to refine the 2015 SOW. That could be in-person or GoTo.

Attachment A. Summary of Technical Risk Management Approach

Summary of technical risk management approach				
Risk Element	**Potential Consequence**	**Risk Mitigation Strategy**	**Risk Assessment Method**	**Conclusions**
Flooding	Project increases flood elevations causing damage to structures	Coordinate with USACE water managers for model inputs and risk tolerances	Evaluate project effects on Libby Dam management using USACE HEC-RAS unsteady flow model.	TBD
Sediment transport	Project causes deposition or scour resulting in channel instability	Coordinate with Modeling Subgroup and PRAT advisors to establish modeling scenarios and review results	Evaluate post-project morphologic changes for pools and islands using 2D bed evolution model.	TBD
Bank erosion	Project increases bank erosion	Design bank treatments to withstand anticipated range of hydraulics	Evaluate project effects along bank margins using 2D hydraulic model	TBD
Subsurface conditions	Unexpected subsurface conditions affect implementation	Evaluate subsurface conditions at proposed pool excavation locations	Subsurface borings and geotechnical characterization of subsurface materials to be used for construction.	TBD
Levees and private property	Project causes damage to private property or levees	Coordinate with landowners to review risks and mitigation strategies	Evaluate localized project effects using 2D hydraulic model.	TBD
Bridges, Utilities and Infrastructure	Project alters hydraulic conditions at bridges	Coordinate with owners to review risks and mitigation strategies	Evaluate localized project effects using 2D hydraulic model.	TBD
Vegetation Establishment	Vegetation does not support island and bank long-term stability	Evaluate suitability of project conditions for vegetation establishment	Evaluate depth, duration and shear stress in planting areas relative to suitability criteria for vegetation	TBD

Attachment B. USACE Flood Risk Memo by Karl Eriksen

CENWS-EN-HH-HE 05 February 2014

MEMORANDUM FOR Water Management Section, Hydrology and Hydraulics Branch

SUBJECT: Kootenai River Habitat Restoration Project Impacts on Libby Dam Flood Regulation at Bonners Ferry, Idaho

1. BACKGROUND

The Kootenai River Habitat Restoration Project (KRHRP) is being conducted by the Kootenai Tribe, with funding from the Bonneville Power Administration (BPA) provided through the Northwest Power and Conservation Council's (NPCC) Columbia Basin Fish and Wildlife Program. The KRHRP started in 2008 with the preparation of a Master Plan that outlined the project's goals and objectives. Since 2007, River Design Group (RDG) has been the lead consultant for KRHRP design work. Prior to that, from 2002 through 2006, the USGS conducted data gathering and hydraulic modeling on behalf of the Tribe. The USGS continues to be an active partner, conducting field investigations and hydraulic modeling for the Tribe.

The purpose of the KRHRP is to restore and enhance Kootenai River habitat by addressing ecological limiting factors and constraints related to river morphology, riparian vegetation, and aquatic habitat. The focus is to provide habitat features that are sustainable under the regulated flow regime provided by Libby Dam operations. Habitat restoration for the endangered Kootenai River white sturgeon is an important consideration in the KRHRP.

The project area covers 55 miles of the Kootenai River from the Moyie River confluence, downstream to the international border. The Braided Reaches extend from the Moyie River confluence downstream to the U.S. Highway 95 Bridge. The Straight Reach extends from the U.S. Highway 95 Bridge, downstream to Ambush Rock. The Meander Reaches extend from Ambush Rock to Porthill. The federally designated Kootenai River white sturgeon critical habitat is included in the project area and spans 18.3 river miles (RM) from upstream of Bonners Ferry to downstream of Shorty's Island.

The KRHRP considered a broad range of habitat restoration alternatives, including in-stream, tributary, and floodplain measures. In 2009, it was decided to focus on restoration of Kootenai River channel and riparian habitats. A three phase plan was developed that started restoration actions at the upstream end of the study area and progressed downstream. Phase 1, built in 2011, involved shoreline improvements at RM 156.8 and 158.7 as shown on Figure 1. Those improvements consisted of regrading the bankline, placing many pieces of wood and planting riparian vegetation. Phase 2, moved downstream to RM's 153.5-156 and was completed in 2012. Shoreline improvements, similar to the 2012 improvements, were built near RM's 155.6-156 and 155.2. Three large rock and wood bards were also built near

RM 156 along the right bank. Two side channels were regraded, realigned, and revegetated near RM 155.6. The third phase will be in the Bonners Ferry reach, RM 152-154, and is scheduled to be built in 2015-16. This phase may include the channel excavations, the construction of islands, boulder fields, and shoreline improvements shown on Figure 1.

