Skagit River Flood Damage Reduction General Investigation
Feasibility Study
Alternatives from Working Group
Reference laminated photo from WG meeting 14 September 2000

1. Do nothing – same level of damages
   Hydraulics
   Economics
   Design
   Environmental
   PM Questions
2. Higher levees, such as raise the Francis Road for 10 to 15 year protection and provide outlet for Nookachamps Creek.
   Hydraulics - This alternative would reduce the frequency of flooding in the Nookachamps area but could result in high river flows downstream for the more minor floods.(but not higher than 30 year protection)

   Economics
   Design
   Environmental
   PM Questions – If Burlington has 30 year protection, what difference would the higher levels make? How about 25 year protection for Sterling and Nookachamps.
3. Set back levee, where levees are moved back 500 feet, 1000 feet or some increment that provides more over back flow. Examples are 500 foot set back levees for Diking District 12 and 17.
   Hydraulics – The only way that set back levees would reduce river levels would be if the entire levee system were to be set back. The major constrictions are the bridge corridor, RR, 99, and I-5, and the West Mount Vernon Bridge. These bridges opening would have to be increased to allow any reduction in river levels. The set back distances would be determined by how the levees are set back. If a new levee is built and the existing is either left or removed would require the largest setback. If over-bank excavation was allowed a smaller setback would be required. The set back would be on the order of 750-1000 feet for just constructing a new levee and 350-600 feet if over-bank excavation were used.

   Economics
   Design
   Environmental
   PM Questions – If the bridges were not an issue, how much setback do you need for the total conveyance? Would this provide conveyance for 100,000 cfs? How much flow do you need to provide for? How much excavation is required? What is the cross sectional area to be excavated?
4. Overtopping levee, where levees are identified as preferred overtopping, and purposely left lower or some other design. The levee would either be hardened for overtopping and/or given shallow back slopes to prevent catastrophic failure.

Hydraulics – This alternative was the preferred alternative in the Recon study. This alternative will allow floodplain flooding in a controlled manner with little or no massive levee failure. The main drawback with this alternative is the it does little to reduce the floodplain flooding depths. All this alternative allows is the when river levels get high the levee will overtop but not fail, but everybody still gets wet and there is a little control over where the overtopping will occur.

Economics
Design
Environmental
PM Questions – Wouldn't we still maintain 30 year protection? This alternative would most likely be used with urban areas ring diked for a 100 year event.

5. Floodway bypass across River Bend where flow is returned to the river.
Hydraulics – This alternative would do little to reduce flood levels. It would allow a slight reduction in levels in the River Bend area, but once the bypass is full it would transport very little water. The reason little water would transported is there is very little head to force the water back into the river just upstream of the West Mount Vernon Bridge. This depends on how it's constructed. If it's just a channel, then there's little storage. If the entire River Bend is opened, this could reduce flood levels.

Economics
Design
Environmental
PM Questions – What about storage? Are there any reduced flooding benefits?

6. Floodway outlet, Avon bypass type outlet where flow is permanently diverted from the river during a flood.
Hydraulics – This is the old Avon bypass alternative first proposed in the 40's?. This alternative would convey approximately 80,000 cfs at the 100 year discharge and would not start to overtop until the 25 year event, concept level only. The concept for the channel would be a wide channel, ½ mile, that would have low velocities, therefore the channel could have winter crops grown in it to reduce erosion during flooding event. A new concept for this channel, would be to open the lower 1 to 2 miles of the channel to tidal forces that would allow new tidal habitat and refuge. This alternative could also be designed to allow a small channel to be constructed which would allow year water flowing in a small creek that could be built in the channel. The greatest benefit for this alternative would be that it would eliminate all floodplain flood form Burlington downstream. See the Recon report.

Economics
Design
Environmental
PM Questions – How wide and how deep?

6½. Floodway outlet, Another floodway outlet would be across Fir Island adjacent to Dry Slough where there are no buildings (West Side). This option would require a controlled inlet but the outlet would be optional. The floodway could be defined and limited by dug channel and dike or to permit land use, bermed floodway with minimal excavation.

