Appendix A: Initial Screening Level Model Results Summary

Screening Level Model Results Summary

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Purpose (UPDATED)

- **General Purpose:** Conduct screening level modeling work to refine conceptual alignments and support screening analysis.

List of Screening Level 1D-Model Simulations

General Notes

-Purpose: Conduct screening level modeling work to refine conceptual alignments and support screening analysis.

-All runs are screening level analysis runs that were be conducted using conceptual level HEC-RAS modeling. More detailed RiverFlow 2D (or similar) modeling as be conducted in the conceptual design phase of this study and used in the final analysis.

These runs are included for completeness only and were used only in the screening analysis.

Run Number	Run Description	1 Adna	2 Newawukum Levees	3 Airport	4 S. Skook	5 China to Salzer	6 N. Skook	7 W. Skook	8 Fort Borst	9 Diversion Included	10 Conveyance Included?
1	200-foot-wide diversion testing									Y	N
2	700-foot-wide diversion testing									Y	N
3	Tests all project features	X	X	X	X	X	X	X	X	Y	Y
4	Test levees and no diversion or conveyance	X	X	X	X	X	X	X	X	N	N
5	Test levees with conveyance, no diversion	X	X	X	X	X	X	X	X	N	Y
6	Not Used	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7	Not Used	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8	Skookumchuck Alternative Alignment Testing	X	X	X	X	X	X	X	X	N	Y
9a	Potential Phase 1				X	X	X			N	N
9b	Potential Phase 2				X	X	X			N	Y
10	Potential Phase 3				X	X	X	X	X	N	Y
11	Not Used	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12	Not Used	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13	Not Used	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
14	Not Used	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15	Testing effectiveness of widening the existing culverts connecting the skookumchuck to the Chehalis to 8 feet.	X	X	X	X	X	X	X	X	N	Y
16	Tests levees with diversion, no conveyance.	X	X	X	X	X	X	X	X	Y	N
17	Tests all levees with smaller conveyance footprint, no diversion	X	X	X	X	X	X	X	X	N	Y (smaller conveyance Area)
18	Not Used	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19	Testing effectiveness of widening the existing culverts connecting the skookumchuck to the Chehalis to 16 feet.	X	X	X	X	X	X	X	X	N	Y
20	Testing water level impacts of raising Pearl street between the levees, with culverts to pass the flow	X	X	X	X	X	X	X	X	N	Y

Notes:

[1]All runs will use the conceptual level levee and floodwall alignments developed as part of this study. Minor tweaks were made to alignments and footprints of project features following the 1D screening level modeling.

[2]Note that in phasing runs (9a-10) the final Phase 4 (i.e. all levees with diversion) is covered by run 3.

[3]Diversion sensitivity testing will be conducted first. Sensitivity testing showed that 700-foot-wide diversion provided more benefits than the 200-foot-wide diversion. Therefore, all subsequent model runs with the diversion used the 700-foot-wide diversion.

Run 1 and 2 Results

Test 700-foot (Previous Phase) and 200-foot Wide Diversion

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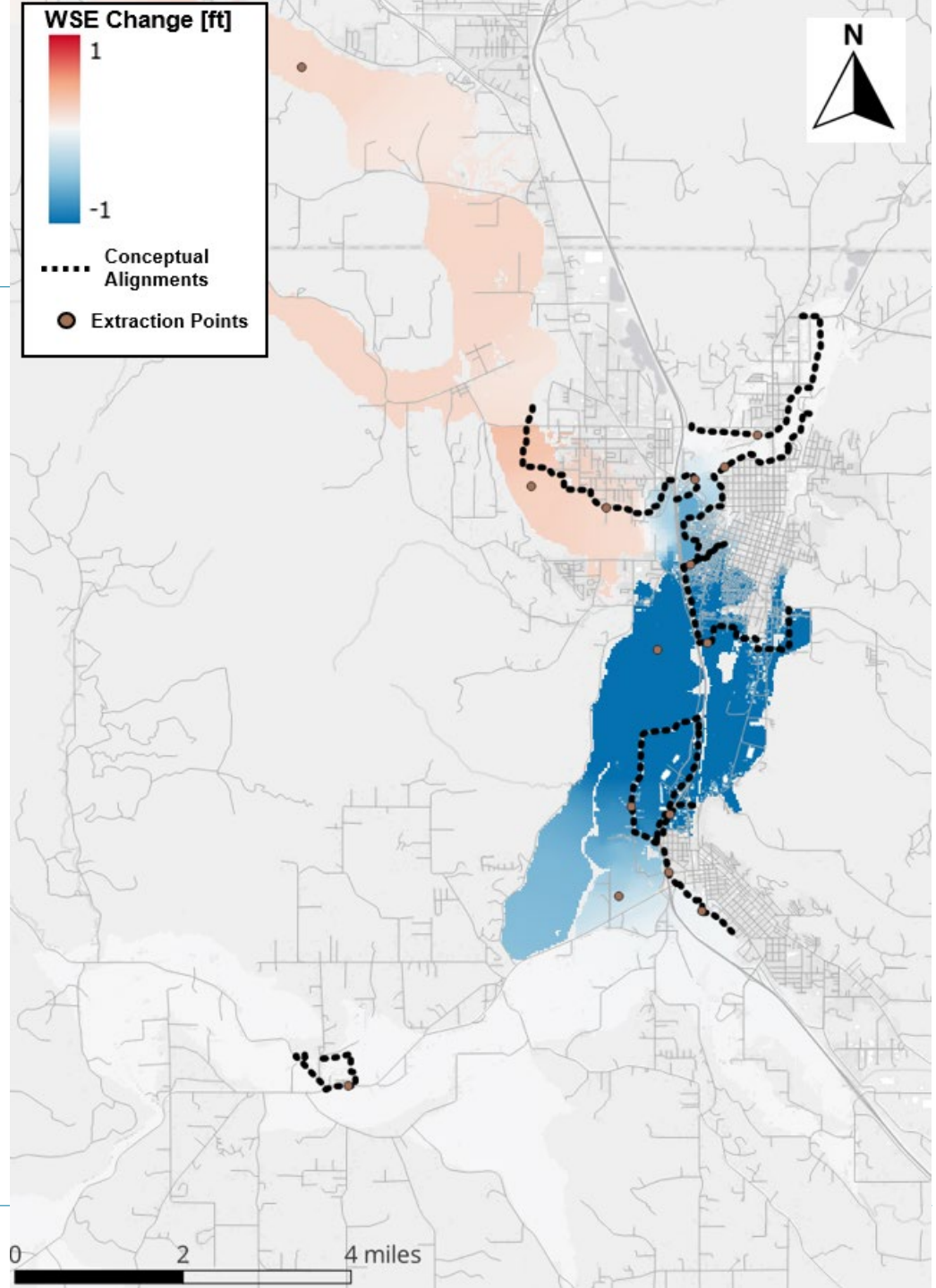
Run 1 – 700-foot Diversion Minus No Action

- **Water Level Difference Plot:**
  - Shows change in water level for 700-foot Diversion from No-Action
  - 100-year-plus-26-percent Flow Conditions

- **General Water Level Changes:**
  - Reduction Upstream: Up to **minus 1.3 feet**
  - Increase Downstream: Up to **plus 0.25 feet**

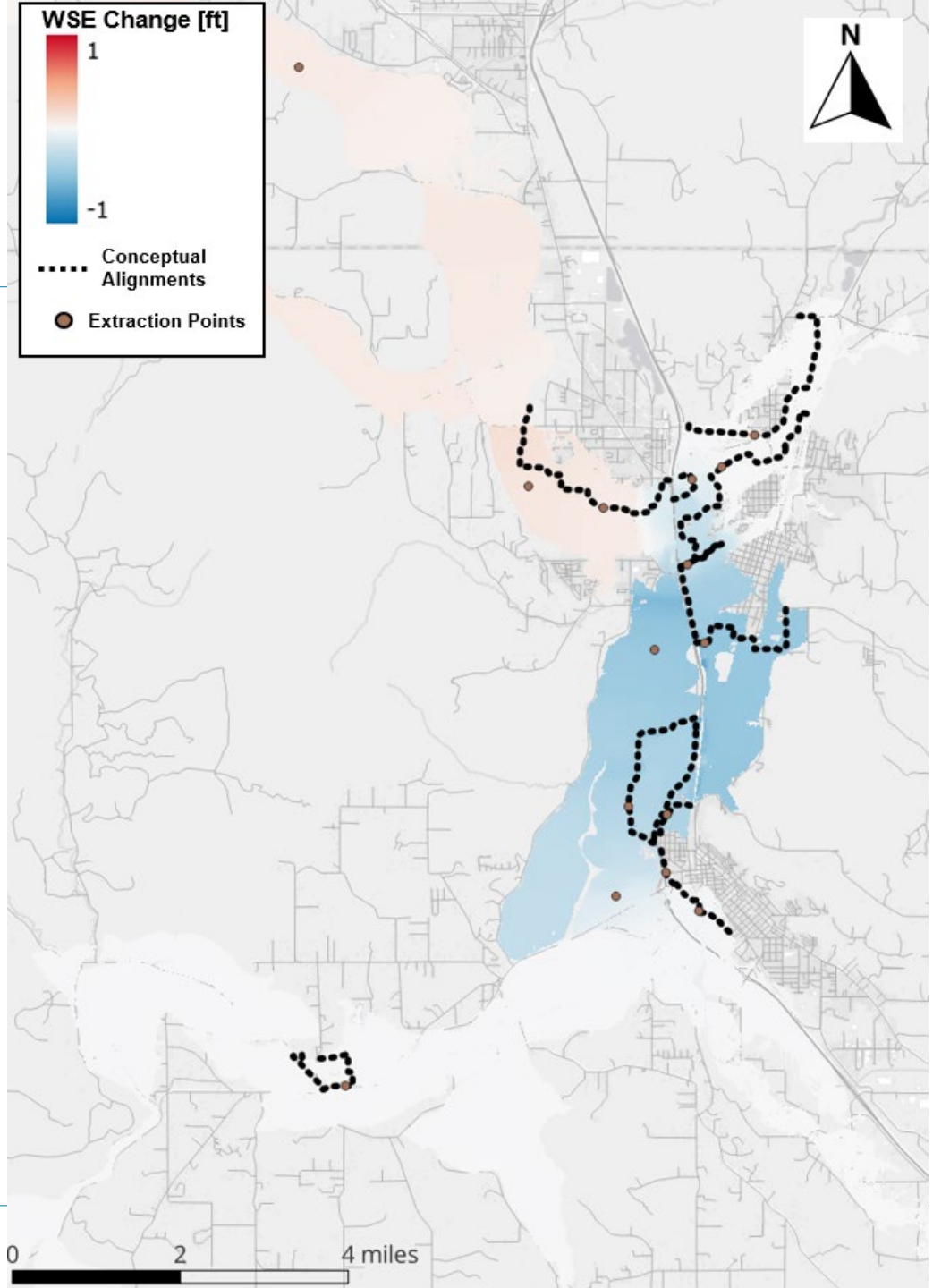


Run 2 – 200-foot Diversion Minus No Action

- **Water Level Difference Plot:**
  - Shows change in water level for 200-foot Diversion from No-Action
  - 100-year-plus-26-percent Flow Conditions

- **General Water Level Changes:**
  - Reduction Upstream: Up to **minus 0.5 feet**
  - Increase Downstream: Up to **plus 0.1 feet**

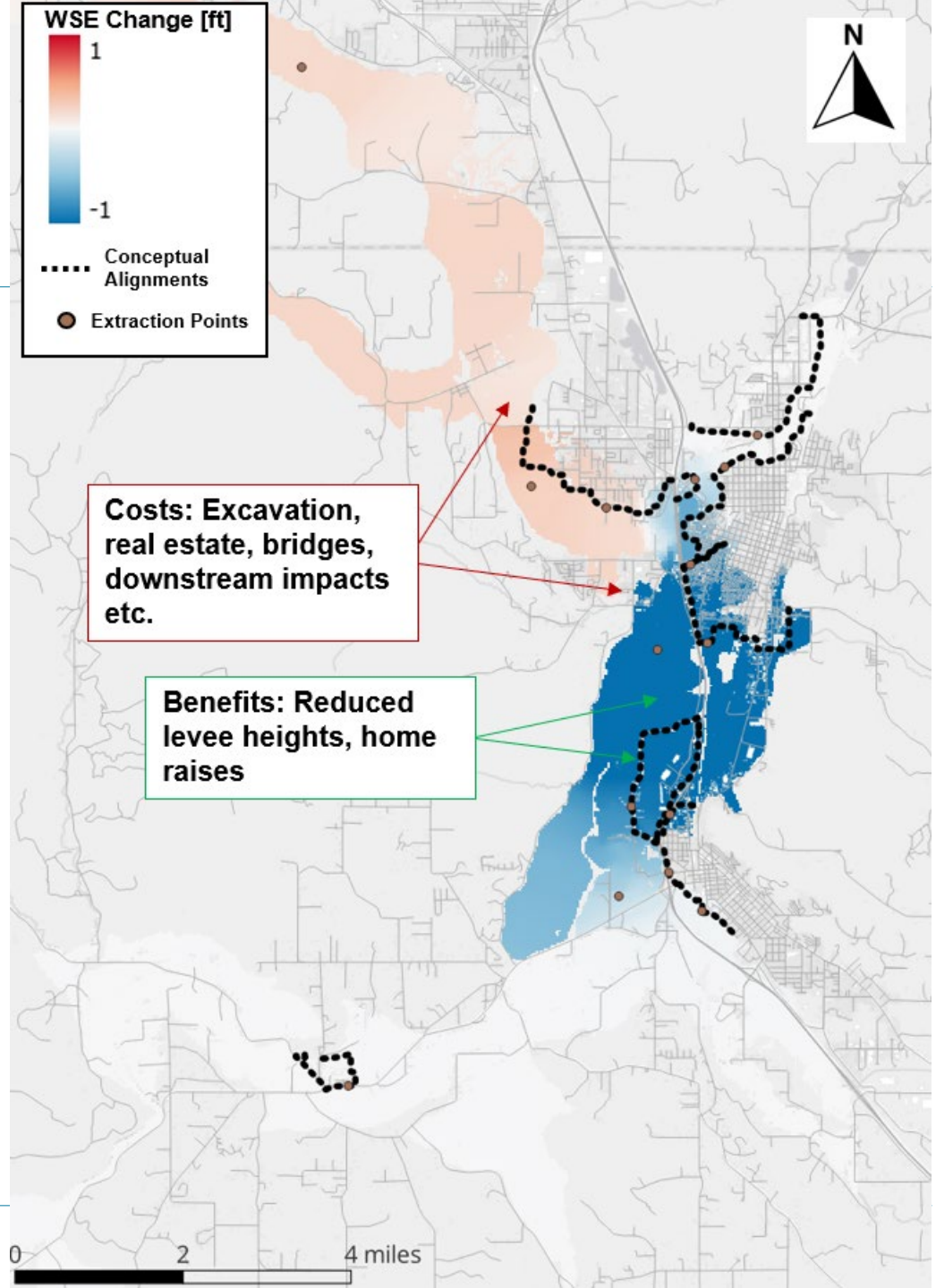
Next Step: Develop A Level "BCR" to see which diversion size performs better.



