Lower Nooksack River Floodplain Integrated Planning (FLIP)

Geomorphic Technical Meeting Notes

March 27, 2018

9:00 am to 3:00 pm

Lynden City Hall Annex

Participants:

Alan Chapman, Albert DeBoer, Andy Wiser, Bo Westford, Bob Mitchell, Carol MacIlroy, Chad Yunge, Chris Elder, Chris Konrad, David Radabaugh, Deb Stewart, Denise Doezema, Duane Holden, Eric Grossman, Fred Likkel, Guillaume Mauger, Joel Ingram, Joel VandeHoef, John Thompson, Karin Boyd, Landon VanDyk, Lonni Cummings, Mark Ewbank, Marvin Hoekema, Michael Maudlin, Ned Currence, Paul Knippel, Paula Harris, Pete Smit, Ray Timm, Rod VanDeHoef, Ron Bronsema, Scott Anderson, Scott Hulse, Sherrie Chang, Theresa Mitchell, Travis Ball, Travis Bouma, Treva Coe, Joanna Curran, Andrew Nelson

Facilitation: David Roberts (Kulshan Services), Nathan Rice (Kulshan Services)

Opening - Welcome, agenda review, introductions, meeting norms

(All presentations summarized below are available on the FLIP website)

Lower Nooksack River Geomorphic Assessment

Geologic and Geomorphic History – Paul Pittman, Element Solutions

Paul explained how the Nooksack River once flowed north to the Fraser River near Everson. Recently, from a geomorphic perspective, the river changed its course (avulsed) into its current alignment discharging to Bellingham Bay. This left a signature that is still present in the current geomorphic conditions. Key points follow:

- The river valley downstream from Everson has a different geologic history from the valley upstream of Everson. The valley is much younger downstream of Everson (~1000 years old) than upstream of Everson, where the Nooksack River has flowed for ~12,000 years.
- The Sumas and Nooksack valleys are still connected today during high flow, when floodwaters from the Nooksack River cross the shallow divide at the “Everson Overflow” near Everson and flow northward to the Fraser River.

Baseline Geomorphic Trends - Karin Boyd, Applied Geomorphology, Inc.

Karin presented an overview of the large-scale geomorphic trends for the Lower Nooksack River. It includes a review of the flood history and characterization of baseline geomorphic parameters by reach over time. The parameters include primary channel length, side channel length and density, active belt width, total channel area, floodplain turnover rate, and bank armoring. Changes in these parameters have resulted in a higher energy channel flowing through a narrower, less complex corridor. This has caused a loss of habitat and ecosystem benefits as well as increased stress on levees. Key points follow:

- The relationship between the flow in the Nooksack River and the flow that tops the banks at the Everson Overflow looks like it has changed through time, with potentially more flow toward the Fraser River at a lower discharge in the Nooksack River.
- The channel naturally transitions between Everson and the Guide Meridian (Reach 3) from steeper with multiple channels upstream of Everson, to low gradient and single thread downstream of the Guide Meridian. The average channel slope drops an order of magnitude from 0.21% to .03% through Reach 3, making this an important zone for sediment transport and flooding.
- The shortening and artificial steepening of the channel during the historic period (post 1872) through meander cut-offs has been most pronounced in upper Reach 2 and Reach 3, where approximately 4 miles of mainstem channel has been lost. This has increased the energy and reduced the sediment storage in these reaches of the river.
- While much of the main channel shortening occurred prior to 1930, the loss of secondary and anabranching channels has continued through the present, with the bulk of the loss occurring before the mid-1970s. Upper Reach 3 and Reach 4 were the most heavily impacted due the historic prevalence of multi-threaded channels in the reaches. Lower Reach 4 still maintains the greatest length of secondary channels.
- The width of the area that has been occupied by the channel (Belt Width) has narrowed throughout the mainstem reaches reflecting a combination of management actions (installation of bank armoring and levees), and regional climate patterns. This tracks with the loss of anabranches and secondary channels, and the reduction in the active channel area (low flow and open bar area), and has led to an increase in energy in the mainstem channel. In locations that have been severely constrained, this has led to increased levee and bank armor erosion due to the increased amount of time the infrastructure is subjected to the energy of the channel.

<u>Questions</u>

- Is there any data you would have liked to have had?

  Historical cross sections. Maintenance data to inform cost estimates. The 1880 mapping is coarse; it would be great to have more detail.