Hydraulics –Any bypass at Fir Island would have limited success unless it was used in combination with widen of the river since the Forks can convey what comes down the main-stem.
Economics
Design
Environmental
PM Questions - ?

7. Sand plug levees, rather than a low section for over topping or a gated structure for a tidal sea gate, a hardened section of the levee would be built to with stand flow velocities and a weak section would be built into the levee.
   Hydraulics – If sand plug levees are used they need to be weakened before the water gets to them. The cost of replacement could be high and after the dike has been removed, the tide would force salt water onto crop land. Need to check with farmers onto how long the salt water can stand on the land before they lose the crop for the coming year. This application would probably only be used on a sea dike. The use of a plug on a river levees, there is potential for releasing too much water.

   Economics
   Design
   Environmental
   PM Questions – You are talking about sea dikes here. Would there be an application for overtopping or bypass channels for this type of inlet?
8. Ring dike possibly Conway, Burlington, Mt Vernon and West Mt Vernon. Maybe other developed areas need protection, too.
   Hydraulics – This alternative is the least cost alternative that would return the largest benefit. The ring dikes or levees would be built to protect Burlington, Mount Vernon and any other urban area from the 100 year flood. The river level would have to increase to go around the ring levees.

   Economics
   Design
   Environmental
   PM Questions – How much increase would have by Sedro Woolley?
9. Sea dike outlet structures, such as Fir Island, Padilla Bay and Samish Bay. Examples are flap gates for one way flow, barn door gates for two way flow at low tide and sand plugs.
   Hydraulics – The least first cost alternative for outlet structures would be sand plugs. If structures are to be built there would have to be many structures to handle the 1,000's of cfs that would be in the overland flow if a levee failed or overtopped. Because of the lack of hydraulic head, it would take over a 1,000 six by six foot tide gates to drain the flood.

   Economics
   Design
   Environmental
   PM Questions – How many? Take a guess at number of 6 foot by 6 foot gates are required.
10. Existing floodway development, Gages and Britts Sloughs

Hydraulics – Alone these would have minimal effect on the flood levees but could be used in combination with others for environmental needs of the system. Gages slough would provide less than 5,000 cfs, probably.

Economics
Design
Environmental
PM Questions – What about if Gages slough was developed, how much conveyance could it take?

11. Cross dike, prevent back flooding of protected areas such as downtown Mt Vernon being back flooded from the South Hydraulics – This would be a component of the project for the ring dike and overtopping alternatives.
Economics
Design
Environmental
PM Questions
12. Open protected areas to flooding (levee removal)
Hydraulics – This would cause induced flood damages and probably not reduce the flood damages elsewhere.

Economics
Design
Environmental
PM Questions
13. Excavated channel, where bench is excavated with in flood plain to allow river more flow within the confines of the setback levee
Hydraulics – see item 3

Economics
Design
Environmental
PM Questions –Need to say how much excavation is required. Describe section of River.
14. Another option is if the towns are ring diked to say, 100 years, and the remainder of the river levee is left at 35 years, that overtopping be allowed at strategic places. The locations are; at District Line Road, above Burlington; at Pulver Road, below the freeway bridge and at Donnelly Road, above West Mt Vernon.
Hydraulics – This alternative is a combination of items 4 and 8.
This alternative would protect the urban areas while allowing the rural areas to flood in a controlled manner. This alternative would reduce damages to the urban areas but the rural areas would still get flooded. The main benefit for the alternative would be that there are no levee failures just controlled overtopping.
Economics
Design
Environmental
PM Questions
15. Minor items

A. setback levee across river from Britt Slough

Hydraulics – alone this alternative does little but could be used in combination with others. The main benefit for this alternative would be environmental benefits.
Economics
Design
Environmental
PM Questions

B. Overtopping levees on North Fork near Beaver Marsh road
Hydraulics – This would be part of item 4. See Recon report.
Economics
Design
Environmental
PM Questions – How much overtopping do we need?

