MEMORANDUM

Date: November 9, 2020
To: Andrea McNamara-Doyle, Office of the Chehalis Basin
From: Merri Martz, Mike Gieschen, and Erik Pipkin, Anchor QEA, LLC; Larry Karpack, Watershed Science and Engineering
Cc: Chrissy Bailey, Office of Chehalis Basin; Jim Kramer and Ken Ghalambor, Office of Chehalis Basin consultant staff; Bob Montgomery and Heather Page, Anchor QEA, LLC
Re: Local Actions Program Near-term Technical Analyses for Office of Chehalis Basin: Local Flood Protection Action Options

Overview

This memorandum is intended to provide options for structural local flood protection actions in the Chehalis Basin for potential inclusion in a Local Actions Program. These options may be modified based on input from the Technical Advisory Group at the direction of the Office of Chehalis Basin (OCB) prior to consideration by the Chehalis Basin Board.

The Chehalis Basin Board has agreed upon several outcome measures for a Local Actions Program, with the following being the most directly relevant to local flood protection actions (the Chehalis Basin Board will define the percentages below when they have more information, including input from the Technical and Implementation Advisory Groups):

- X percent of all structures in each county that could be flooded by the 2080 predicted 100-year flood levels in the basin would no longer be vulnerable to flood damage, because they are protected by localized infrastructure, floodproofed/elevated, or the structure has been removed (Outcome 1: Valuable structures protected from mainstem, catastrophic flooding).
- X percent of all critical facilities that could be flooded by 2080 predicted 100-year flood levels would no longer be vulnerable to flood damage, because they are protected by localized infrastructure, elevated/floodproofed, or relocated (Outcome 5: Critical Facilities Protected).
- A substantial reduction in the overtopping and closure of Interstate 5 (I-5) and the BNSF rail mainline would be achieved for 2080 predicted 100-year flood levels, and alternative routes would be available to minimize negative effects of closures on freight mobility and commerce (Outcome 6A: Transportation Routes Protected).
- Key county and city intersections and interchanges would not be closed due to flooding, and for flood events that result in short-term closures, alternative routes would be available to ensure emergency services are not interrupted (Outcome 6B: Transportation Routes Protected).
- A substantial reduction in the closures of State Highways 6 and 12 due to flooding would be achieved, and alternative routes would be available to ensure emergency services are not

interrupted and to minimize negative effects of closures on freight mobility and commerce (Outcome 6C: Transportation Routes Protected).

The purpose of this memorandum is to summarize existing flood protection facilities in the Chehalis Basin, review and summarize previous studies related to proposed flood protection facilities, and identify example priority areas (to be supplemented by Board input) where improved or new local flood protection facilities could be considered. Preliminary screening of options from previous studies was based on an updated evaluation of predicted late-century (2080) catastrophic flood conditions and recently developed economic damage maps (GDS Associates 2020) for the modeled mainstem Chehalis floodplain. Some actions, such as floodproofing or relocation of structures from the floodplain, have been identified as strategies within the Community Flood Assistance and Resilience (CFAR) program that could be implemented as part of a Local Actions Program or with the proposed flood retention facility.

Summary of Options

This memorandum identifies options for structural local flood protection facilities or other actions in locations with relatively high potential flood damages and relatively dense development that could support local governments and tribes in the Chehalis Basin in reducing long-term risks and damages from catastrophic flooding. As described in this memorandum, the following example priority areas could be considered for local flood protection facilities or other actions:

1. Adna
2. Lower Newaukum
3. Airport Levee/Chehalis
4. Centralia
5. West Centralia
6. Military Road
7. Galvin
8. Independence Road and north floodplain
9. Oakville
10. Elma
11. South Aberdeen Levee Area
12. East Aberdeen

These example priority areas highlight a range of types and intensities of development to demonstrate the differing types of structural local flood protection facilities or other actions that could be considered in combination with structural facilities. Facilities or actions that could be considered in these example priority areas or in the basin more widely include relocating or floodproofing at-risk structures or infrastructure, localized levees or floodwalls, raising road segments, bridge lengthening, combined flood reduction or storage and habitat restoration measures, pump stations, tide gates, or restrictions on construction of new facilities or structures in floodplain areas.