- What is the general cost for repairs?

  Paula Harris – We have a general idea of what we've spent but not what the Corps has spent. We could work with Corps to determine those figures.

  Travis Ball, USACE – Regarding levee repairs, we look at costs versus benefits per repair, but if you take the whole picture and look at problem areas with multiple repairs, you get a different picture of economic evaluation. If you add in FEMA claims for flood insurance, you get a bigger picture look at impacts. We are slowly working on revising the way we do cost-benefit analysis for levees that have multiple repairs.

- Is there anything in the data reflecting the installation of the new bridge in Everson? Locally, we've seen changes in the river sedimentation.

  We can zero in on that. There have been some issues associated with the bridge replacement. Between 1990 and 1995 would be a timeframe to hone in on to evaluate how the change in the bridge may affect river management.

Hydraulics, Bed and Bank Material, Sediment Transport and Regime Analysis – Andrew Nelson, NHC

Andrew explained how channel morphology is a function of hydraulics, sediment transport, and bank material. Datasets for various parameters were developed for each of these drivers of channel morphology. Rational Regime Analysis can define a range of plausible channel forms in different reaches. Human activities like wood removal and modification of bank materials through vegetation removal or armoring can significantly affect the channel form that results. Key points follow:

- The size of the sediment that makes up the bed of the river changes from Deming (cobble and gravel) downstream to the delta (sand and finer) as the slope flattens and the energy of the river drops. There is a transition from predominantly gravel to predominantly sand that occurs near the break between Reaches 1 and 2. Coarse sediment from upstream reaches appears to be deposited in Upper Reach 3 and may be being pushed slowly (prograding) down the channel through Reach 3.
- Flow constrictions at several locations (Ferndale, downstream of Guide Meridian, Upper/ Lower Reach 3 break, Everson Bridge) cause upstream backwaters that lead to sediment deposition during floods. This sediment may be remobilized as the flow drops and continue moving downstream, although in some cases it appears associated with local sediment storage in the channel.
- As the slope decreases moving down the river, the river is able to move smaller and smaller particles. This is somewhat off-set by the increase in flow depth in the lower reaches. Backwaters caused by the flow constrictions interrupt the smooth transport of material down the river- leading to localized changes in the size of the river bed material.
- The nature of the stream bank material also changes from gravel and cobble in the upper reaches to fine grained materials in the reaches downstream of Everson. Some of the finer bank material is comprised of glacial materials, reflecting the young age of the valley downstream of Everson. Changes in bank material likely reflects both the geologic history of the valley (older and younger), as well as the gradient of the channel. The finer bank materials are more resistant to erosion and likely contribute to the single thread channel shape and low rates of channel migration.
- Based on the slope, bank material, stream side vegetation and bed material, it appears that the channel favors a single-thread planform downstream of Upper Reach 3. Based on a modeling approach, it appears that the channel will likely maintain this planform, which is consistent with the current channel shape and the historic record. The channel shape in the reaches around Everson and upstream appear to be more sensitive to changes in bank resistance and instream wood volume, with changes in those parameters having the potential to change the channel from single thread to multithread. This is also consistent with the history of those reaches, where climate variation, wood removal and bank armoring have led to periodic changes in the channel from a single thread to multiple channels.

<u>Questions</u>

- What is the covariate matrix?

  Slope, uncertainty in grain size distribution, discharge, and bank strength

- How do you move the variables together?

  Monte Carlo simulation. Calibrate to existing condition and then only change one parameter to determine influence.

- Did you publish the covariate matrix?

No.

- Lower Reach 3 is sensitive to past management. Does that fit with historical management? Have there been changes due to management seen in the past compared to sensitivity?

  All channels have narrowed. We should discuss each reach further.

- Is vegetation encroachment consistent with sensitivity?

  I think so. It may depend on degrees.

- Can you estimate how much wood used to be in the channel to inform restoration?

  That would require going back to paleogeographic reconstruction work. We can use that to think about targets. We don't have old-growth trees available for restoration, so it may be irrelevant. What we need is similar engineered structures.