Run 1 and Run 2 Cost and "Benefit" Analysis Approach

- **Costs:**
  - Costs of the diversion were calculated to consider the following:
    - Excavation
    - Home raises for downstream properties that are negatively impacted (i.e. they flood WITH the diversion but DON'T flood without it)
    - Property acquisitions
    - Bridge & Fords
    - PED/Environmental/Mob/Demob

- **Benefits:**
  - Benefit of the diversion is the reduced height of water level upstream, which will reduce:
    - The cost/height of the levees and floodwalls, and number of structures raised.

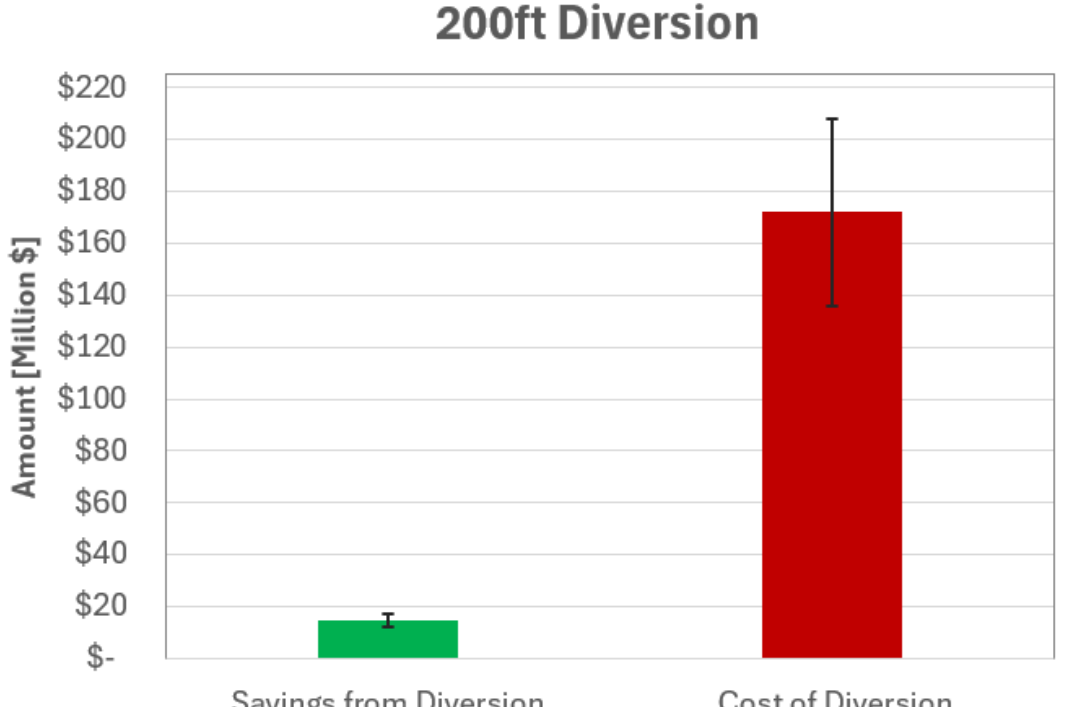


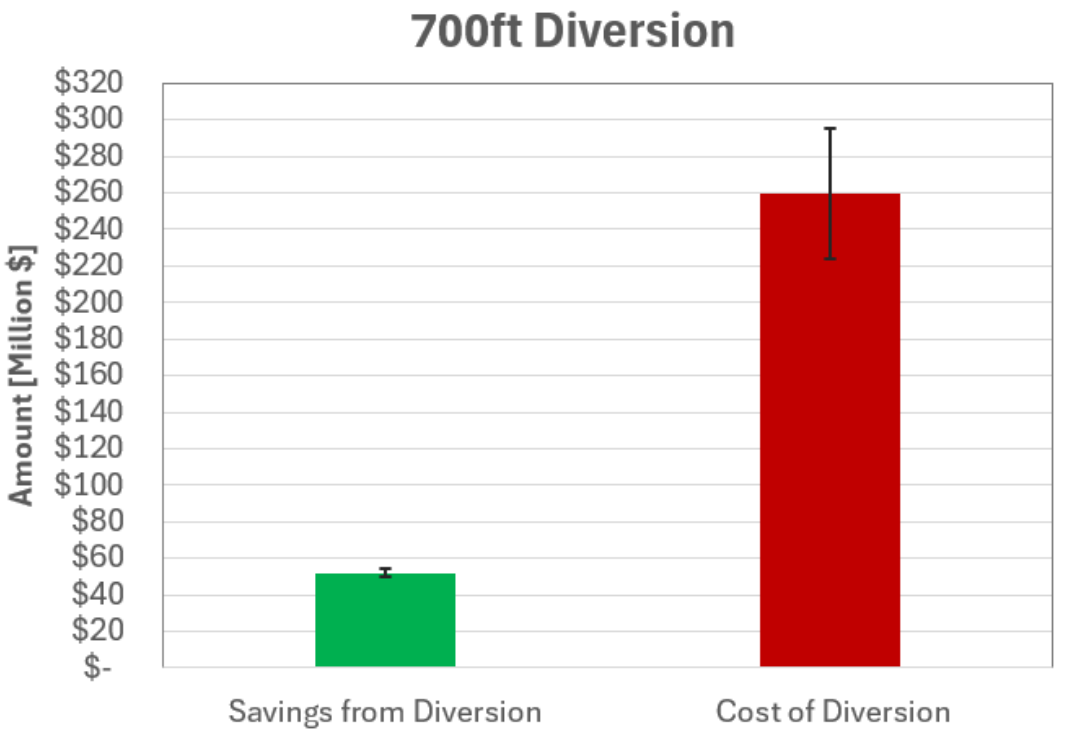
Run 1 and Run 2 Cost and "Benefit" Analysis Results

- **200-foot Diversion (top):**
  - Cost estimated $136 Million and $208 Million
  - Benefit (i.e. reduction in levee & home raise costs) between $12 Million to $17 Million
  - "BCR" of approx. 0.10

- **700-foot Diversion (bottom):**
  - Cost estimated $208 Million and $311 Million
  - Benefit (i.e. reduction in levee costs) between $42 Million to $62 Million
  - BCR of approx. 0.2

Note: This does not include analysis of changes in the duration of inundation due to the diversion. This analysis is covered in the next set of runs (3, 4, 5, and16)



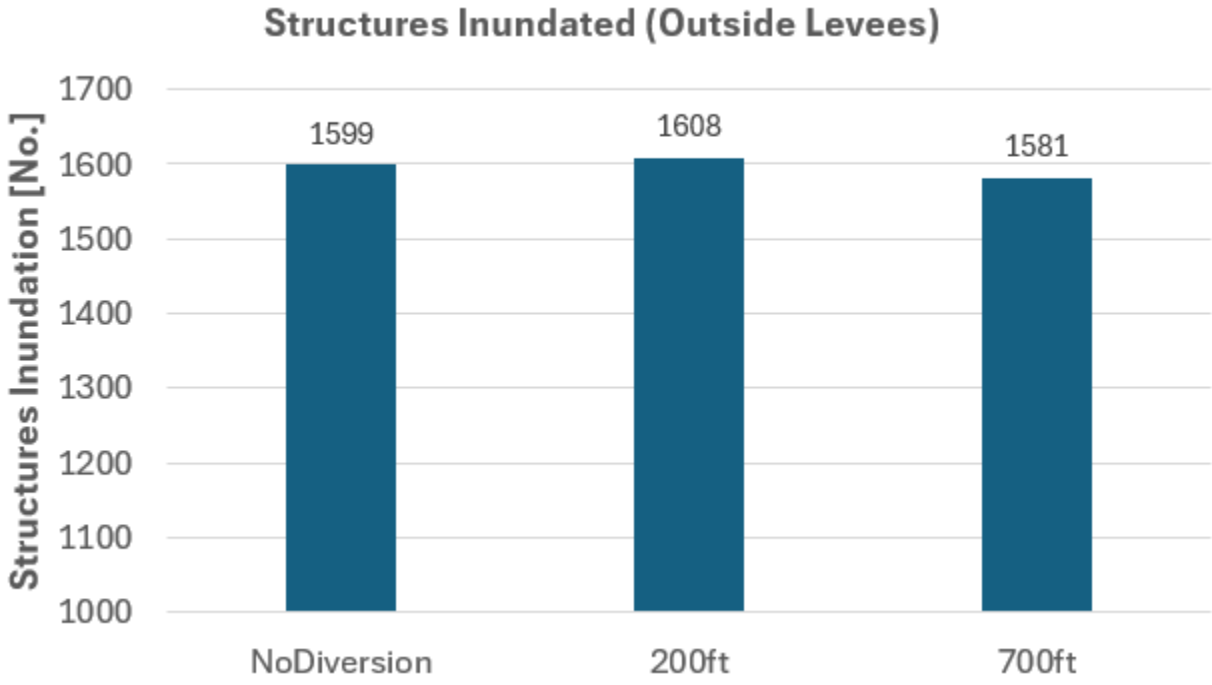


Run 1 and Run 2: Structure Inundation Comparison

- **Structure Inundation**
  - Graph shows a comparison of number of structures inundated outside of levees.
  - Inundation Conclusion: Slightly increases number of structures inundated outside levees for 200-foot Diversion. Less for 700 foot.

Overall Conclusion: Neither diversion width appears to make sense from a cost benefit perspective (previous slides) and show similar structure inundation to no diversion.

Next Step: Move forward with 700-foot Diversion in next set of model runs to analyze impacts. Potentially recommend dropping diversion pending these model results.



Note: These are for comparative purposes only, and do not include the levees. More detailed analysis of structural inundation will be conducted and summarized in other model runs.

Runs 3, 4, 5, and 16

Impact Analysis for Diversion, Conveyance (with Conceptual Levee Alignments in Place)

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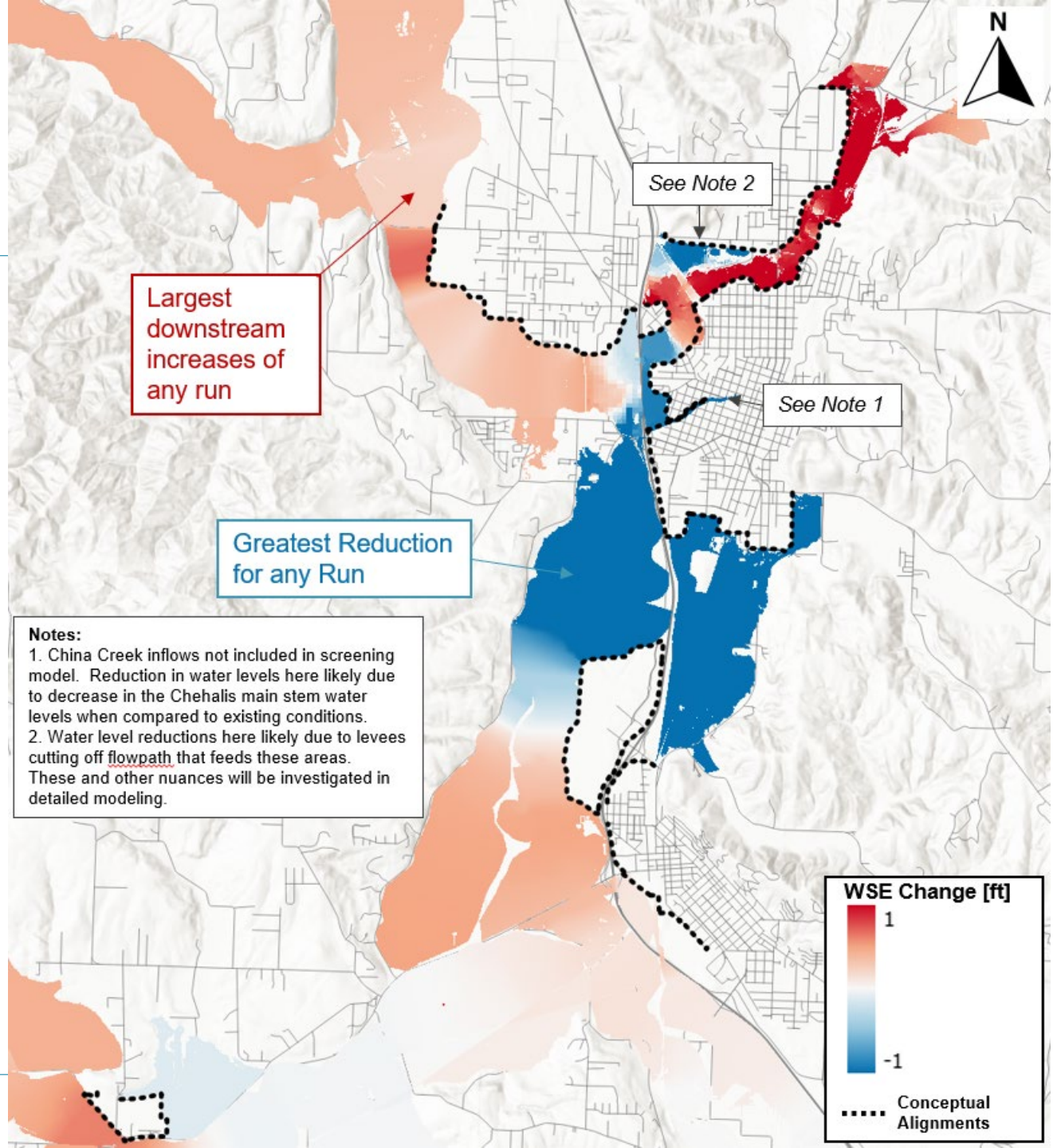
Run 3 – All Levees with Diversion and Conveyance

- **Water Level Difference Plot:**
  - Shows change in water level for Run 3 (Conveyance plus Diversion plus Levees) from No-Action
  - 100-year-plus-26-percent Flow Conditions for both Run 3 and No-Action.