In most situations, installing or raising a levee could increase flood elevations in upstream or downstream areas. This indicates that a combination of a facility with other actions is likely required at any given priority area to achieve flood damage reduction while mitigating for flooding impacts to upstream or downstream areas. Unlike many other basins in Washington, there are very limited opportunities for setting back existing levees as a flood damage reduction measure in the Chehalis Basin. The few levees that are present in the basin only protect relatively small areas of intensive development. Therefore, there may not be an increase in flood capacity with levee setbacks. In most of the example priority areas described in this memorandum, flood facilities should be considered in combination with the potential need to floodproof, remove, or relocate structures that either would not be protected or could experience increased flooding.

Questions for the Technical Advisory Group

Specific questions for the Technical Advisory Group to consider while reviewing this memorandum:

1. Are you aware of other areas, besides the example priority areas listed in Table 1, that have relatively high potential for flood damages and relatively dense development that should be added to the list for near-term consideration?
2. Are there other possible structural or non-structural solutions and technical considerations for the options in Table 1 that should be considered?
3. From a technical perspective (e.g., design, engineering, hydrology and hydraulics), how would you categorize the options in terms of the extent of damage/risk reduction potential relative to the degree of project complexity/cost (e.g., HIGH, MEDIUM, LOW potential for damage/risk reduction relative to LOW, MEDIUM, HIGH degree of project complexity/cost)?
4. Which options have the greatest potential overlap with the Aquatic Species Restoration Plan (ASRP) habitat protection/restoration priorities (either positive synergies or potential negative impacts)?
5. What are the pros and cons of each option described in this memorandum?

Previous Studies

Previous studies related to flood protection are summarized in this section, as well as in Appendix A and the technical memorandum titled *Summary and Evaluation of Options for Increasing Floodplain Storage* (WSE and Anchor QEA 2020).

Centralia Flood Damage Reduction Project

The *Centralia Flood Damage Reduction Project* (Corps 2003) was a feasibility study of a combination of levees along the Chehalis and Lower Skookumchuck rivers, modifications to Skookumchuck Dam, non-structural measures, and mitigation measures to protect Centralia, Chehalis, and I-5 from 100-year flooding (as modeled in the early 2000s). The study was completed and approved in 2007 with a recommended plan that would provide protection at the 100-year flood and had a positive benefit-to-cost ratio.

Centralia Flood Risk Management Project

The *Centralia Flood Risk Management Project Close-out Report* (Corps 2012) was the initial follow-on design phase of the *Centralia Flood Damage Reduction Project* (Corps 2003) study. The U.S. Army Corps of Engineers (Corps) 2003 study identified levee, dam modification, non-structural, and mitigation measures to protect Centralia, Chehalis, and I-5 from 100-year flooding. Following the 2007 and 2009 flood events in the basin, the hydrology, hydraulics, economic, environmental, and cost analyses required updating. The analysis conducted in this phase indicated that the project would no longer have a positive benefit-to-cost ratio and also would have a localized rise in flood elevations in areas not protected by levees, ranging from 0.2 to 1 foot in the Chehalis to Centralia reach.

Chehalis River Basin I-5 Flood Protection near Centralia and Chehalis

The *Chehalis River Basin I-5 Flood Protection near Centralia and Chehalis* (WSDOT 2014) study evaluated six alternatives to protect I-5 from flooding near Centralia and Chehalis. The alternatives evaluated included levees and floodwalls, raising and widening I-5, creation of express lanes, temporary bypass lanes, placing I-5 on a viaduct, or relocation of I-5 away from the river. The levee and floodwall alternative was the less expensive alternative, with a cost estimated at $90 million to $110 million, and this alternative could raise floodwater elevations to the west of the highway by up to 0.9 foot. The other alternatives evaluated had much higher costs (from $450 million to $2 billion) or would likely have significant adverse impacts to residential and commercial areas in Centralia and Chehalis. Some very preliminary consideration was also given to raising State Highways 6 and 12 to reduce flooding of those highways. An initial cost estimate was $30 million to $40 million, which did not include potential mitigation needs or flood impacts. Following this report, some additional consideration was given by WSDOT regarding whether additional levees and floodwalls were needed in combination with a flood retention facility in order to provide more protection to I-5. These options were put on hold pending the outcomes of the National Environmental Policy Act (NEPA) and State Environmental Policy Act (SEPA) Draft Environmental Impact Statement (EIS) environmental reviews being conducted for the Chehalis River Basin Flood Control Zone District's flood retention dam and airport levee improvements.