Break

Lower Nooksack River Geomorphic Assessment (continued)

Geomorphology and Habitat – Paul Pittman, Element Solutions

Paul presented on the relation between geomorphology and habitat. His analysis included looking at floodplain connectivity during relatively frequents floods, characterizing vegetation within the channel migration zone and tree canopy composition, and LWD occurrence and distribution. A channel bank conditions study still needs to be completed. Key points follow:

- Unlike many rivers, the Nooksack River has a fairly well-connected floodplain, with substantial areas connected during a 2-year flood. Reaches 2 and 3 had the most inundated area during both the 2- and 10-year floods. The Reach 4 floodplain is largely isolated from the historic channel area of the river at the 10-year flood level. There are still opportunities to improve floodplain connectivity to improve habitat.
- The bank-full channel area narrows downstream of Reach 4 (reflecting the geologic change in the river valley from older to younger) and the amount of side channel and connected forested floodplain area decreases. As a result of this change in the river, when the flow increases the greatest increase in habitat area occurs in Reach 4.
- Riparian vegetation is an important local source of wood and shade to the river. The majority of the taller riparian trees are located in Reach 4, although portions of the riparian area are isolated from the channel by bank armoring. Agricultural land is the most common vegetation class in the riparian zone of the river from Deming downstream to the delta- it is most prevalent in Reaches 2 and 3. Forested areas are dominated by young deciduous forest, with trees between 16 and 80' tall. Very few large trees- those that could provide functional wood to the channel, are present in the riparian zone. Reach 4 has the greatest potential to provide wood to the channel. A wider corridor could reduce channel migration turnover rates and enable riparian forest maturation.
- Because the channel is generally less confined in Reach 4 (particularly in Lower Reach 4), there is the greatest area of forested islands and side channels. Forested islands are important for fish because they are associated with stable side channel habitat. Increasing corridor widths could increase forested island quantity and stability.

- Instream wood is greatly reduced from the early historic period. Degraded riparian conditions (smaller wood recruited to the channel), changes in the channel (increased energy and transport of wood), and loss of storage have all contributed to the loss of stable logjams. Increasing corridor widths could improve wood occurrence and persistence.

Questions

- Where is large wood still available to the river rather than being on the wrong side of the river?

  We will be looking at that.

- Is there a parameter to look at bed height over time?

  Yes, USGS will be discussing that.

- Is the encroachment of vegetation a consequence of modification or the opposite? Could encroachment affect the future of the river?

  Yes, if the river stabilizes and vegetation encroaches. Encroachment may be due to levees, but those trees won't be available to the river. The change in probability is the next step. It takes conifers 100 years to get mature.

- This is all about large woody debris. Are there other elements that we should be thinking about for FLIP?

Reach Summaries – Karin Boyd

Karin reviewed issues in each of the reaches.

- Upper Reach 4: The north side of the historic channel migration area has been narrowed by levees and bank armoring and the mountain hillslope on the south side. This has led to a higher floodplain turnover rate within the current migration area. This has increased the wood recruitment rate and limited the age of the forest that the river has access to. The narrowing has also led to a large decrease in anabranching channel length since the early 1930s. Extensive levee erosion has occurred in the reach, primarily on hooks and at pinch points where the river is frequently interacting with the levee.
- Lower Reach 4: Lower Reach 4 includes the area where the channel avulsed from the Fraser River to Bellingham Bay. The channel area is the widest of any reach, but has narrowed substantially since 1933. The reach currently has the greatest extent of floodplain channels inundated at a 2-year flow, and the potential for channel migration and avulsion to create anabranches. Bank armor has encroached on the historic migration zone and this has led to a high levee repair frequency in the reach. In places the bank armoring has simplified the channel and isolated maturing forest from the channel.
- Upper Reach 3: Upper Reach 3 is a transition from the higher gradient upstream into the low gradient of Reach 2 and Reach 1. The reach is bound by the Everson Bridge constriction upstream and a downstream constriction at the Abbott/Timon levees. The reach has seen substantial artificial narrowing and straightening between levees and bank armoring, which has resulted in a loss of anabranching channels and extensive bank armor erosion. Bank protection and levees have isolated portions of the historic channel area and reduced floodplain connectivity. The constriction at the downstream reach break limits sediment transport through the reach.