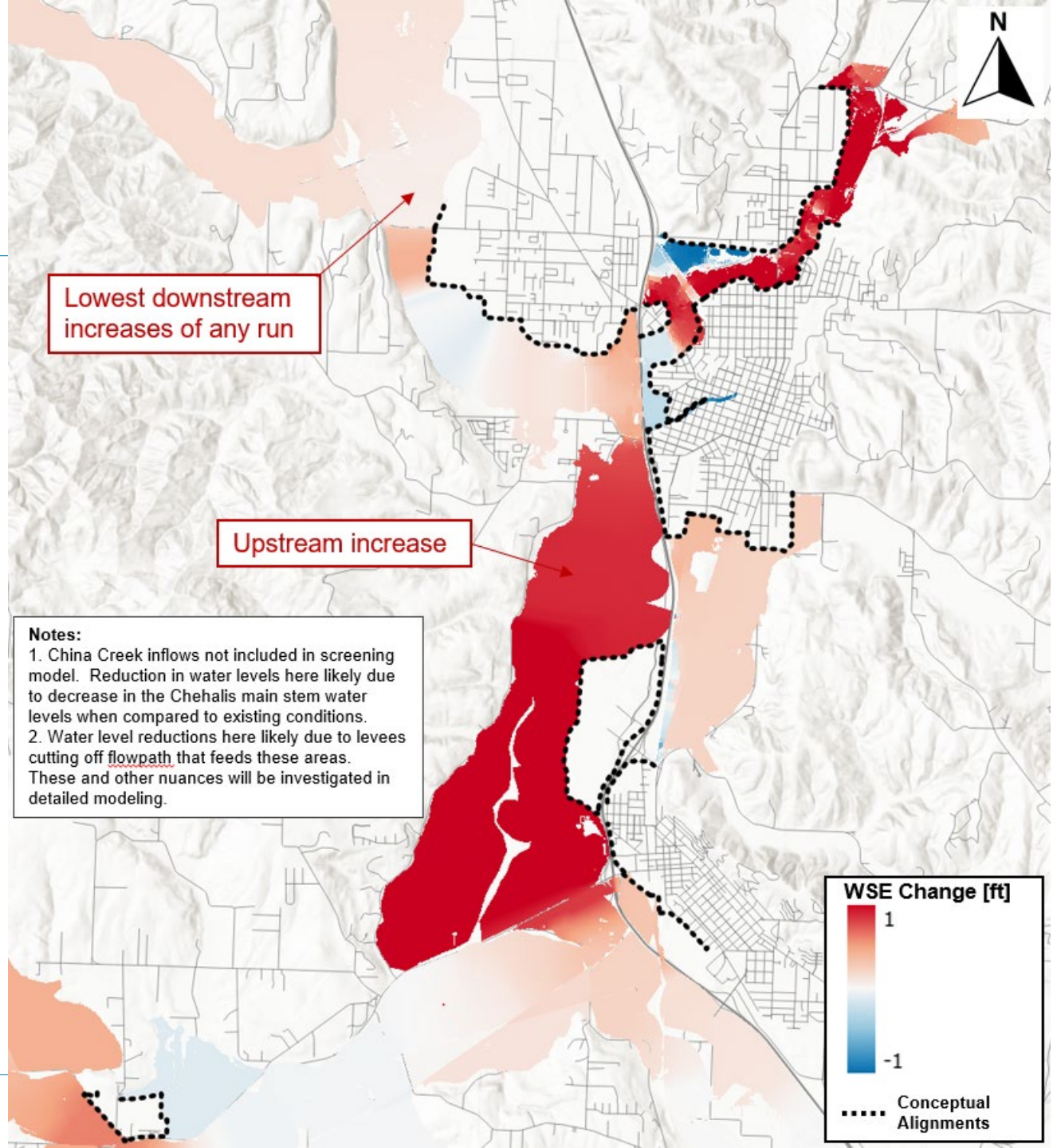
- **General Water Level Changes:**
  - Reduction Upstream: Approx **minus 1.5 feet**
  - Increase Downstream: Approx **plus 0.35 feet**



Run 4 – All Levees, No Diversion or Conveyance

- **Water Level Difference Plot:**
  - Shows change in water level for Run 3 (Levees Only) from No-Action
  - 100-year-plus-26-percent Flow Conditions for both Run 3 and No-Action.

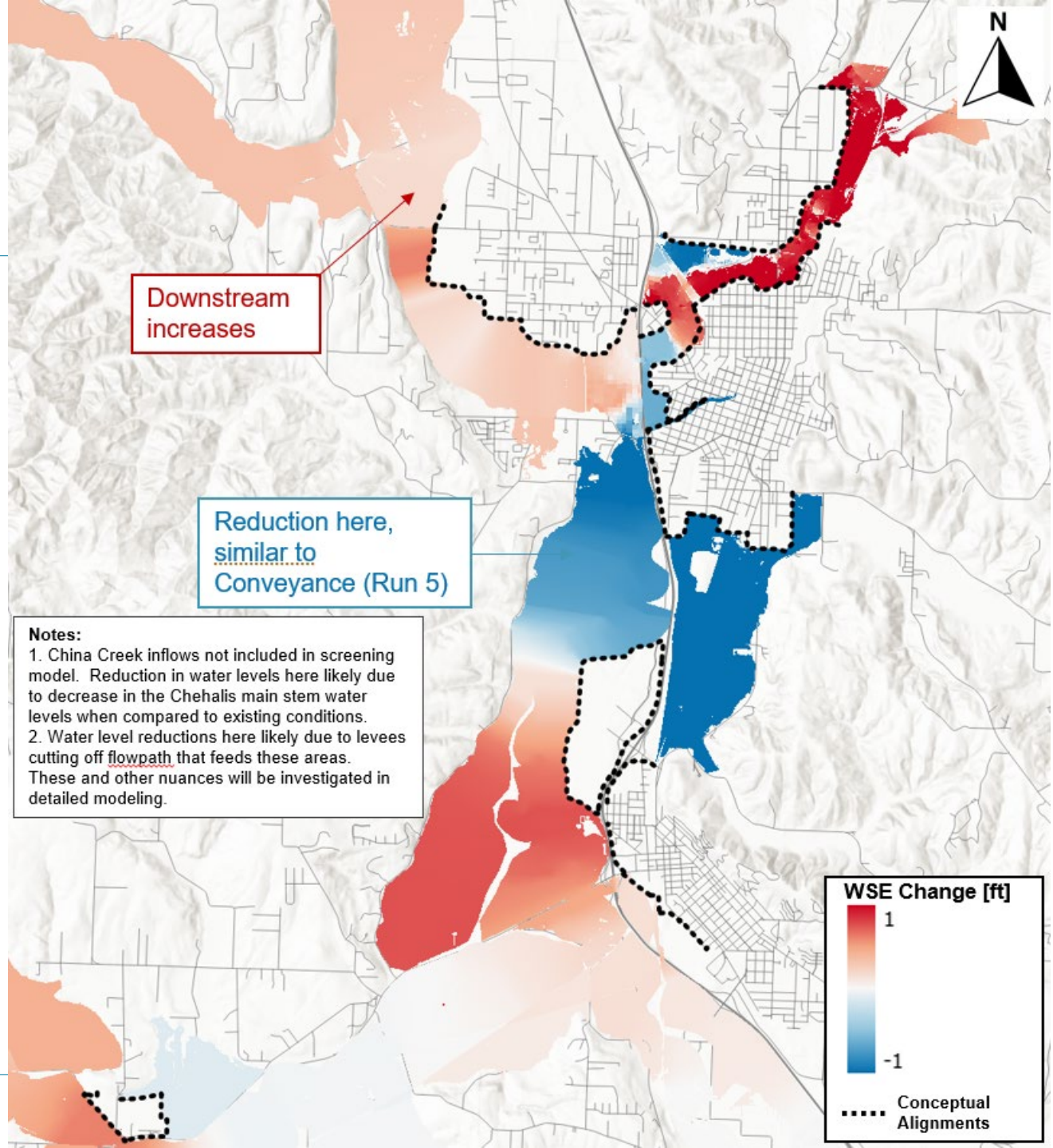
- **General Water Level Changes:**
  - Increase Upstream: Approx **plus 0.9 feet**
  - Increase Downstream: Approx **plus 0.1 feet**



Run 5 – All Levees, Conveyance Only

- **Water Level Difference Plot:**
  - Shows change in water level for Run 3 (Conveyance plus Levees) from No-Action
  - 100-year-plus-26-percent Flow Conditions for both Run 3 and No-Action.

- **General Water Level Changes:**
  - Reduction Upstream: Approx **minus 0.7 feet**
  - Increase Downstream: Approx **plus 0.3 feet**

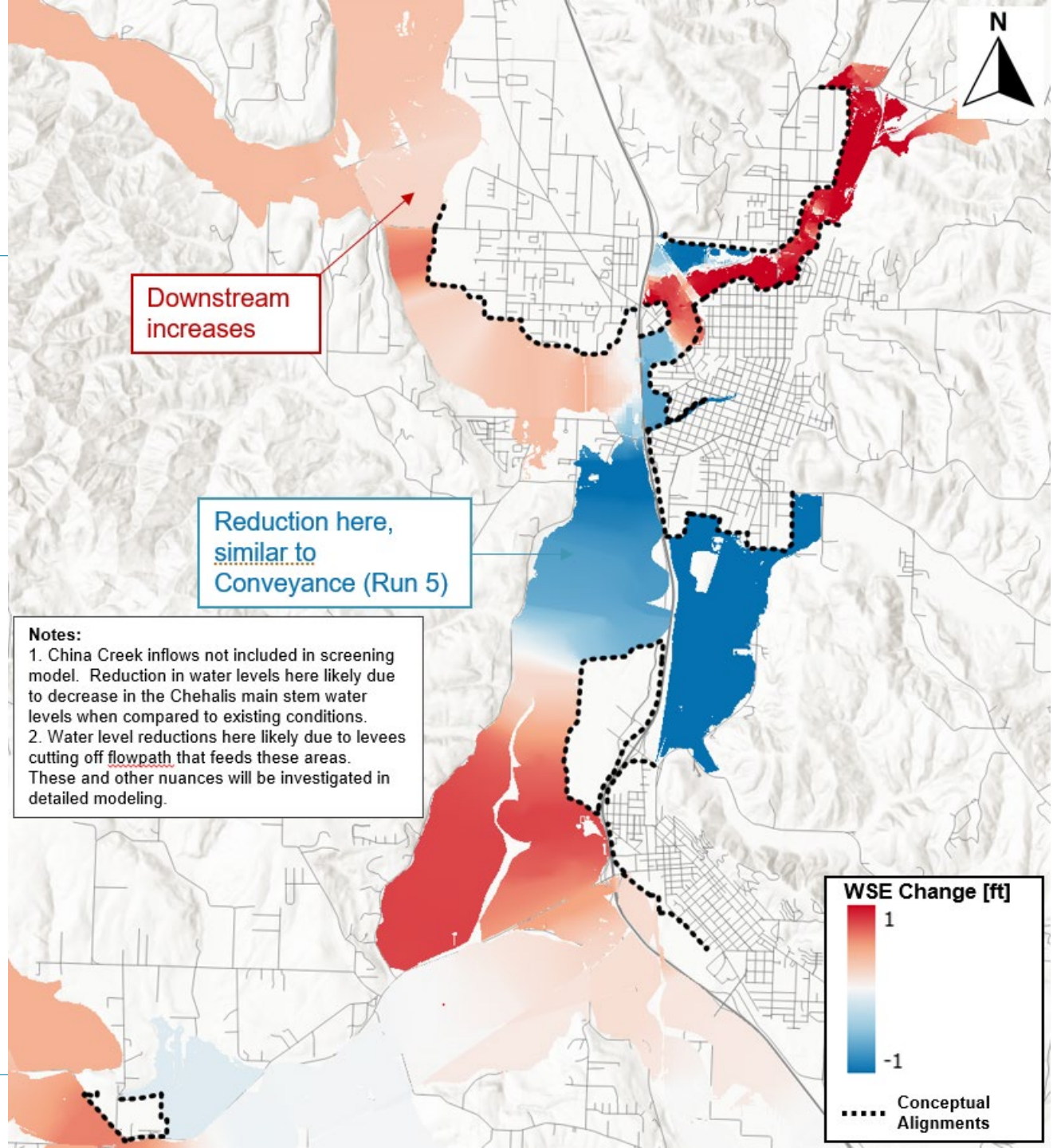


Run 16 – All Levees, Diversion Only

- **Water Level Difference Plot:**
  - Shows change in water level for Run 3 (Diversion plus Levees) from No-Action
  - 100-year-plus-26-percent Flow Conditions for both Run 3 and No-Action.