C. Opening up Brown and Hall Sloughs
Hydraulics - Alone these alternatives do little but could be used in combination with others. The main benefit for this alternative would be environmental benefits. Little hydraulic benefit.
Economics
Design
Environmental
PM Questions

D. Cutting point in river above Burlington
Hydraulics – This alternative could cause extensive damage upstream of the breakthrough. Shortening the channel at the narrow point could cause head-cutting upstream. This headcutting could cause damage to (threaten?) the highway 9 bridge.
Economics
Design
Environmental
PM Questions

E. Overtopping or drain structures in levee adjacent to Conway. (to drain West)
Hydraulics – If there is any proposed controlled flooding along the left bank that would direct water to Conway drain structure that would direct the water back to the Skagit would be required to reduce flood elevation in Conway. The structures should be tide gate type structures.
Economics
Design
Environmental
PM Questions

16. Excavation on both sides of river at Mt Vernon opening up the channel to carry more flow and raising the bridge approaches.
Hydraulics - This area is one of the main constrictions in the river . This alternative should be considered for all alternatives except the bypass channel.

Economics
Design
Environmental

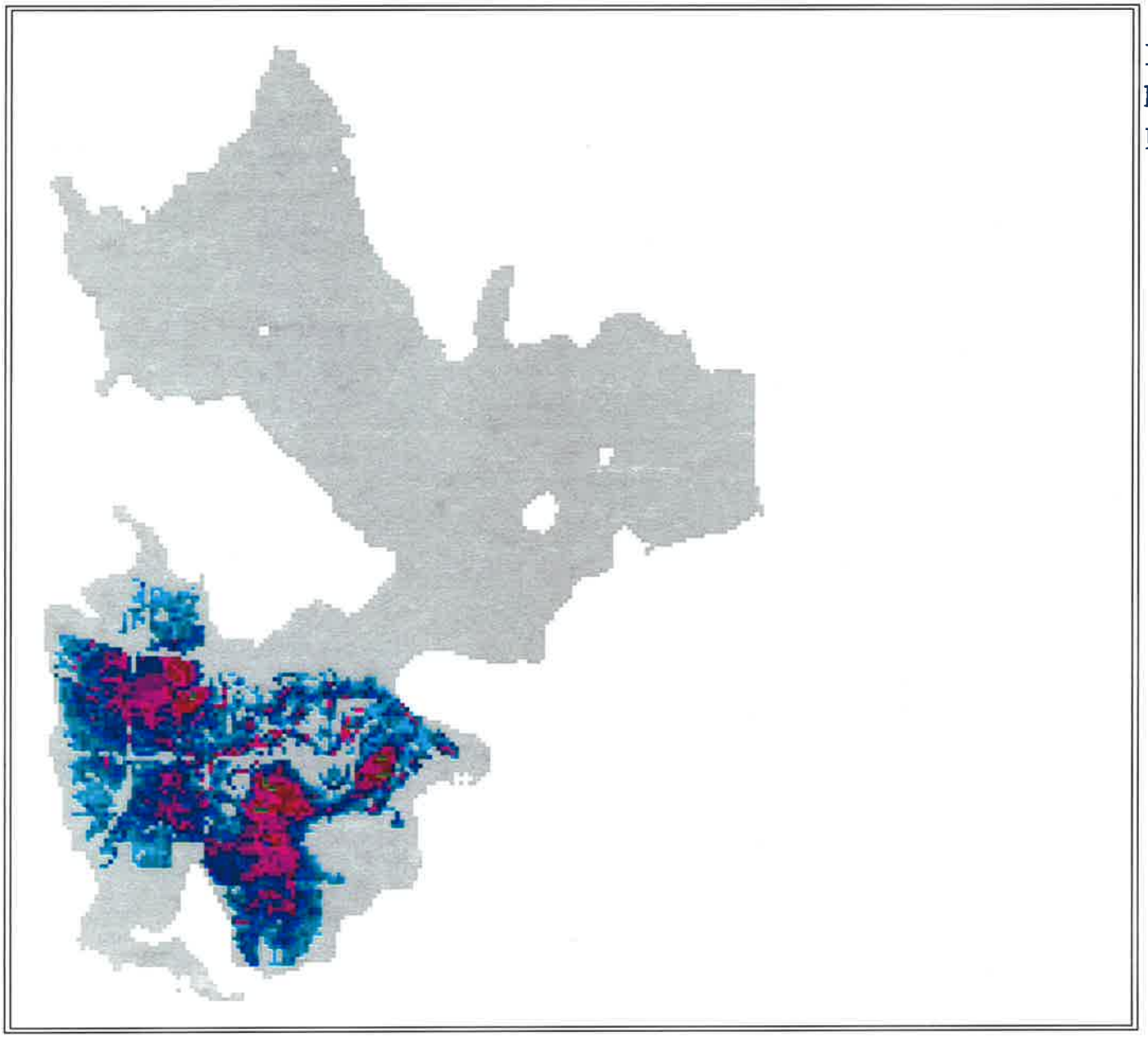
PM Questions – How much cross sectional area is required for the excavation to do any good? What will the channel be shaped like if it could take the entire flow?

