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Appendix D.1- 1D Numerical Model Results Discussion

To: Office of Chehalis Basin (OCB)

From: Moffatt & Nichol (MN)

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Subject: 1D Numerical Model Results Discussion

M&N Job No.: 232215

1 General Progress Update

The Office of Chehalis Basin (OCB) has contracted Moffat & Nichol (MN) to perform an alternatives assessment and conceptual design to advance the Local Actions Non-Dam (LAND) Alternative. This effort aims to develop an approach to reduce long-term flood damage across the Chehalis Basin. To advance this task, the Moffat & Nichol team conducted an alternatives analysis, including screening level modeling intended to refine the LAND alternative alignments and project features prior to conducting more detailed, conceptual design level modeling. The screening level model simulations were grouped into the following categories:

- **Diversion & Conveyance Refinement:** Investigating the effectiveness of smaller diversion, the diversion in combination with and/or without conveyance features.
- **Lighter Touch Options:** Evaluating the effectiveness of a smaller array of levees and conveyance improvements.
- **Project Phasing:** Investigate hydraulics, qualitative impacts of project phasing.

The conceptual level alignments of the levee & floodwalls, diversion, and conveyance improvements are shown below in Figure 1 for reference.

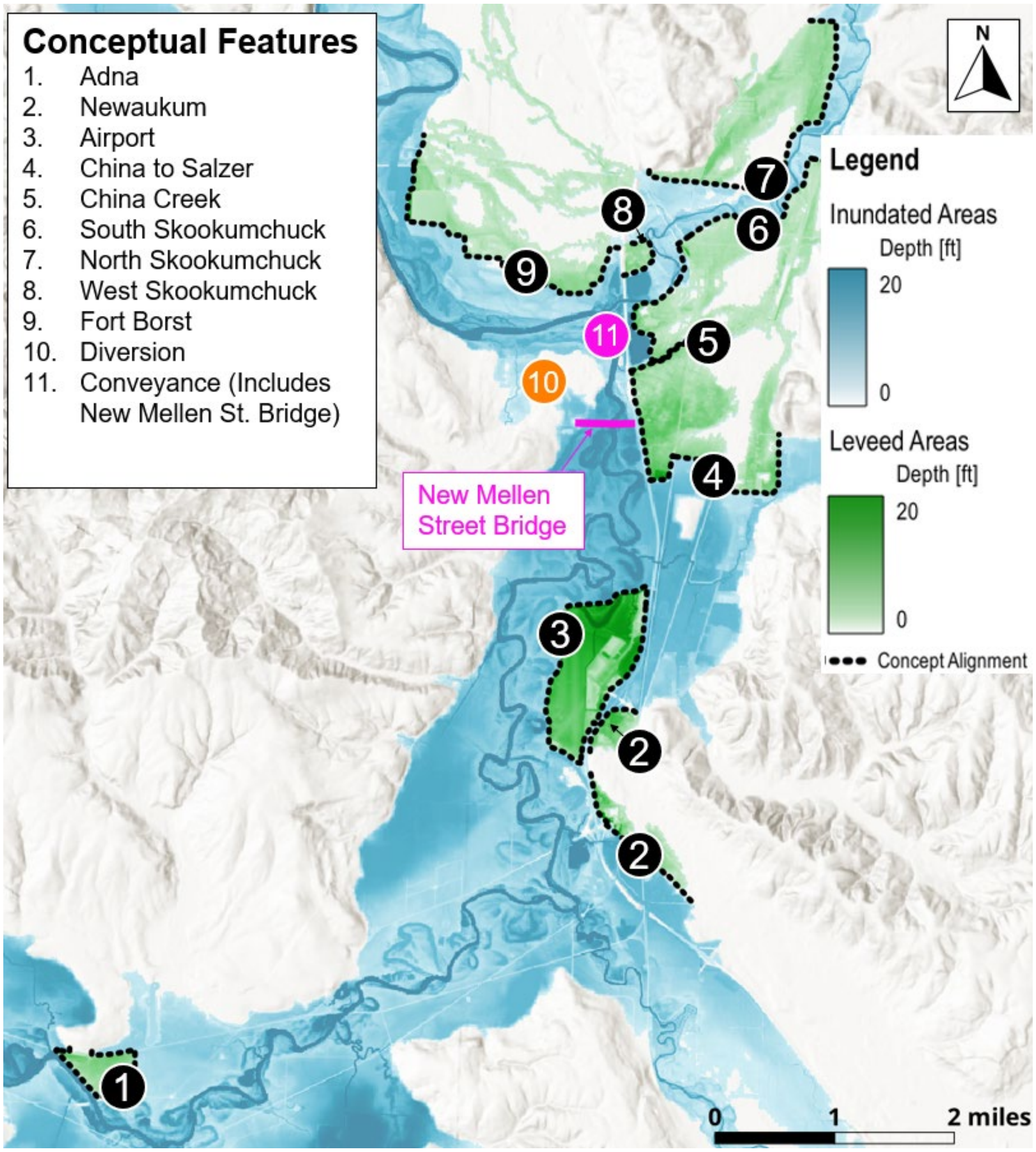

Figure 1. Conceptual project features including levees (black), conveyance improvements (pink), and diversion (orange). Inundated areas shown are for the 100yr + 26% design flood event model results for the No-Action scenario. Blue areas will be inundated without the project, green areas are now protected with the proposed alignments.

This memo and the associated appendix describe the high-level, initial findings from the diversion and conveyance refinement simulations.

2 Screening Level Modeling Update

A screening level analysis was conducted to assess and refine the LAND alternatives developed in the previous phase of the project. The model runs use the same 100-year + 26% flow rates as in the previous phase of LAND. The goal was to assess the effectiveness, both in cost and water level reductions, of the diversion, conveyance, and other project features. These model runs are conducted using a conceptual level, 1-D HECRAS model. The model is suitable for screening-level analysis but has limitations in capturing complex flow dynamics and floodplain interactions. Therefore, the results presented herein are intended for screening level analysis only. More detailed, 2D modeling was later in the conceptual design phase of this project. Given the preliminary nature of these results, the costs shown were used for screening level decisions only, are not indicative of the final project cost, and were updated during conceptual design. The first set of model runs included:

- **Run 1:** Test the effectiveness and relative impact on peak water levels of a 700-foot bottom width diversion.
- **Run 2:** Test the effectiveness and relative impact on peak water levels of a smaller, 200-foot bottom width diversion.

The conclusions of these conceptual model runs are as follows:

- **Diversion Width:** The 700-foot bottom width provides more relative benefits, including reductions in upstream peak water level, and is more cost effective than the 200-foot bottom width. Therefore, the 700-foot bottom width diversion was used in the next set of screening level model runs.

The next set of screening level model runs were conducted to analyze the relative effectiveness of the 700-foot diversion and conveyance improvements (including relocation of the Mellen Street Bridge), with the latest levee and floodwall alignments in place. The cost effectiveness of these runs was determined by comparing the total cost of constructing each alternative (i.e. project cost) against the cost to raise and/or floodproof all structures inside of the levees (i.e. project benefit). This Preliminary Cost Effectiveness Ratio (PCER) was used to help determine the best performing alternatives relative to cost. Note that this was not meant to be a full benefit cost analysis, does not include other potential benefits realized by the project outside of reduction in structural raise costs, and only serves to aid in determining the rough cost effectiveness of each scenario for screening purposes. The runs analyzed included:

- **Run 3:** Determine change in water levels for all levees, plus diversion (700-foot) and conveyance improvements.

- **Run 4:** Determine change in water levels for all levees, No diversion or conveyance.
- **Run 5:** Determine change in water levels for all levees, with conveyance only.
- **Run 16:** Determine change in water levels for all levees, with diversion (700-foot) only.

The high-level conclusions resulting from these conceptual model runs are as follows:

- **Diversion + Conveyance (Run 3):**
  - *Preliminary Cost Effectiveness Ratio:* The relative benefits of the diversion plus conveyance do not appear to justify the construction costs, as this alternative had the lowest "PCER".
  - *Water Level Changes from No-Action Scenario:* This alternative results in the largest increases in water level downstream of the project area, and the largest decreases upstream.
  - *Environmental & Social Considerations:* This run involves the most diversion and/or conveyance excavation, resulting in the largest footprint of direct environmental impacts. Also, the diversion excavation requires relocation of a low-income housing development.
  - *Summary:* This scenario was removed from consideration in the screening analysis due to the relatively low performance in the metrics described above after coordination with OCB.
- **Levees Only (Run 4):**
  - *Preliminary Cost Effectiveness Ratio:* This run (Run 4) proved the most cost-effective alternative, with the highest "BCR".
  - *Water Level Changes from No-Action Scenario:* This alternative results in the smallest increases in water level downstream of the project area, and an increase in water levels upstream.
  - *Environmental & Social Considerations*: This run involves no diversion and/or conveyance excavation, resulting in the largest footprint of direct environmental impacts. Since the diversion is not included in this scenario, this run does not require relocation of the low-income housing development within the diversion footprint.

  - *Summary:* This alternative was the most cost effective (i.e. highest “PCER”), lower direct environmental and social impacts. However, it did not meet the guiding principles and was removed from consideration after coordination with OCB.