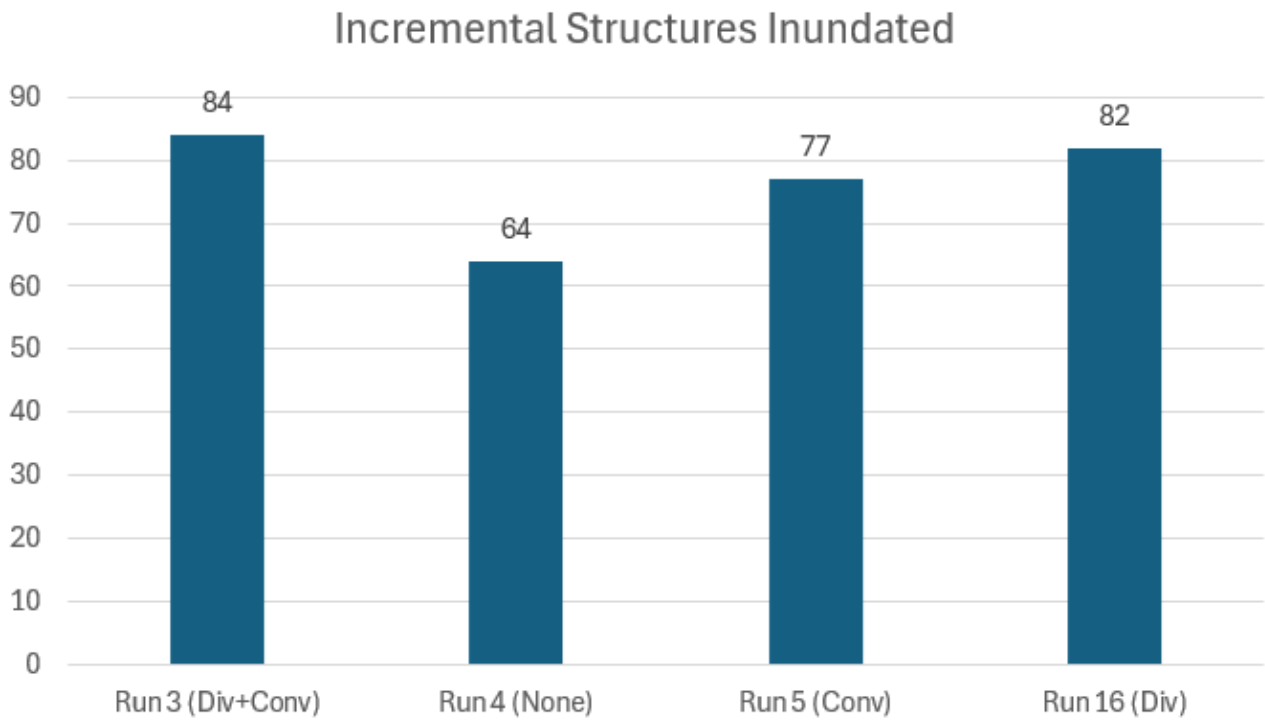
- **General Water Level Changes:**
  - Reduction Upstream: Approx **minus 0.7 feet**
  - Increase Downstream: Approx **plus 0.3 feet**

General Conclusions: Conveyance, Diversion both cause lower water levels upstream, but cause slight increase in downstream water levels.
Next Step(s): Look at where structures are inundated, perform conceptual level "BCR" analysis.



Comparison:
Incremental Structures Inundated

- Use the 100 year plus 26 percent event, simulated using screening level model setup.
- Determine the number of structures that **are** inundated *with the alternative* but **are not** under *existing conditions.* These are referred to as the "incremental structures inundated".
  - These structures will need to be raised as part of the project & are included in project costs analysis on the next slide.
  - The total number of incremental structures inundated for each model run are shown on the plot to the right.

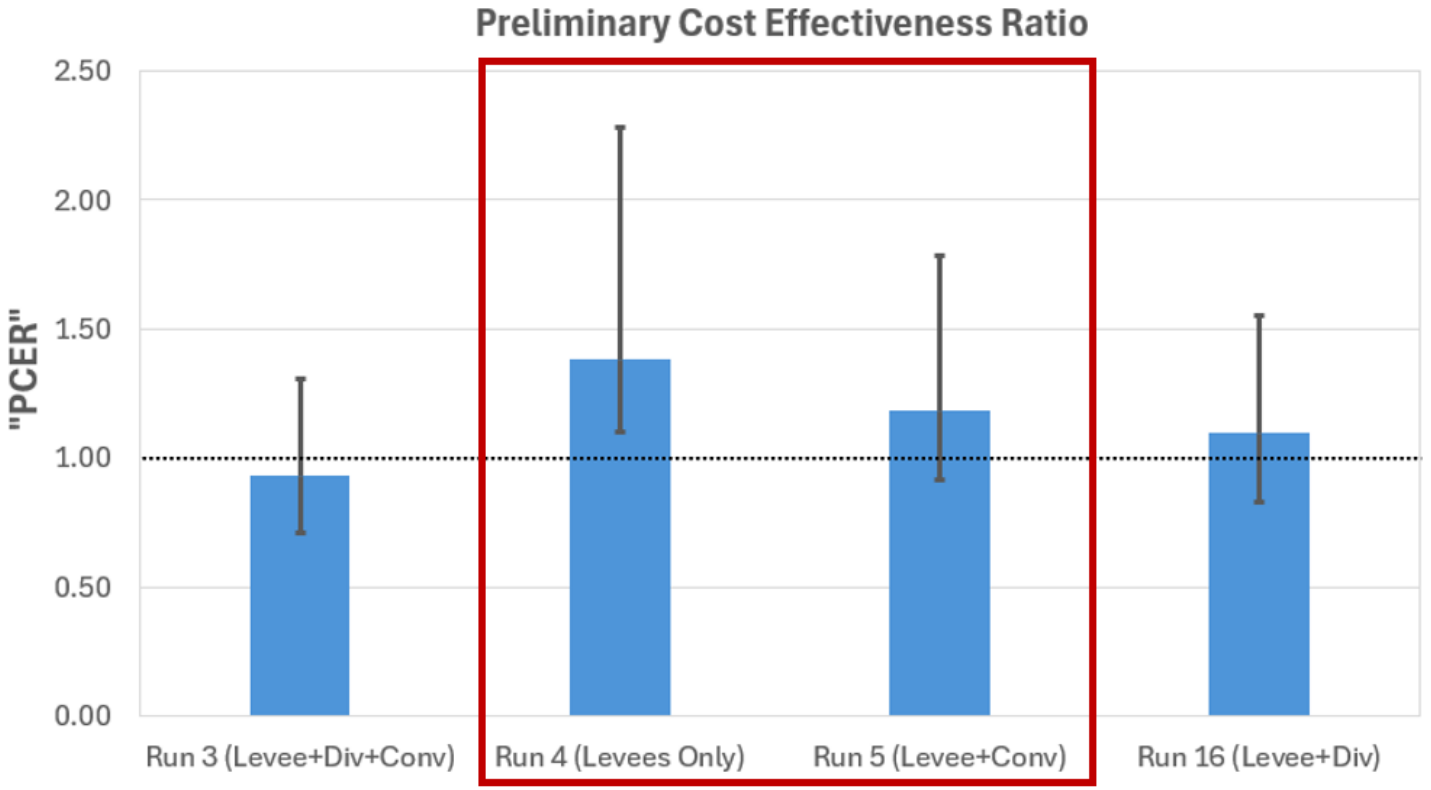


General Conclusions: Run 3 causes the most induced structure inundations due to the downstream water level increases.

Preliminary Cost Effectiveness Ratio (PCER)

- **PCER Calculation:**
  - Cost of raising all structures inside levees (benefit), divided by the total cost of each alternative (cost).
  - Cost to construct each alternative includes:
    - All levee costs
    - Diversion Construction Costs
    - Conveyance Construction Costs
    - PED, Environmental, Mob/Demob.
    - Costs to mitigate induced flooding of structures & Property Acquisitions
- **PCER Calculation Results:**
  - Runs 4 (Levees Only) and 5 (Levee plus Conveyance) have the highest “BCR”.

Conclusion: Run 4 and Run 5 should be investigated further.



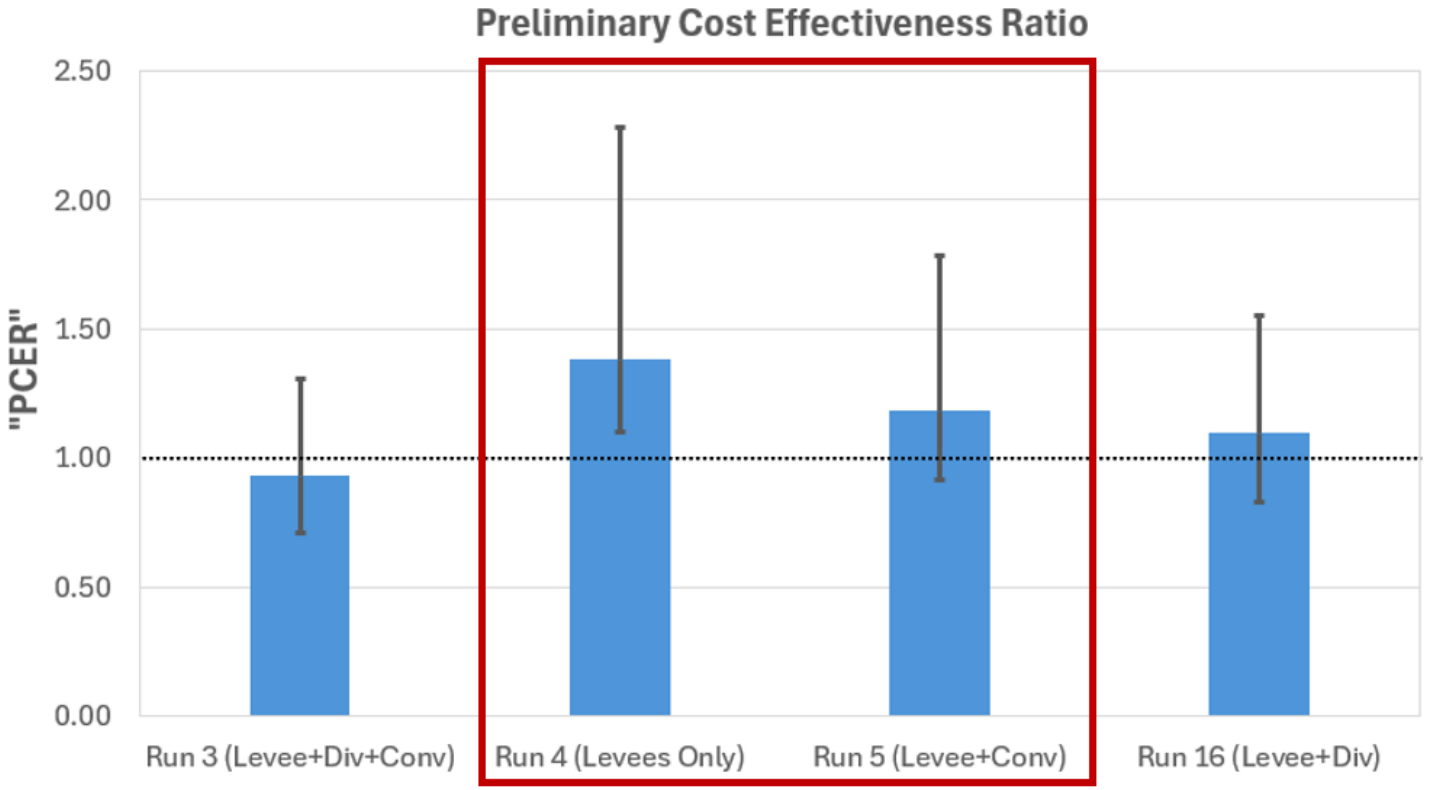
Note: The plot above is not meant to be an all encompassing benefits calculation and only serves to investigate the relative cost effectiveness of each alternative for screening purposes. Full benefit and cost calculations should be conducted in future phases of the project.

Conclusions and Next Steps

- Run 4 (Levees Only), Run 5 (Levees plus Conveyance) most cost effective.
- Run 3 (Levees plus Conveyance plus Diversion) and Run 16 (Levees plus Diversion) less cost effective

Conclusions:
- Run 4 and Run 5 should be investigated further.
- Preliminarily recommend dropping diversion from project consideration, pending coordination with OCB/Subgroup

Suggested Next Steps:
- Investigate smaller conveyance area.
- Run the rest of the concept model scenarios, including phasing, “lighter touch” and runs water level mitigation projects



Note: The plot above is not meant to be an all encompassing benefits calculation and only serves to investigate the relative cost effectiveness of each alternative for screening purposes. Full benefit and cost calculations should be conducted in future phases of the project.