17. Flood protection for Lyman, Cockreham Island, Hamilton, Cape Horn and Thunderbird Lane.
    Hydraulics – Although not proposed by the working group alternative the reduce flooding in the major upriver communities need to be included. The hydraulic modeling extends upriver to Concrete, therefore alternative such as raising existing levees or adding levees could be model to determine the benefits to these communities.

    Economics
    Design
    Environmental
    PM Questions – Non-structural solution are available if there are not enough benefits to build a levee or other structural solution. The Corps and county prepared flood maps for theses locations in 1996 and there is no plan, at this time, to update this information.

Assumptions used in developing the Skagit River Floodplain model

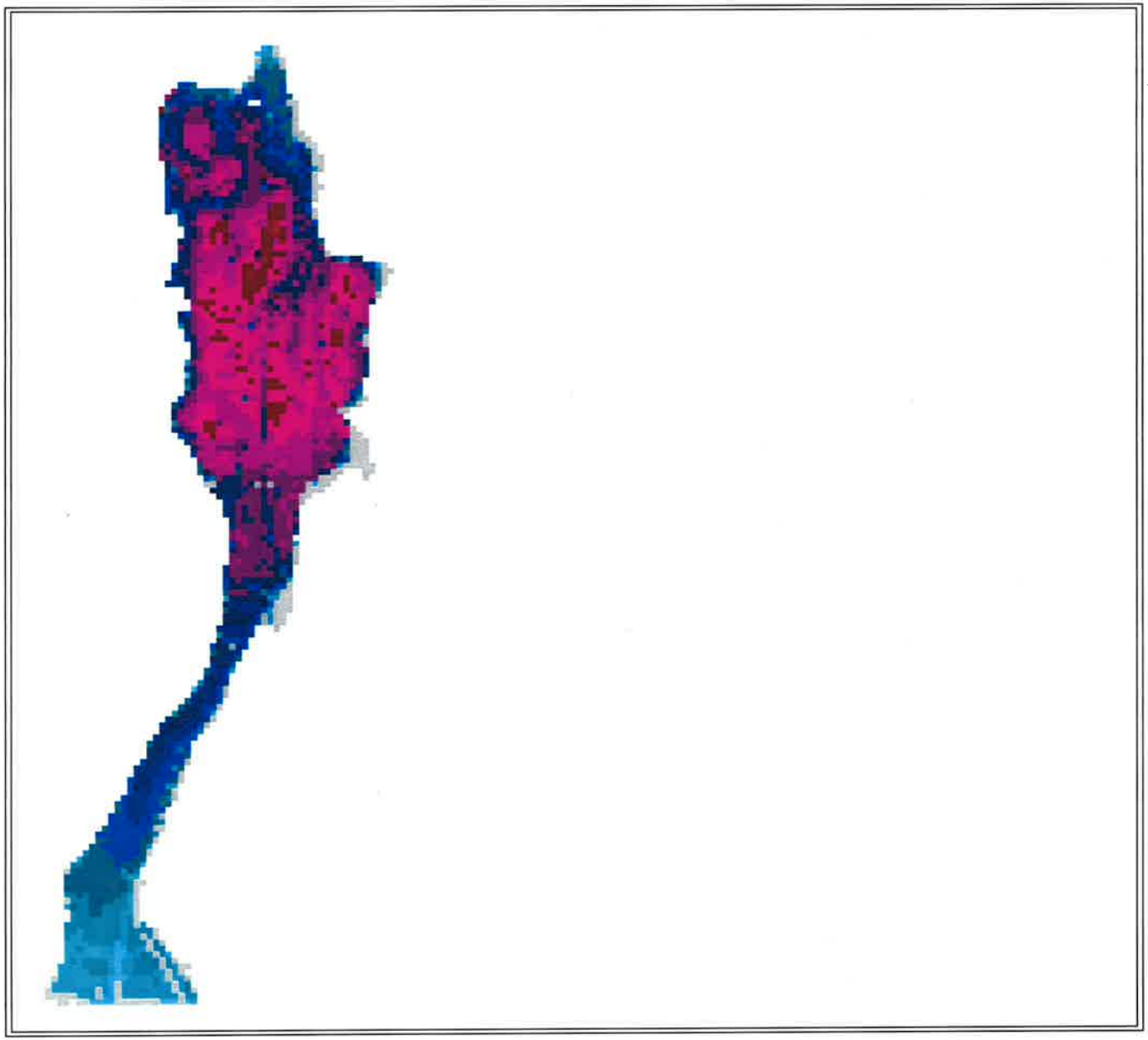
- Levees would break at either the PFP (probable failure point) or PNP (probable non-failure point) elevation, no overtopping. Even though Diking District 12 feels that their levees will overtop before breaking, we had to stop someplace.
- Breaks widths are randomly set at 350 or 450 ft. This was determined in consultation with geotech. The levees eroded down to the land elevation on the land side of the levee.
- It was assumed that the levee would eroded instantaneously, or at least in less that 1 hour.
- The UNET, river model used new cross sections surveyed by the county.
- The flow from levee breaks was determined by the UNET river model.
- The bridges are not modeled with debris.