Chehalis Basin Flood Hazard Mitigation Alternatives Report

The *Chehalis Basin Flood Hazard Mitigation Alternatives Report* (Ruckelshaus 2012) was prepared to consider a wide range of previously considered flood protection alternatives and new alternatives as an initial study for the Chehalis Basin Strategy. Alternatives evaluated that were intended to benefit many areas of the basin included a flood retention structure, improvements to the Chehalis Airport levee, levees and floodwalls to protect I-5 (from WSDOT study), levees and floodwalls to protect Centralia and Chehalis (from Corps study), and a variety of other small projects such as land use management, floodproofing, home elevations and buyouts, livestock evacuation and sanctuary areas, flood bypasses, widening of bridges, localized floodwalls and levees, and dredging.

The recommended actions to analyze further were as follows:

1. Finish the analysis of large-scale capital projects such as a flood retention structure and Airport Levee improvements.
2. Design and construct localized projects that will provide immediate flood damage reduction and develop a long-term strategy for local projects.
3. Implement projects that improve fish habitat and floodplain functions and develop a long-term strategy for habitat projects.
4. Reduce repetitive damages through a program of buyouts and floodproofing and encourage a comprehensive effort to reduce new development from increasing flood damages.
5. Ensure that flood warning and flood preparedness systems remain ready and effective.

The levees and floodwalls alternatives to protect I-5 or Centralia and Chehalis were not recommended to be carried forward at this time because these projects are not supported by basin communities and do not address flood concerns throughout the basin. These recommended actions were further evaluated in the Chehalis Basin Strategy Programmatic SEPA EIS (Ecology 2017), which evaluated actions and combined alternatives for reducing flood damage and restoring aquatic species habitat in the Chehalis Basin.

Scenario of Small Flood Damage Reduction Projects

The *Scenario of Small Flood Damage Reduction Projects* (HDR and WSE 2014) was prepared as part of the Chehalis Basin Strategy to evaluate potential combinations of several small projects to protect key infrastructure, reduce shoreline erosion, and improve flow conveyance and drainage at several locations throughout the basin. Some of these projects have moved forward into design or construction, including the following:

- Fry Creek pump station and tide gate (Aberdeen)
- Roundtree Creek realignment (Oakville/Chehalis Tribe)
- Mill Creek dam replacement, tide gate, and pump station (Cosmopolis)
- City of Elma wastewater treatment plant outfall erosion protection
- Wishkah Road sheet pile wall
- City of Montesano wastewater treatment plant outfall erosion protection
- City of Napavine culvert replacements
- Salzer Creek realignment at Centralia Alpha Road

Some additional projects were evaluated for feasibility but have not moved forward, to date, including the following:

- SR-6 flow bypass and road raise
- Dillenbaugh Creek realignment
- City of Chehalis Main Street stoplogs
- Highway 12 Black River Bridge widening

- Salzer Creek backwater protection
- Town of Bucoda Main Street reconstruction
- Moon Road raise (Chehalis Tribe)
- Wynoochee Valley road raise

Restorative Flood Protection Alternative for Upper Chehalis Basin and Newaukum River

The Restorative Flood Protection Alternative (RFPA) reports for the Upper Chehalis Basin and North and South Forks of the Newaukum River (Abbe et al. 2016, 2020) screened multiple locations in the Upper Chehalis Basin for the potential to increase flood storage throughout the basin, as well as provide multi-ecosystem and geomorphic process benefits to the fluvial system. A more detailed analysis in the Newaukum River subbasin was undertaken to understand the potential effectiveness of flood storage at reducing flood damages. Both reports note that areas in the basin where channel slopes are less than 0.003 foot per foot (ft/ft) are the most viable for increasing flood storage through floodplain restoration. While these studies were not structural alternatives, areas identified with the potential for flood storage could be considered in combination with structural actions to reduce flood damages in localized areas. This is also described in the technical memorandum titled *Summary and Evaluation of Options for Increasing Floodplain Storage* (WSE and Anchor QEA 2020).