Separate from, but in coordination with the KRHRP, NWS has conducted two 1135 studies in the same reach of the Kootenai River. The 1135 for the Braided Reach was abandoned when it became apparent that costs for an effective project would exceed the 1135 ($5 million) limit. The Shorty's Island 1135 study was completed, but implementation of the rock habitat placement has been deferred indefinitely. The KRHRP may construct a pilot scale rock habitat near Shorty's Island.

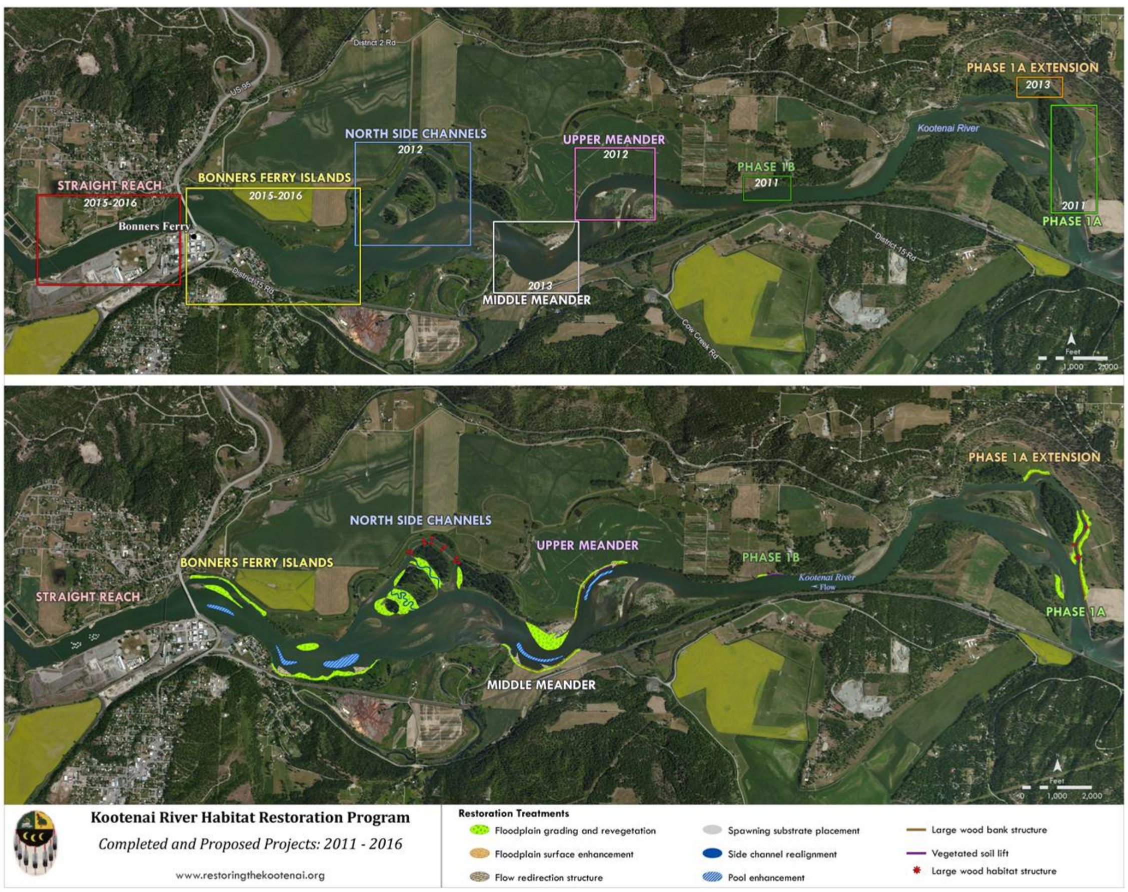

Figure 1. Kootenai River habitat restoration projects in the Bonners Ferry reach of the Kootenai River.

2. ADVISORY COMMITTEES

The Kootenai Tribe established advisory and technical committees early in the KRHRP planning stages to facilitate project management and design. There is a Kootenai Habitat Policy Team, comprised of appointed policy level representatives from the Kootenai Tribe, Confederated Salish and Kootenai Tribes, federal agencies, B.C., and the states of Idaho and

Montana. They provide ongoing policy guidance, coordination and help resolve critical issues as they arise. An interdisciplinary technical advisory group provides technical input and review, assistance in development of potential habitat treatments, and evaluative tools. This group includes various project consultants, and technical representatives from BPA, USACE, USFWS, USGS, IDFG, Montana Fish Wildlife and Parks (MFWP), and B.C. Ministry of Environment (BCMoE). NWS representatives on the technical advisory group have included, Greg Hoffman, Karl Eriksen, Alan Coburn, Pat Wheeler, Jeff Laufle, and Evan Lewis.