- **Conveyance (Run 5):**
  - *Preliminary Cost Effectiveness Ratio:* The conveyance plus levees run (Run 5) proved the second most cost-effective alternative
  - *Water Level Changes from No-Action Scenario:* This alternative tied for the second largest increase in water level downstream and tied for the second largest decreases upstream. Note that the results are very similar to Run 16.
  - *Environmental & Social Considerations:* This run involves second lowest diversion and/or conveyance excavation volumes, resulting in the second lowest footprint of direct environmental impacts. Since the diversion is not included in this scenario, this run does not require relocation of the low-income housing development within the diversion footprint.
  - *Summary:* This alternative was the second most cost effective (i.e. second highest “PCER”) and should be investigated further.

- **Diversion (Run 16):**
  - *Preliminary Cost Effectiveness Ratio:* The relative benefits of the diversion do not appear to justify the construction costs based on the results of model run 16.
  - *Water Level Changes from No-Action Scenario:* This alternative tied for the second largest increase in water level downstream and tied for the second largest decreases upstream. Note that the results are very similar to Run 5.
  - *Environmental & Social Considerations:* This run involves second highest diversion and/or conveyance excavation volumes, resulting in the second highest footprint of direct environmental impacts. Also, the diversion excavation requires relocation of a low-income housing development.
  - *Summary:* This scenario was removed from consideration in the screening analysis due to the relatively low performance in the metrics described above after coordination with OCB.

The next set of model runs were conducted to analyze one potential project phasing scenario. The project features contained in each set of model runs are described below:

- **Run 9a (Phase I):** Construct (4) China to Salzer, (6) South Skookumchuck, (7) North Skookumchuck,
- **Run 9b (Phase II):** Construct (11) Conveyance and Bridges
- **Run 10 (Phase III):** Construct (8) West Skookumchuck and (9) Fort Borst
- **Run 3 (Phase IV):** Construct (3) Airport, (2) Newaukum, (1) Adna

This analysis revealed that the conveyance feature is critical for preventing upstream water level increases and avoiding induced flooding of structures. As a result, it is recommended that conveyance improvements be prioritized early in the project timeline. Additionally, excavated material from the conveyance improvements could potentially be repurposed for levee construction, provided geotechnical analyses confirm the material meets the necessary soil property requirements. This resulted in the following potential phasing scenario.

- **Phase I:** (4) China to Salzer, (6) South Skookumchuck, (7) North Skookumchuck, (11) Conveyance and Bridges
- **Phase II:** (8) West Skookumchuck and (9) Fort Borst
- **Phase III:** (3) Airport, (2) Newaukum, (1) Adna

Note that this is one potential scenario to investigate the feasibility of constructing the LAND project tin phases. Further analysis of phased construction approaches is recommended for future studies.

The following additional simulations were also conducted:

- **Increasing Skookumchuck Culvert Size (Run 15 & 19):** These runs were conducted to determine whether increasing the size of the existing Skookumchuck culverts, and adding new culverts, improved hydraulic conditions upstream of the Skookumchuck and Chehalis River confluence. The results showed minimal change with the increased culvert size.
- **Smaller Conveyance Testing (Run 17):** This run tested a smaller conveyance footprint to compare to Run 5, which had a larger footprint. In general results were similar, with the larger conveyance showing greater reductions in water levels upstream. For conceptual design, the larger conveyance footprint was selected. Further refinement of the conveyance footprint and cross-sectional design should be conducted in future phases.

- **Pearl Street Bridge Culverts (Run 20):** As part of future phases of LAND, emergency bypass routes to ow vehicular traffic to continue to emergency services during flood events have been identified. One such route connecting northern and southern Centralia is across the Skookumchuck bridge on Pear Street. This run investigated the viability of raising the road north of the bridge to the levee and constructing culverts to bypass flow. Water levels increased upstream of the road raise as expected. However, future analysis should be conducted, as this may be a viable solution if larger culverts are investigated.

3 Key Findings & Next Steps

The following key findings are presented for consideration:

- **Diversion**: Based on the screening analysis summarized herein, the diversion was removed from consideration after coordination with OCB and the OCB Board.

- **Conveyance**: The conveyance appears to be more cost effective than the diversion and should be investigated further.

- **Phasing:** The conceptual level numerical modeling showed that the project could potentially be built in phases, as described above.

The following next steps were conducted as part of the conceptual design alternative:

- Based on the results of these model runs, the conveyance feature seems more cost effective than the diversion. The Moffatt & Nichol Team will conduct screening level simulations to investigate alternative conveyance size(s) and excavation areas.

- Finalize the alignments that were included in the more detailed conceptual design level modeling conducted as part of this study.

4 A. Preliminary Model Results