- Bridge low and high cords were modeled along with bridge piers.
- The floodplain was modeled with a 400 by 400 foot grid.
- Elevations of the grid element were determined by topographic maps developed in 1999?
- All structures were included in the floodplain model, by reducing the flow surface that each grid element could use.
- All elevated roads were input so that the height of the roads could direct flow.
- Culverts under roads were not modeled. The reason that culverts weren't modeled for overland low was that the capacity of the culverts are small compared with the overbank discharge.
- Sea dikes were included in the model.
- Erosion and sedimentation in the floodplain was not modeled.
- Floodfighting at the revetment was assumed to be successful, to the level it already is.
- It was assumed that there would not be any floodfighting along highway 20 east of Burlington.



Floodplain Maximum Flow Depths

Depth Legend

- 8.0 < DEPTH < 8.5
- 7.5 < DEPTH < 8.0
- 7.0 < DEPTH < 7.5
- 6.5 < DEPTH < 7.0
- 6.0 < DEPTH < 6.5
- 5.5 < DEPTH < 6.0
- 5.0 < DEPTH < 5.5
- 4.5 < DEPTH < 5.0
- 4.0 < DEPTH < 4.5
- 3.5 < DEPTH < 4.0
- 3.0 < DEPTH < 3.5
- 2.5 < DEPTH < 3.0
- 2.0 < DEPTH < 2.5
- 1.5 < DEPTH < 2.0
- 1.0 < DEPTH < 1.5
- 0.5 < DEPTH < 1.0
- TOL < DEPTH < 0.5
- DEPTH < TOL



Floodplain Maximum Flow Depths

Depth Legend

24. < DEPTH < 26.
22. < DEPTH < 24.
20. < DEPTH < 22.
18. < DEPTH < 20.
16. < DEPTH < 18.
14. < DEPTH < 16.
12. < DEPTH < 14.
10. < DEPTH < 12.
8.0 < DEPTH < 10.
6.0 < DEPTH < 8.0
4.0 < DEPTH < 6.0
2.0 < DEPTH < 4.0
TOL < DEPTH < 2.0
DEPTH < TOL