- Lower Reach 3: Lower Reach 3 has seen a substantial loss of channel length due to meander cut-offs since the late 1800s. The reach has lost a quarter of its length through the historic period, resulting in a 46% reduction in the mean belt width. The reach is heavily constrained, with 86% of its length leveed and 90% armored. Much of this bank armoring is old and is often overgrown with tree roots or buried in floodplain deposits. The extensive bank armoring has seen the highest frequency of repairs in the lower river- particularly at the Upper/Lower Hampton levees. The channel is perched within natural levees which are elevated above the floodplain- running on a hogback through the floodplain. Because of this, the floodplain is relatively well connected through this reach, with broad areas of inundation during a 2-year flood.
- Upper Reach 2: Similar to Lower Reach 3, Upper Reach 2 has seen a substantial (21%) loss of channel length through time as meanders were cut-off. The river continues to run on a hogback, perched above the floodplain. Similar to the upstream reach, this leads to a well-connected floodplain at the 2-year flood. Reflecting the youth of the valley, there are exposures of glacial material in the banks of the river. This indicates that the channel has not eroded that portion of the floodplain over the last ~10,000 years. In places where there is room between the river and the levees, the river has deposited a floodplain of fine sediment between the levees. Some of these deposits have persisted long enough to become forested and provide wood to the channel.
- Lower Reach 2: The gradient continues to flatten into Reach 2, dropping to .03%, or roughly a tenth of the gradient near Deming. The channel continues to be elevated above the floodplain, with a substantial portion of the floodplain inundated at a 2-year flood. The downstream extent of the reach is a natural constriction between outcrops of resistant glacial material at the City of Ferndale. This constriction leads to a backwater through the reach at higher floods. Between the levees there are often fine sediment deposits adjacent to the channel that bury the bank armoring that lies along 91% of the channel length.
- Upper Reach 1: This reach has less bank armoring and levees than the upstream levees. There is a substantial length of natural bank along the Hovander Homestead. The bed of the river through the reach rapidly shifts from fine-gravel to sand near Slater Road. In places the banks of the river contain wood embedded in the banks reflecting the burial and subsequent exposure of past bars along the river.
- Middle Reach 1: This reach is completely leveed along both banks of the river, with the right bank approaching a 100-year level of protection. Sediment deposition in this reach has led to aggradation in the lower extent of this reach.
- Lower Reach 1: This is the start of the modern delta of the Nooksack River. The river has prograded rapidly into Bellingham Bay, creating multiple channels, separated by forest floodplain and saltmarsh. Historically, this was an area of large-scale logjams (both natural and from the transport of wood down the river), and frequent channel maintenance to ensure navigability of the channel. The challenges of managing wood in this reach continue today, with extensive logjams impairing navigation in many of the channels. The reach contains no levees or bank armoring.

Nooksack River Fluvial Sediment Investigation – Chris Konrad and Scott Anderson, USGS

Changes in sediment storage from 2006 to 2015

In general, upstream of Nugent's Corner, the channel has been stable or incising. Downstream of Nugent's Corner, the channel has been stable or aggrading.

- Based on a comparison of different topographic surface data (from 2005/06 and 2013 lidar for the North Fork Nooksack near Glacier Creek downstream to the boundary between upper and lower Reach 3) and cross-sections (surveyed 2006) and bathymetry (surveyed in 2015) for the river downstream of Lower Reach 3, the changes in sediment storage in the channel was determined. Over this short period, it appears there was a net erosion of the floodplain upstream of Nugent's Corner, with the channel generally stable to near Everson. Downstream of this area, there has been a net increase in sediment storage. While the error associated with the magnitude of the volumetric change in sediment is large, the direction of change (erosion or deposition) is evident.
- Looking at a longer timeframe using changes in the relationship between the discharge and water surface of the river, changes in the bed of the river were inferred. Over longer time period (1930s to current) the gages appears appear to show periods of bed aggradation and incision through time that track with decadal climate patterns, considering a 20 year lag between the climate and the channel response. These changes in the channel bed occur on the scale of approximately one foot per decade. There appears to be a period of bed aggradation that is making its way down the mainstem from the North Fork. It is hypothesized that this aggradation wave has been moving down the river at between 0.5 and 3 miles/ year and is now reaching the gage at Everson. Downstream, near Ferndale, the channel channel has aggraded, but it appears to be entering a period of channel incision prior to the next aggradational wave reaching that part of the channel.
- The suspended sediment load of the river is driven by sediment from the forks of the river, with more than three times more sediment coming from each of the upper forks watersheds than from the rest of the watershed. Each of the forks generates a similar sediment yield (between 190,000 and 430,000 tons per year).
- Comparing streamflow, precipitation and the river stage, it appears that there has been a seasonal increase in the river stage at several gages that is not explained by the changes in precipitation. This would indicate that local aggradation is increasing the stage of the river. For example the ~1 foot of channel aggradation at Ferndale may be the reason for the 0.2 feet of spring time increase in stage. Even a small change in stage could increase the extent of flooding and drainage issues in the low-lying areas where the floodplain is already lower than the river.
- In Reach 1, the water surface elevation, bed elevation and sediment transport appears to be influenced by the tidal inundation at Marine Drive. A sediment "mound" that is approximately 2 feet high is present in the channel upstream of the Marine Drive Bridge.