Phasing Analysis Runs

Runs 9a, 9b, 10, 3

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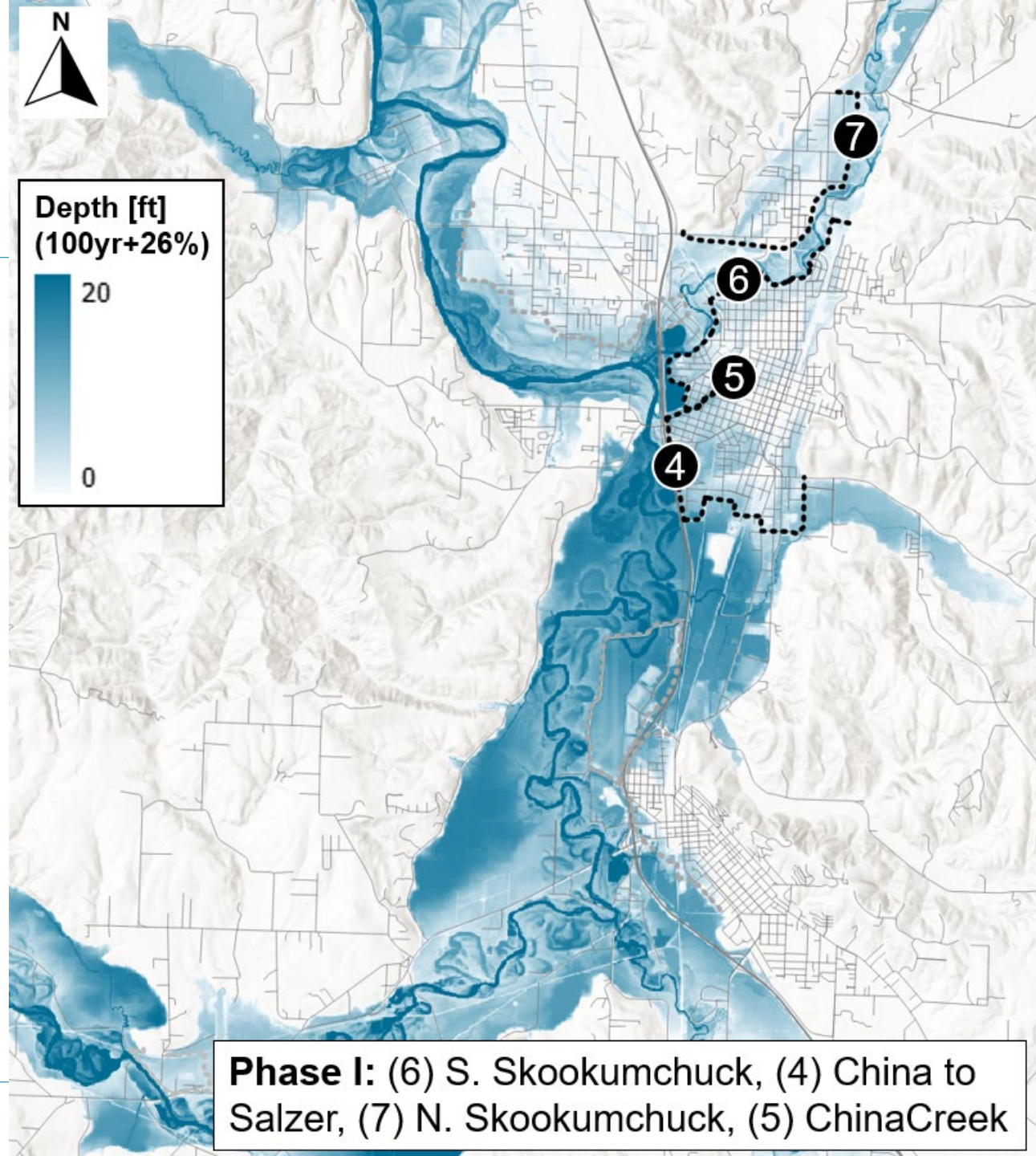
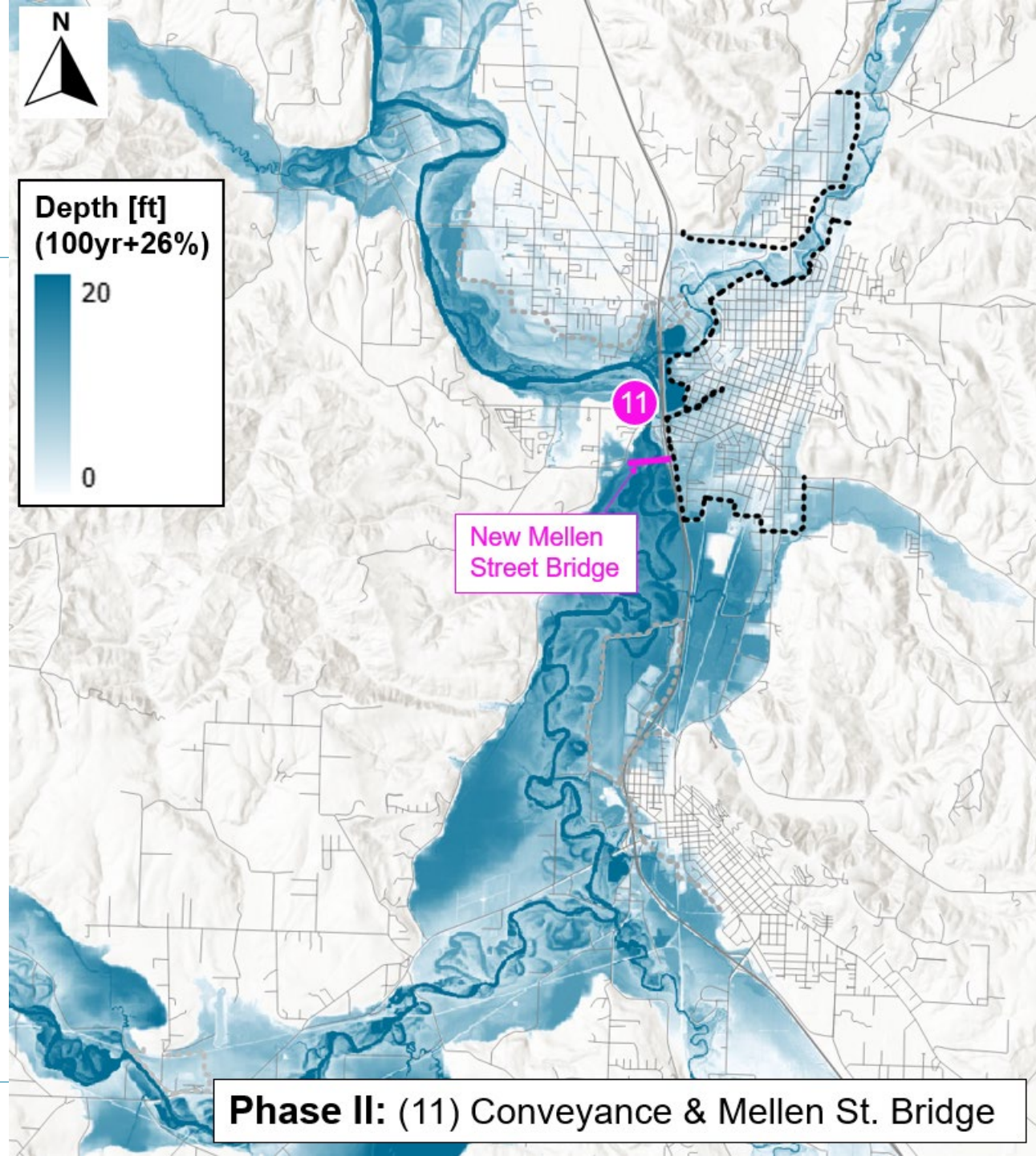
Phased Construction Modeling

- **General Purpose:** Model runs to investigate hydraulics, water levels, qualitative impacts of project phasing.
- **Conceptual Phasing:**
  - *Phase I:* (6) S. Skookumchuck, (4) China to Salzer, (7) N. Skookumchuck, (5) China Creek plus Induced Structure Raises



Phased Construction Modeling

- **General Purpose:** Model runs to investigate hydraulics, water levels, qualitative impacts of project phasing.
- **Conceptual Phasing:**
  - *Phase I:* (6) S. Skookumchuck, (4) China to Salzer, (7) N. Skookumchuck, (6) China Creek plus Induced Structure Raises
  - *Phase II:* (11) Conveyance & Mellen St. Bridge

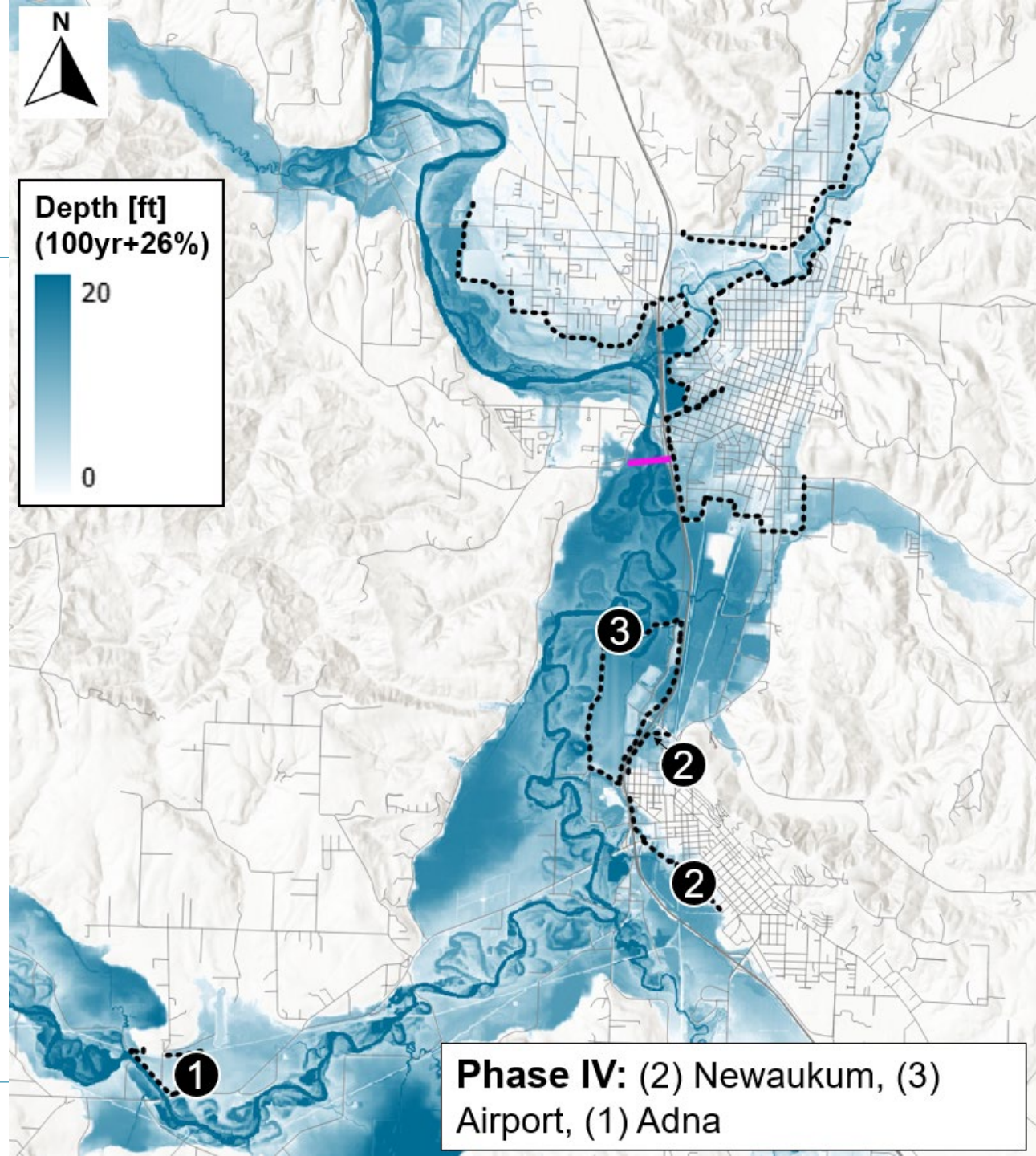


Phased Construction Modeling

- **General Purpose:** Model runs to investigate hydraulics, water levels, qualitative impacts of project phasing.
- **Conceptual Phasing:**
  - *Phase I:* (6) S. Skookumchuck, (4) China to Salzer, (7) N. Skookumchuck, (6) China Creek plus Induced Structure Raises
  - *Phase II:* (11) Conveyance & Mellen St. Bridge
  - *Phase III:* (8) West Skookumchuck, (9) Fort Borst