A hydraulic modeling advisory sub-group was formed in 2010. The group includes; Matt Daniels, Mitch Price, and Chris Nelson, RDG; Karl Eriksen, NWS; Stanford Gibson, HEC; Molly Wood, Gary Barton, Rich McDonald, and Jon Nelson, USGS; and Sean Welch, BPA. This group has met three times (December 2010, April 2012, and March 2013) to review hydraulic and sediment data, 1- and 2-D hydraulic modeling, project designs, and to recommend future analysis. For the restoration actions up stream of RM 154 the design questions have focused on sediment transport and the potential for deposition in reconstructed side channels or erosion at or around bank protection structures. The islands and channel modifications being proposed between RM's 152 and 154 raised additional questions about flood elevation in Bonners Ferry and potential impacts to Libby Dam flood regulation operations. RDG has presented their flood compliance modeling work to the modeling advisory group and that work has been found to be very comprehensive. However, since 2010, the hydraulic modeling advisory sub-group has been advising RDG/KRHRP that they would have to work with the floodplain regulators and NWS WM Libby operations to identify the necessary analysis and standards to gain project approval.

3. FLOOD COMPLIANCE

The RDG/KRHRP is addressing two separate, but related, flood issues at Bonners Ferry. The first is the potential increases in flood elevations that may be caused by the proposed restoration actions. This relates to the FEMA flood insurance program and is being worked out with the state and local governments. The second issue involves NWS WM and is the potential impacts to Libby Dam flood regulation operations. RDG has met twice (May 2012 and December 2013) with WM to describe their analysis and discuss what impacts to Libby operations may be acceptable to WM.

RDG has been building on the original Kootenai River modeling work by the USGS and has developed a very detailed HEC-RAS model of the river. The RDG/KRHRP model incorporates 2012 bathymetric data collected by the USGS and has many more cross-sections than the Corps' 2005 Bonners Ferry Flood Level Study or 2012 CRT models. At the December 2013 meeting, RDG presented their modeling approach, calibration results, and pre- and post-project comparisons. The RDG HEC-RAS model was calibrated to the 2011 Kootenai River freshet, with stage differences generally ranging between -0.1 to 0.1 ft at Bonners Ferry. To demonstrate the potential hydraulic impacts of the restoration actions proposed for the Straight and Braided reaches at Bonners Ferry, the freshet hydrographs for 2011 and 2012 were modeled in an unsteady mode for with and without project conditions. The resulting stage differences were presented for Bonners Ferry gage, the Tribal Casino, and the upstream end of the FEMA Zone 10A. At the Bonners Ferry gage and the Tribal Casino, the post-project water surface elevations were typically 0.05-0.1 ft higher than the pre-project elevations for discharges between 35,000 cfs and 60,000 cfs. Based on WM's 3-way Lookup Table for Bonners Ferry, the calculated water surface elevation difference would equate to 155-160 cfs difference in Kootenai River discharge. These changes are so small that they could not be measured in the river, but can only be found in numerical model results. For comparison, the error in the 2012 and 2013 Bonners Ferry calculations presented in the Lookup Table spreadsheet are 0.5-0.7 ft and 2,500-3,000 cfs.

The KRHRP restoration plans for the Bonners Ferry reach, as presented at the December 17, 2013 Flood Compliance Meet, would have very minor impacts on flood elevations at Bonners Ferry and reservoir regulation at Libby Dam. The 2011 and 2012 hydrographs that were modeled by RDG cover a wide range of discharges, 20-60,000 cfs, and show consistent 0.05-0.1 ft elevation increases over that range. In 2011, observed water surface elevations were above 1762 ft for about 11 days, but did not exceed 1764 ft. In 2012, observed water surface elevations were above 1762 ft for 47 days and exceeded 1764 ft for 16 days. The proposed KRHRP would not have required any alteration to Libby operations in 2011. However, in 2012, to produce the same water surface elevations with the KRHRP in place would have necessitated a 155-160 cfs discharge reduction for those 16 days that exceeded 1764 ft. This would have required Libby to store an additional 5,000 ac-ft of water, raising the pool level by 0.1 ft.

4. RECOMMENDATION

The proposed KRHRP actions are not likely to have a measurable impact on Bonners Ferry flood elevations, so no changes in Water Management activities are recommended for Libby Dam flood regulation operations. The KRHRP should be asked to reanalyze the flood impacts if the final design differs from the December 2013 proposal. KRHRP should provide NWS-EN-WM with the final HEC-RAS models used in the evaluation so we can conduct a quality review.

Karl Eriksen, P.E.
Hydraulic Engineer,
Hydraulic Engineering Section