Questions

- If we reduce constraints from levees upstream from Nugent's Corner, might we have more or less incision?

    We can't say.

- Any local change will have a local effect, but how far downstream will that effect go? Could sediment from the other two forks be aggraded in Nugent's Corner area?

    Yes, but we were just looking at storage, not where sediment is from.

- Thanks for including error bars.

Long-term trends in bed elevation at USGS streamflow gages

Scott explained the climate forcing of bed elevation change. A "wave" of sediment moves downstream as a function of climate with a 20year lag between the change in climate regime and the sediment wave being recorded at the North Fork gage. It takes another 45 years for the wave to travel from the North Fork gage to the Ferndale gage.

<u>Questions</u>

- How do the South Fork and Middle Fork compare to the Lower Nooksack?

  There is not much coherence between them. The forks don't show the sediment wave seen in the North Fork and mainstem.

- Did you correlate warm, dry periods with glacial recession?

  Yes, it fits pretty well but glaciers were persistently retreating from late 1800s to 1930s, which is unexpected. It looks like a correlation with bed dynamics since the '40s, but it breaks down before that. Glacier retreat isn't the sole influence. The river seems to follow the climate signal and not the glacier signal.

- Are there similarities with Pacific Decadal Oscillation analysis elsewhere in the state?

  Yes, the outlets of the Nooksack and the Skagit look identical. They correlate with sediment accumulation in Alder Lake and Southwest British Columbia. This makes a pretty good case that there is regional coherence in these trends.

- Do you have a sense of confidence in these fits?

  The aligned correlation to each other explains about 65 – 70% of the variance in the long term signal. It doesn't explain short-term variability.

Suspended sediment transport and loads

Fine sediment is largely produced in the headwaters. There are similar sediment yields from all three forks, but there is a sandier load in North Fork and Middle Fork due to glacial influence.

Trends in precipitation, streamflow and stage in relation to flooding and drainage issues

<u>Questions</u>

- Did you look at increases in temperature and snowmelt?

  We looked at maximum temperature but not days above or below freezing. I wouldn't be surprised if that had an influence.

- Did you look at the water table levels?

  We didn't look at water table levels, but the water table is likely tracking the river stage.

Recent sediment dynamics in the lower main-stem (Reach 1)

<u>Questions</u>

- Is the mound in the tidally influenced section?

  Yes, right at Marine Drive. During low flow periods, the mound may increase. It may not be a persistent feature. It could be seasonally transient.

- How much of that might be controlled by the log jam by the bridge pier?

In one of the major channels, a log jam has blocked it off. There is accumulation of sediment and wood on half of the Marine Drive bridge. They are certainly related but not sure what caused what.

- Does the history of modifications to the river relate to the changes seen?

  The trends in streamflow and stage are recent since 80s and 90s. Sediment storage trends have occurred since 2006. However, there could be some legacy effects.

- Are there fewer modifications on the North Fork?

  Yes, there are no levees.

What did we learn?

David Roberts led a discussion with questions and comments regarding what was learned today. Below is a list of input received from the meeting attendees:

- There is pooling (backwater) due to channel constrictions that affect sediment storage.
- The Lower River wants to be narrow and deep.
- There are substantial losses and changes in Reaches 2 and 3.
- It's complicated and difficult to go back in time and reconstruct the historic form the river had.
- Stage changes at gauges are attributable to/correlated to bed elevation changes. Changes in precipitation are also contributing.
- Systematic groundwater level monitoring in the floodplain would help tease out influences that changes in river stage and bed elevation may have on drainage, with an emphasis on the spring season. Landowner observations are that it takes longer to drain and more areas have water.
- We see increases in forest cover and stand age with a decrease in fluvial function. Take care in how that's presented so it's not misinterpreted.
- Has there been any macroinvertebrates work?
  - Yes Limited work was done by Utah State University related to Watershed Management Plan development. It would be interesting to look at the available data if they are available.
- Pinch points (i.e. channel constrictions) lead to sediment building up, which is a huge issue for farms. How much are the sediment waves v. pinch points related?
- Most of the total sediment yield is suspended.
- Is there a net bed elevation change at the Trans Mountain oil pipeline?
- With the Sumas-Abbotsford semi-contained aquifer, the river is feeding the aquifer. With a lower stream bed, it would switch (i.e. aquifer would flow to the river). Is there a way to focus in on that drainage dynamic on Lower Reach 4? River bed elevation change has a lot to do with that.
- Thinking ahead to alternatives, it will be very complex to account for all those trends and determine which actions might affect which parameters. There will likely be lots of trade-offs.
- If Reach 4 goes deeper and narrower, will it affect the forks? How will that affect salmon and habitat?
- Did gravel removal create different changes in system? What did that do exactly? That was a management decision that had big impacts.
- South bank hardening by Nugent's Corner bridge – was that planned or just a convenient place to dump concrete waste? Can it come out now if the need for it is gone?

- Are spawning grounds affected by pinch points if long term storage isn't remobilized? Is it consistent?
- Understanding the interplay of sediment dynamics between the forks and mainstem is critical.
- It's important to provide context for the 1930s data. A lot of the change had already taken place before then and the river was already pretty severely disturbed. Not a good baseline for comparison.
- Dominant fluvial processes that control habitat connectivity are separated at Reach 3 midpoint. There are two different expectations for habitat quality and use. The mechanics of how habitat is connected are different.
- Can you push the successional stage of forested areas that have become isolated?
    - Yes. You could interplant or augment with conifers. That's happening now for mitigation through SWIF.
- We are having a harder time understanding the wood history. We know a lot has been taken out. How to reconstruct it spatially? We are a little weaker in terms of understanding what we had and what the losses have done.
- Do you have any future statements about climate impacts? Any guidance? How will it respond over the next 50 – 100 years? We will need USGS support to look at that reach by reach.
- There has been a pretty consistent change of about a foot per decade of aggradation or incision (mean elevation change). Climate change could cause a significant departure from the past.
- In terms of the climate change forecast for habitat function and productivity of fish and agriculture, where would the ideal spatially explicit plan be laid out? In Skagit, we are thinking through the loss of glaciers with glacier outwash terraces providing cold water to river. That could be a mitigating factor to plan around. Does that exist in Nooksack? What are the other drivers?
- How do we modify the infrastructure to achieve different objectives, starting with CFHMP 1999?
- Resilience from a geomorphic perspective is about having room. Can you integrate goals to create the most adaptable system to change?
- I see a lot of things that we can study, but we also study things to death. What can we do that can lead to some action? What would a project look like?
- Forest patches are separated by agriculture and development. Could there be an analysis of how much areas are disconnected by modern infrastructure and how to fix that?
- I'm impressed by the amount sediment coming down and I'm concerned that as it comes down we will have more flooding. Planting conifer trees can take away the volume of the river. Study it before we plant a lot of them.
- How does the timing of rainfall events affect loading and transport?
- Regarding the planning process, how do we want this to look? What will be the future condition with climate change? We should look forward to what we want to achieve. The planning process is important but we need projects that we can see to see how they are functioning and see what works.
- I'd like to see a project concept and model it and see how it works and pick a handful of spots to see what might work.
- It was interesting to see anecdotal farmer observations corroborated by USGS results.
- I know places where we have potential opportunities on farmer properties. I'm excited to find those areas and try a project. It's inspiring and overwhelming at the same time.
- Has there been monitoring on past projects like Bertrand?
    - No. A lot of sediment deposited between the creek and the setback levees; we could make some estimates.
- These projects need to be monitored.

- The CFHMP may be our best shot at salmon recovery. What is the time horizon that we should be planning for with this?
- With all this brainpower, we ought to be able to maximize processes and build in resilience over a range of flows. Is there some way to increase what we consider to be habitat? It's been so screwed up that it's likely not to get back to natural. Let's see if we can engineer something to replicate nature more resiliently.
- Will flashiness changes with climate change affect Reach 3?
- Clearly define uncertainties in modeling so that people don't come to expect something that really doesn't exist.

How was the day?

- Good job on lunch
- The content was good
- The AV could be better
- Handouts would help to see what's on the screen.
- It's like drinking from a fire hose.