Phased Construction Modeling

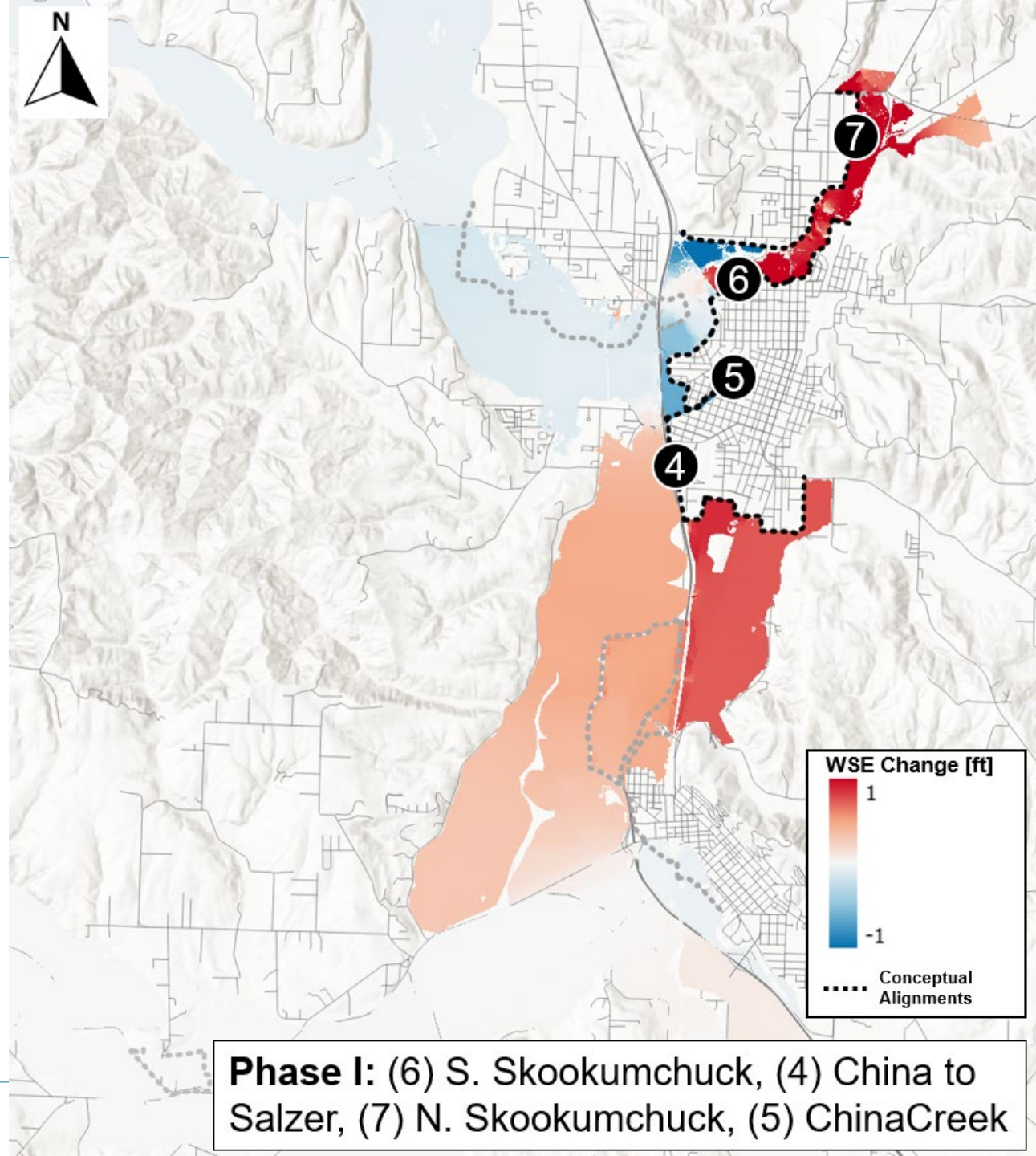
- **General Purpose:** Model runs to investigate hydraulics, water levels, qualitative impacts of project phasing.
- **Conceptual Phasing:**
  - *Phase I:* (6) S. Skookumchuck, (4) China to Salzer, (7) N. Skookumchuck, (6) China Creek plus Induced Structure Raises
  - *Phase II:* (11) Conveyance & Mellen St. Bridge
  - *Phase III:* (8) West Skookumchuck, (9) Fort Borst
  - *Phase IV:* (2) Newaukum, (3) Airport, (1) Adna



Phased Construction Modeling Phase I-IV

- **Water Level Changes**
- Phase I: Causes incremental water level increases

- **Key Notes/Observations**
  - Constructing just levees (i.e. no conveyance) during Phase I causes water level increases upstream.

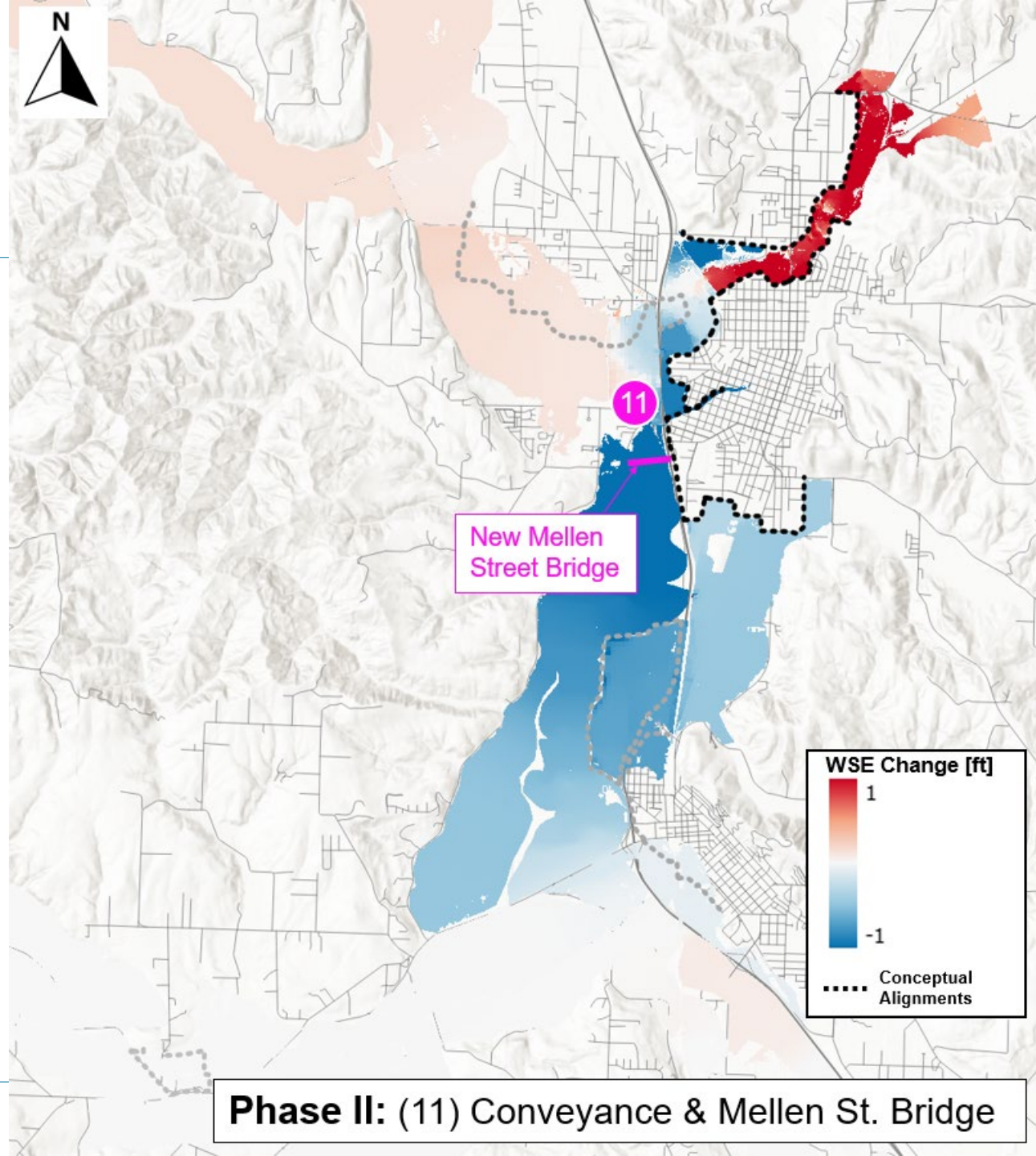


Phased Construction Modeling Phase I-IV

- **Water Level Changes**
- Phase I: Causes incremental water level increases
- Phase II: Water level decreases due to conveyance.

- **Key Notes/Observations**
  - Construction of conveyance removes most water level increases upstream.

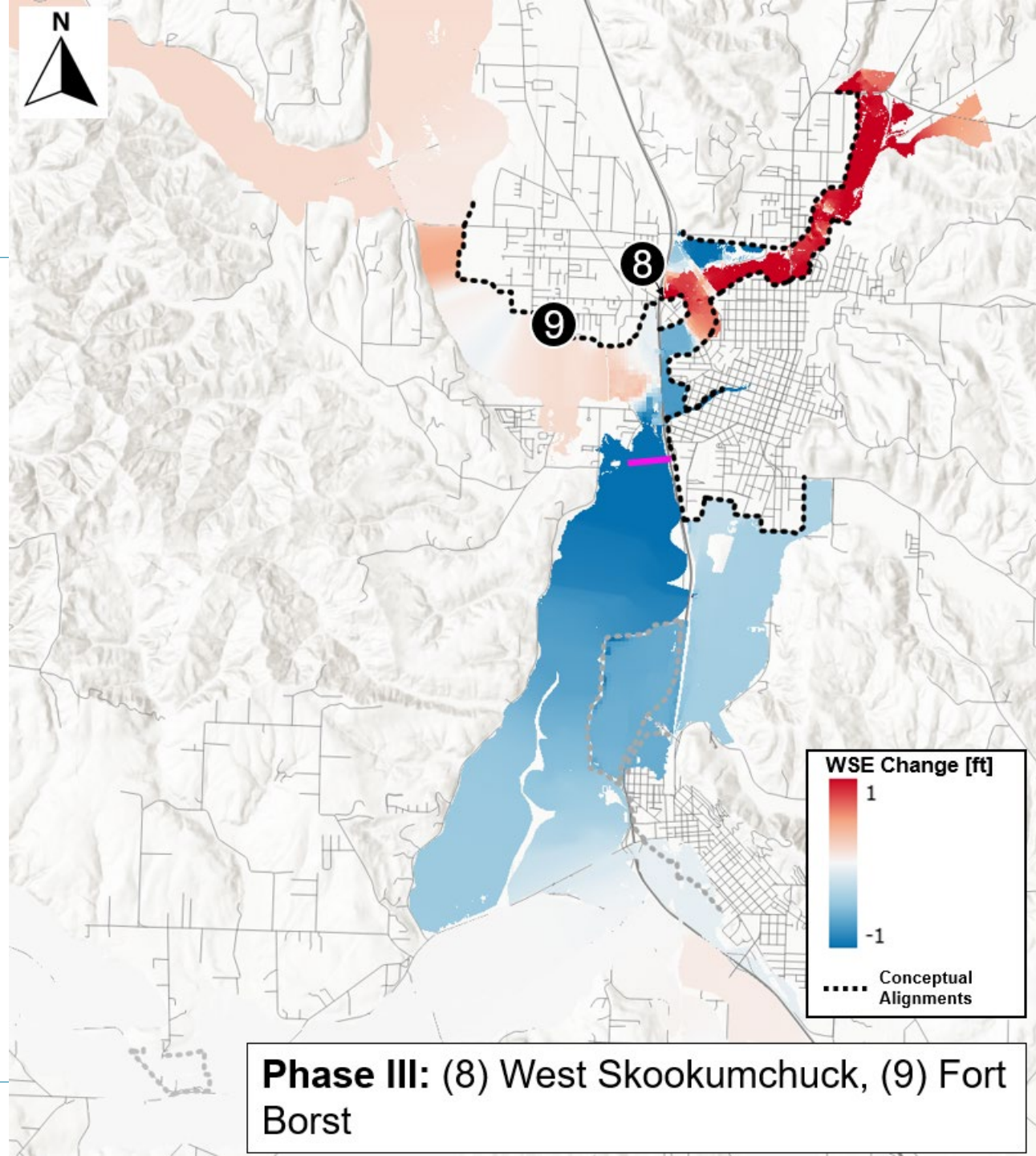
Preliminary Findings: Constructing conveyance during Phase I if possible – avoids induced flooding.



Phased Construction Modeling Phase I-IV

- **Water Level Changes**
- Phase I: Causes incremental water level increases
- Phase II: Water level decreases due to conveyance.
- Phase III: Minor increases from Fort Borst levee.

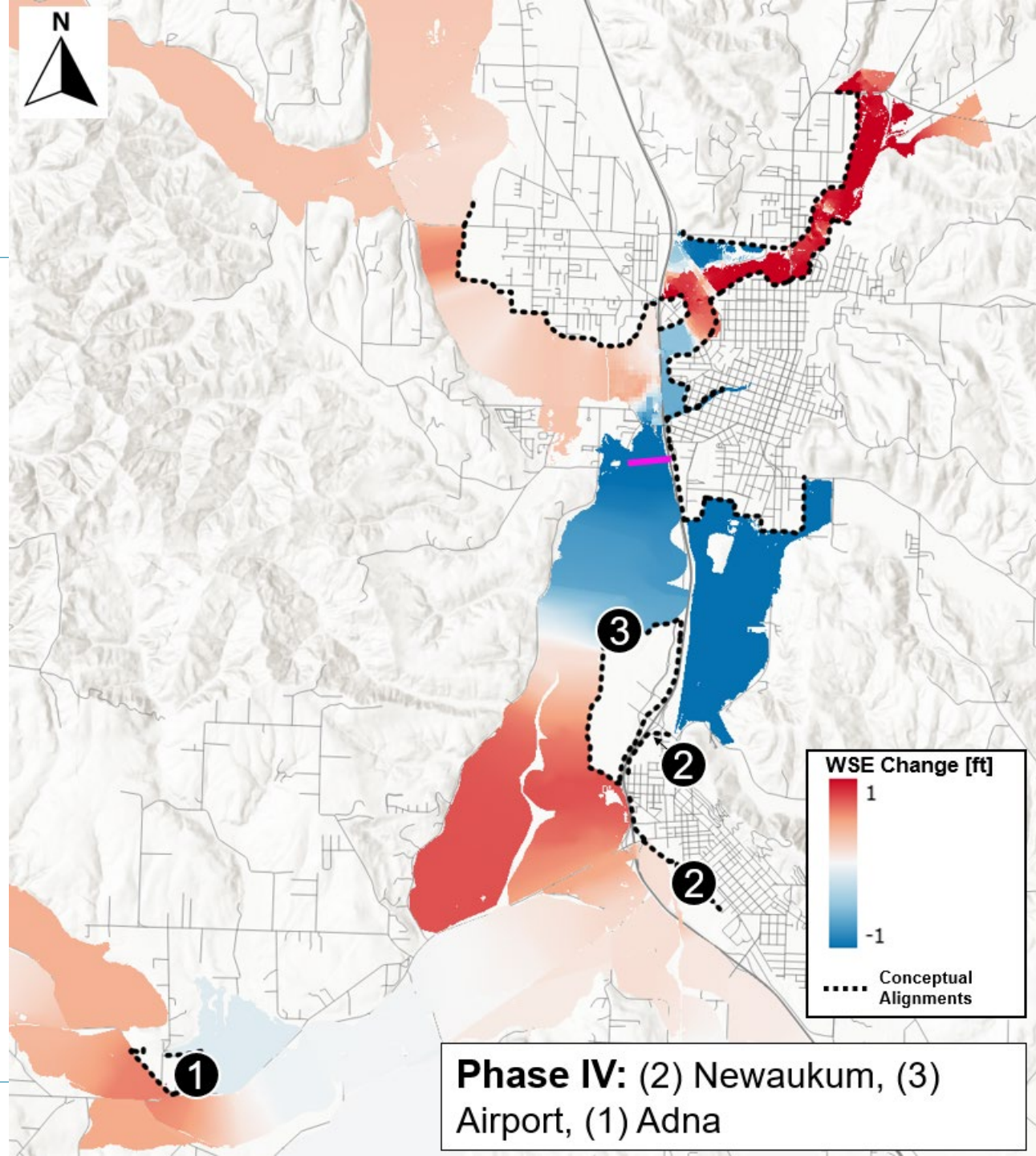
Preliminary Findings: Constructing conveyance during Phase I if possible – avoids induced flooding.



Phased Construction Modeling Phase I-IV

- **Water Level Changes**
- Phase I: Causes incremental water level increases
- Phase II: Water level decreases due to conveyance.
- Phase III: Minor increases from Fort Borst levee.
- Phase IV: Water level increases from Airport, Adna Levees.

Preliminary Findings: Constructing conveyance during Phase I if possible – avoids induced flooding.



Additional Model Runs

Runs 15, 17, 19, 20

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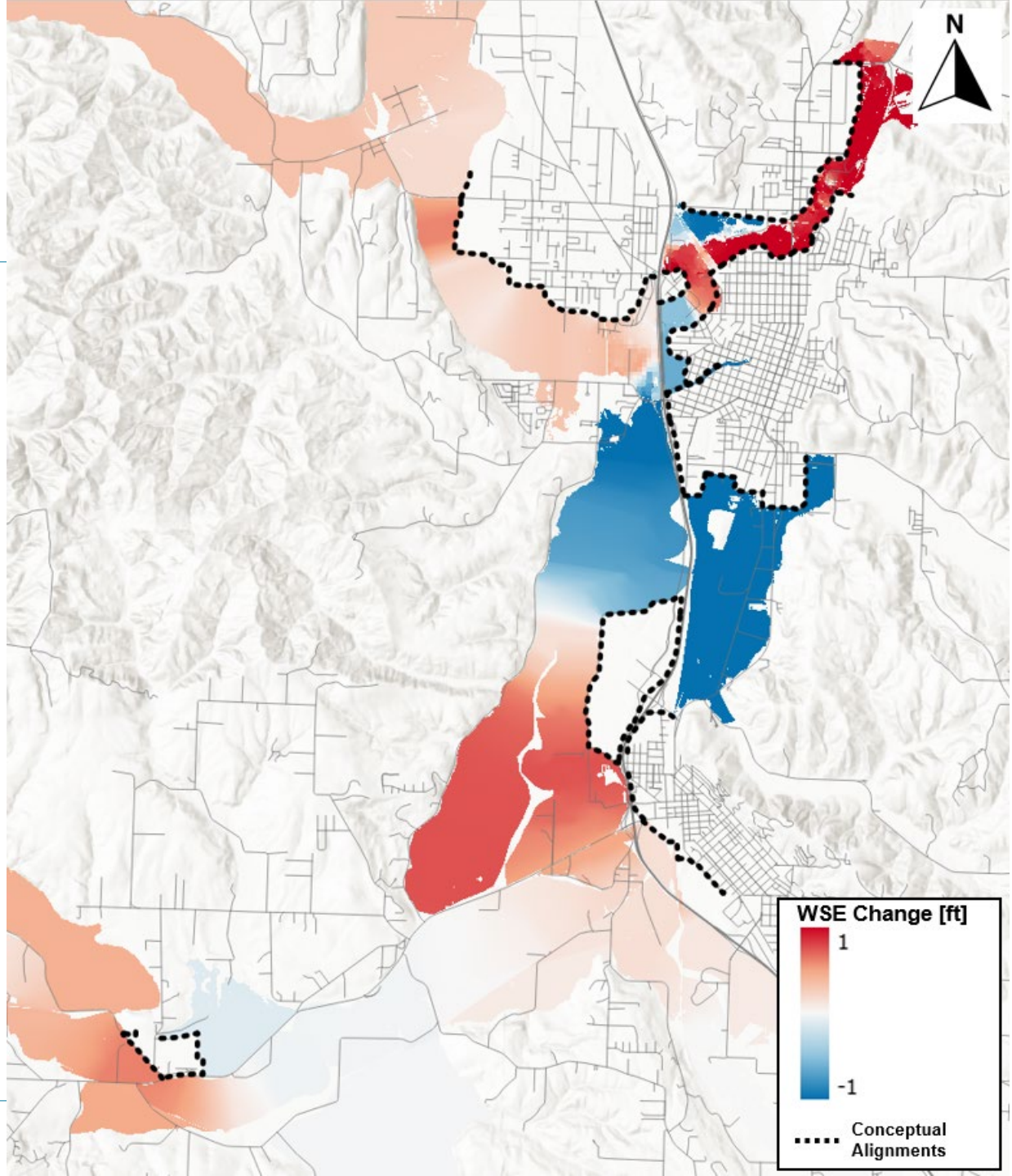
Run 5 – All Levees, Large Conveyance

- **Water Level Difference Plot:**
  - Shows change in water level for Run 3 (Diversion plus Levees) from No-Action
  - 100-year-plus-26-percent Flow Conditions

- **General Water Level Changes:**
  - Reduction Upstream: Approx **minus 0.7 feet**
  - Increase Downstream: Approx **plus 0.27 feet**

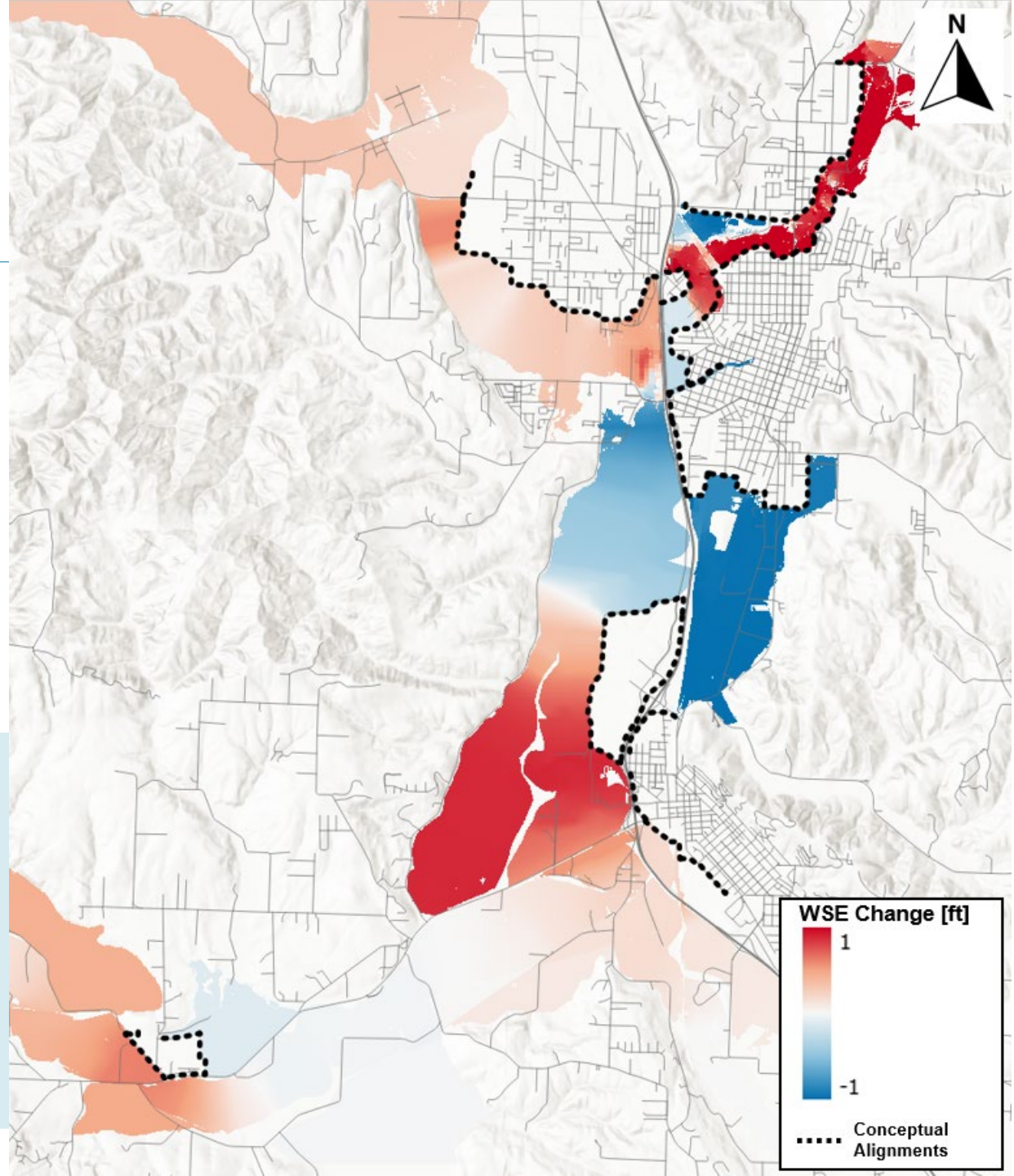


Run 17 – All Levees, Small Conveyance

- **Water Level Difference Plot:**
  - Shows change in water level for Run 3 (Diversion plus Levees) from No-Action
  - 100-year-plus-26-percent Flow Conditions

- **General Water Level Changes:**
  - Reduction Upstream: Approx **minus 0.5 feet**
  - Increase Downstream: Approx **plus 0.25 feet**

Note:
- In general results were with smaller conveyance (Run 17), with the larger conveyance (Run 5) 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.

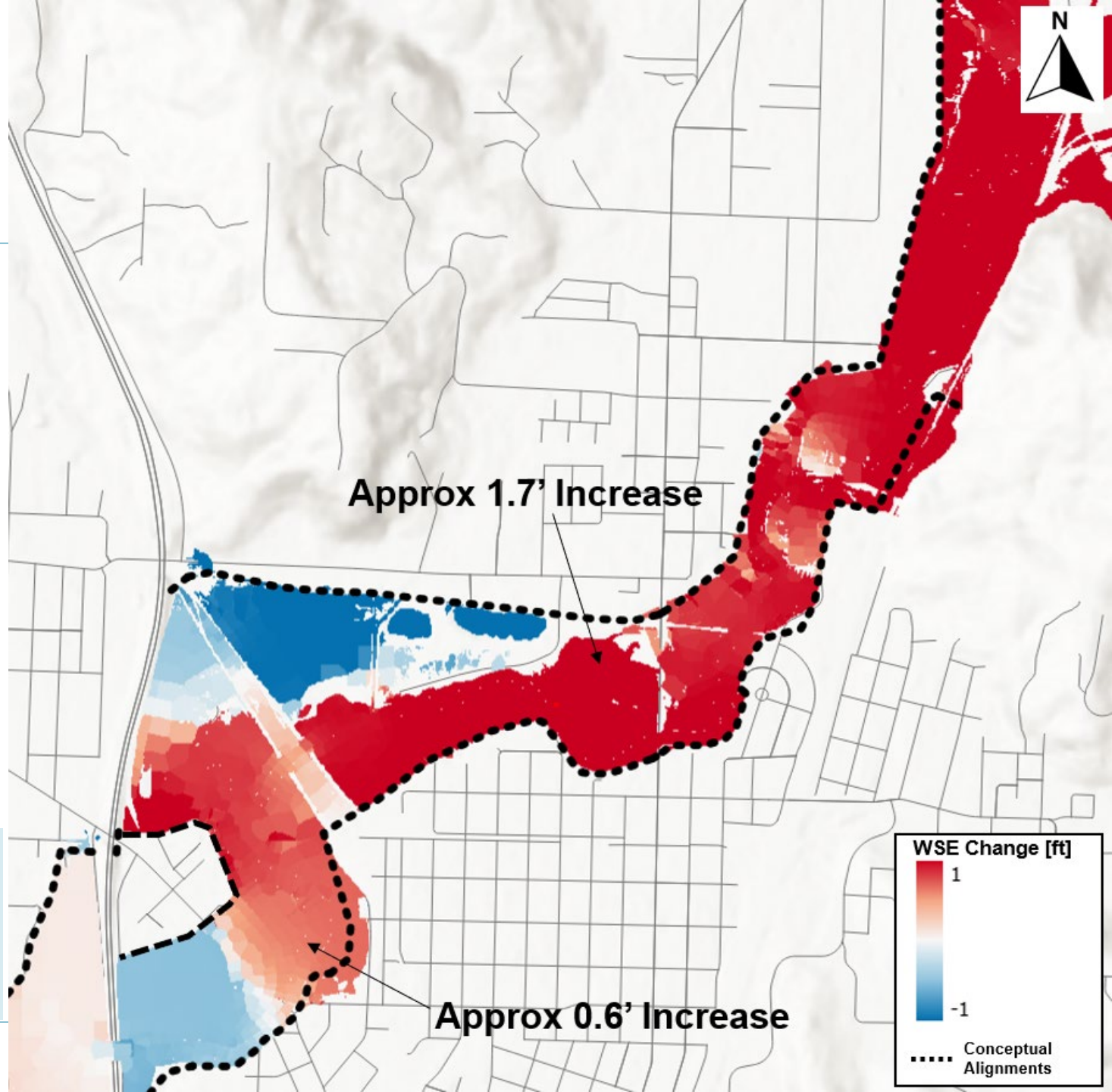


Run 5 – All Levees, Large Conveyance

- **Water Level Difference Plot:**
  - Shows change in water level for Run 3 (Diversion plus Levees) from No-Action
  - 100-year-plus-26-percent Flow Conditions

- **General Water Level Changes:**
  - See callouts to right

Note:
-Areas outside of Skookumchuck area are very similar, zoomed view shown to focus on different areas.

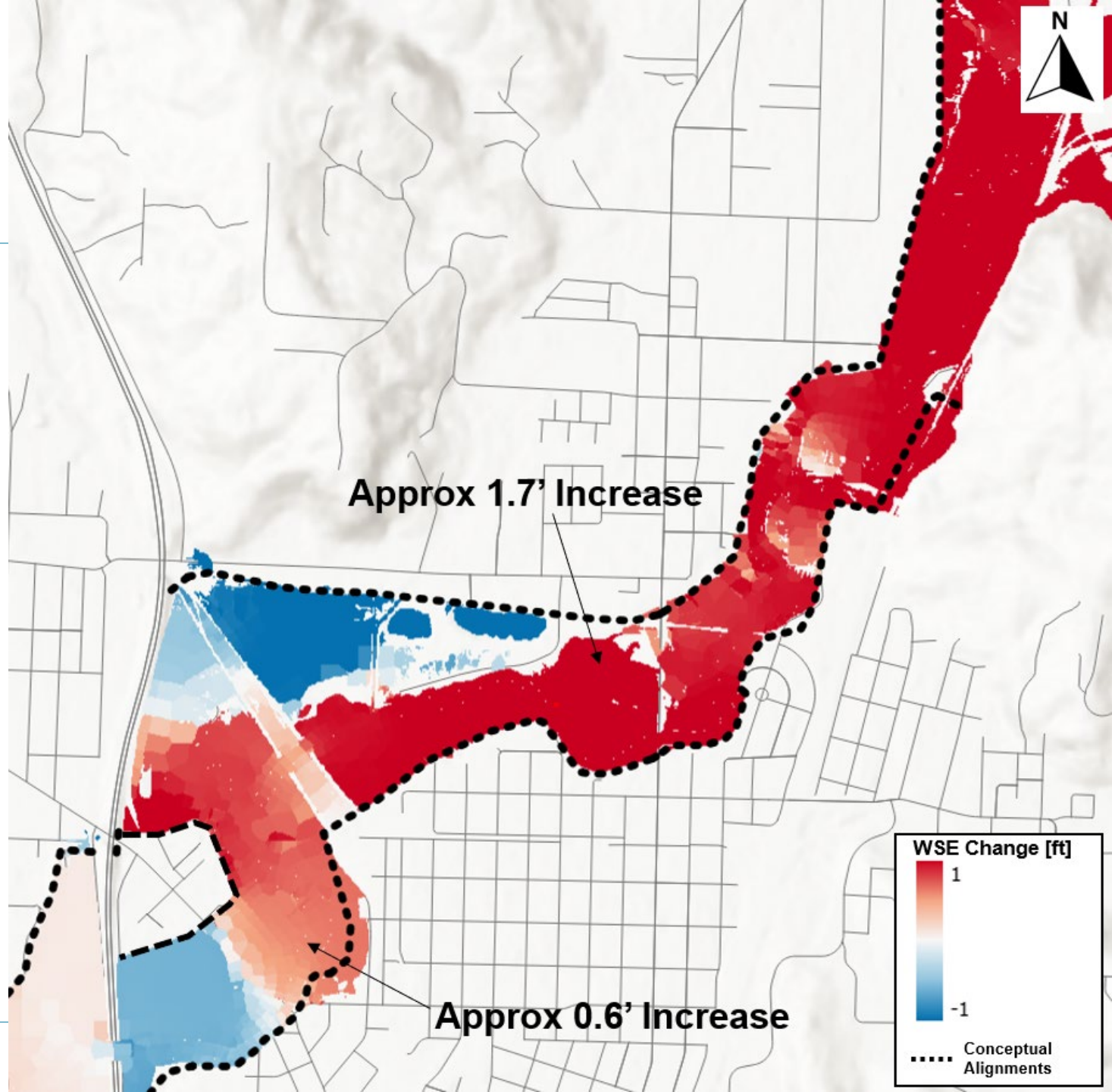


Run 15 – All Levees, Large Conveyance, 8-foot I-5 Culverts

- **Water Level Difference Plot:**
  - Shows change in water level for Run 3 (Diversion plus Levees) from No-Action
  - 100-year-plus-26-percent Flow Conditions

- **General Water Level Changes:**
  - See callouts to right
- **Takeaway:** Minimal change when compared to no Culvert increase (Run 5).

Note:
-Areas outside of Skookumchuck area are very similar, zoomed view shown to focus on different areas.

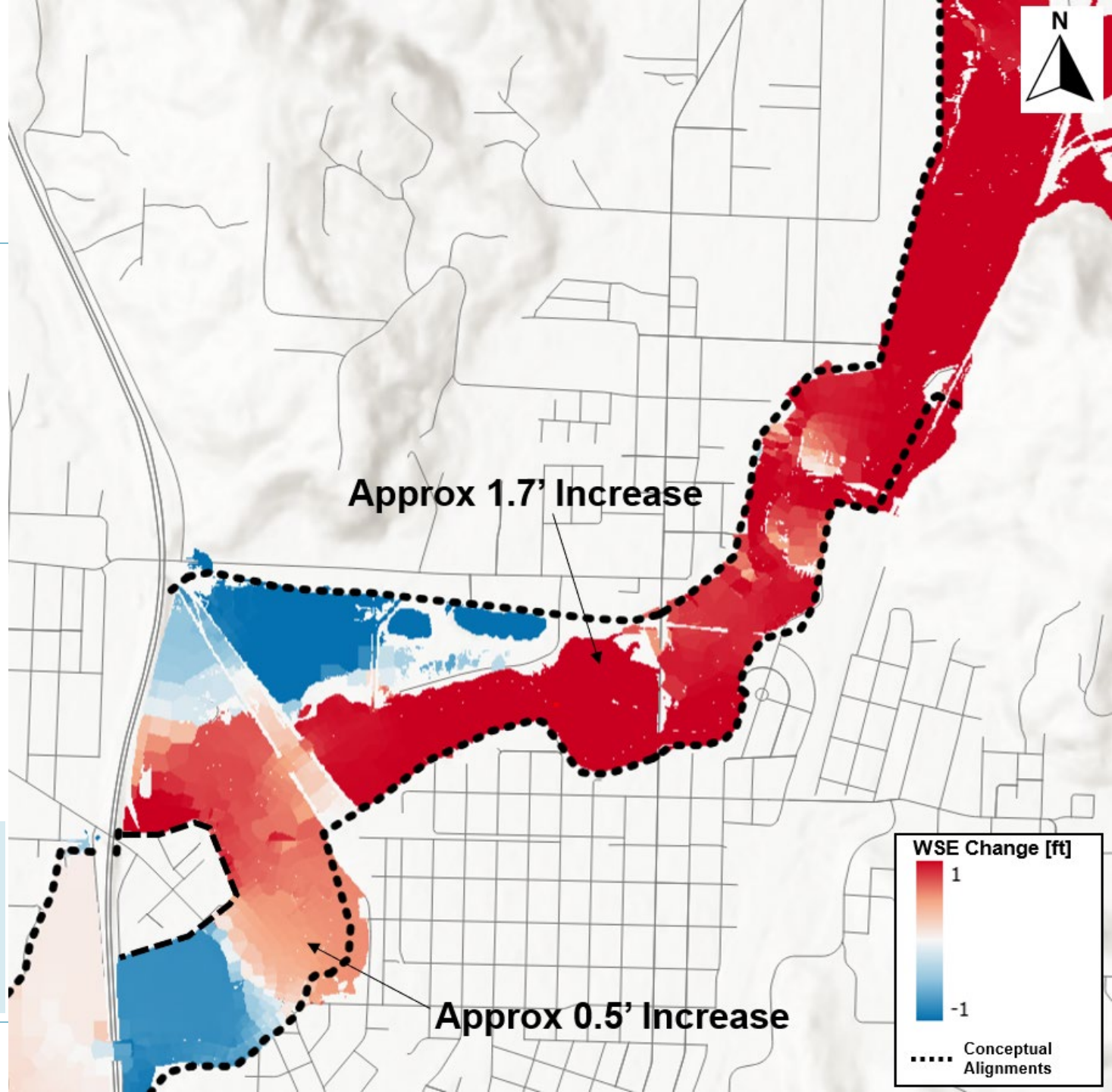


Run 19 – All Levees, Large Conveyance, 16-foot I-5 Culverts

- **Water Level Difference Plot:**
  - Shows change in water level for Run 3 (Diversion plus Levees) from No-Action
  - 100-year-plus-26-percent Flow Conditions

- **General Water Level Changes:**
  - See callouts to right
- **Takeaway:** Minimal change when compared to no Culvert increase (Run 5).

Note:
-Areas outside of Skookumchuck area are very similar, zoomed view shown to focus on different areas.

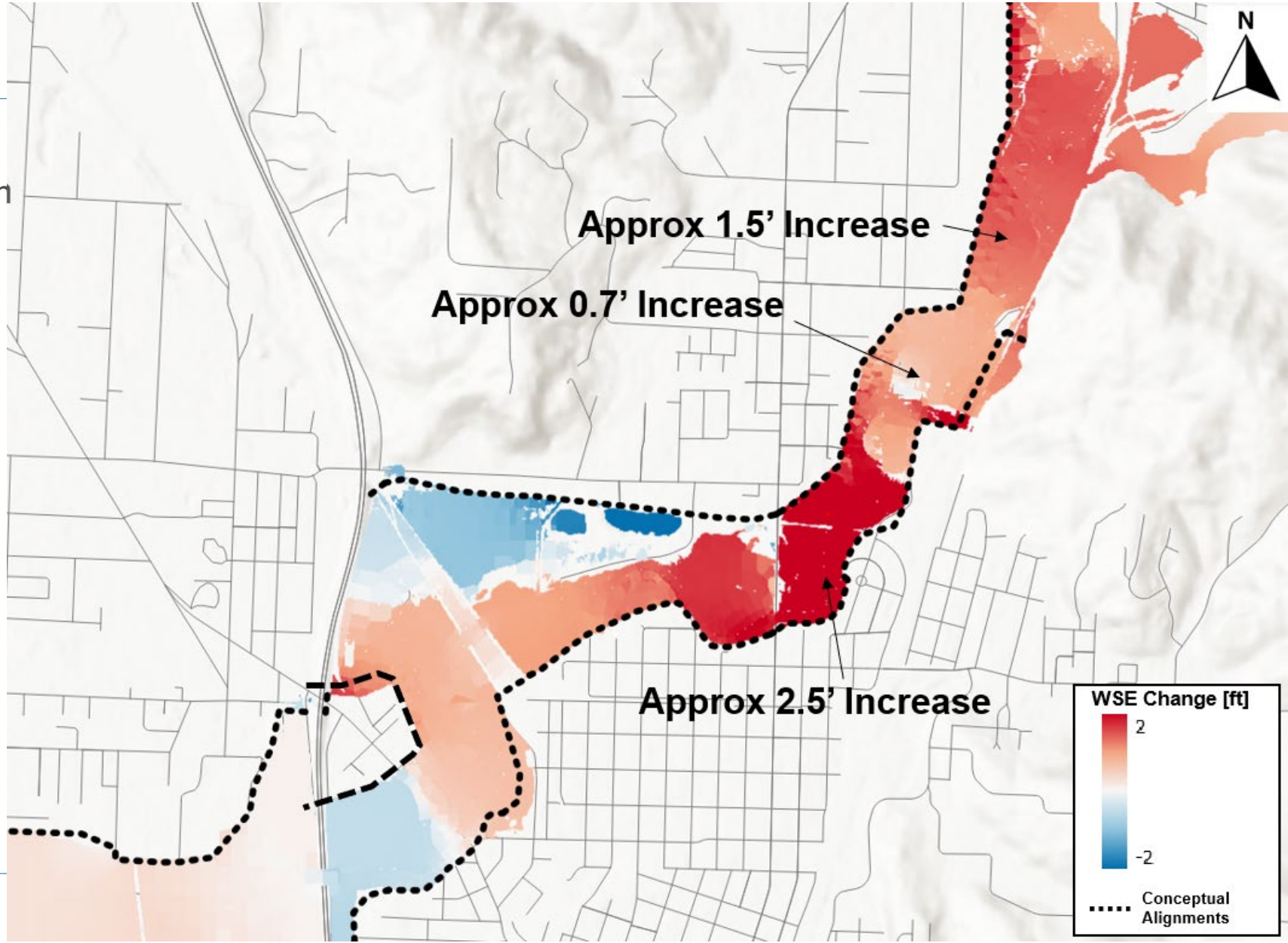


Run 20 – All Levees, Large Conveyance, Skookumchuck Road Raise and Culverts

- **Water Level Difference Plot:**
  - Shows change in water level from No-Action
  - 100-year-plus-26-percent Flow Conditions

- **General Water Level Changes:**
  - See callouts to right

Note:
-Areas outside window are very similar. More analysis needed, but shows potentially feasible change to raise Pearl Street with Culverts.



Thank you