Existing Structural Flood Protection Facilities

The Chehalis Basin has relatively few existing flood protection facilities, with levees protecting only a few areas of commercial and residential development, and pump stations providing improved localized flood reduction. Unlike many other rivers in the Pacific Northwest, there is little opportunity in the Chehalis Basin to set back levees because there are few, if any, significant levees with the exception of the Chehalis airport and perhaps a few levees on the Lower Skookumchuck River. The existing primary flood protection facilities in the Chehalis Basin are shown in Appendix A, Table A-1 and Figure A-1. In addition to flood protection facilities, there are also mapped areas of rock revetment that provide erosion protection to some landowners. The mapping of revetments is not comprehensive throughout the basin and is only shown for Lewis County (Lewis County 2016).

The Wynoochee Dam was designed and constructed, in part, to provide flood reduction (primarily for downstream reaches of the Wynoochee Valley), while also providing water supply, hydropower, and recreation. The Skookumchuck Dam was not designed or constructed to provide flood reduction and is operated to provide water supply to the Centralia Steam Generating Plant.

None of the existing flood protection facilities along the Chehalis River were designed to provide protection for the modeled 2080 catastrophic flooding or from 2080 sea level rise. These facilities could be raised or otherwise improved to provide protection at the modeled 2080 catastrophic flood event or for 2080 sea level rise.

Previously Identified Structural Local Flood Protection Facilities

A number of localized flood protection facilities and pump stations are described in the studies previously mentioned. Some previously implemented smaller projects to improve drainage or provide localized flood protection are provided in Appendix A, Table A-2 and Figure A-2.

The primary reason that previously proposed levee or flow/floodplain bypass projects were not advanced or implemented was high cost and adverse flood impacts on other properties that are outside of protected areas. Most levees—individually or in aggregate—are likely to have effects upstream or downstream because a levee would reduce flooding in the protected area while increasing flooding outside of the protected area.

Example Areas to Consider Structural Local Flood Protection Facilities

To identify high-priority flood protection areas, the modeled 2080 catastrophic floodplain was overlain on recent economic damage mapping (GDS Associates 2020; attached as Appendix B) and recent aerial photographs. Using this method, 12 example areas were selected due to both their relatively high potential for flood damages and the dense concentration of development in the area. Note that these example areas are not intended to be exhaustive of every location where local flood protection facilities or other actions could be considered. These areas were also identified using the existing mainstem Chehalis River floodplain and do not include areas along tributaries that have not been modeled for the 2080 catastrophic flood event. Tributaries with a high risk of flooding include the Skookumchuck, Satsop, Humptulips, Wynoochee, Black, and Newaukum rivers, as recommended for additional modeling in the *Additional Near-term and Long-term Hydrologic and Hydraulic Modeling Options Memorandum* (WSE 2020).

Other areas within the mainstem Chehalis River 2080 floodplain were not included for consideration, even though they may have predicted relatively high economic damages (GDS Associates 2020), because the density of development is limited—there were only sparse valuable structures[1] or infrastructure (generally agricultural areas with sparsely spaced individual structures). In many parts of the Chehalis Basin's floodplain, development is sparse and dominated by agricultural land uses and rural residences. These areas are not generally economically feasible to protect with levees or pump stations due to their dispersed nature. However, these areas could be protected through other measures such as raising individual structures above flood elevations (floodproofing) or relocating individual structures out of the floodplain, bank protection that is compatible with other Chehalis Basin Strategy programs, localized drainage improvements, or potentially combined localized flood reduction and restoration projects associated with the ASRP.

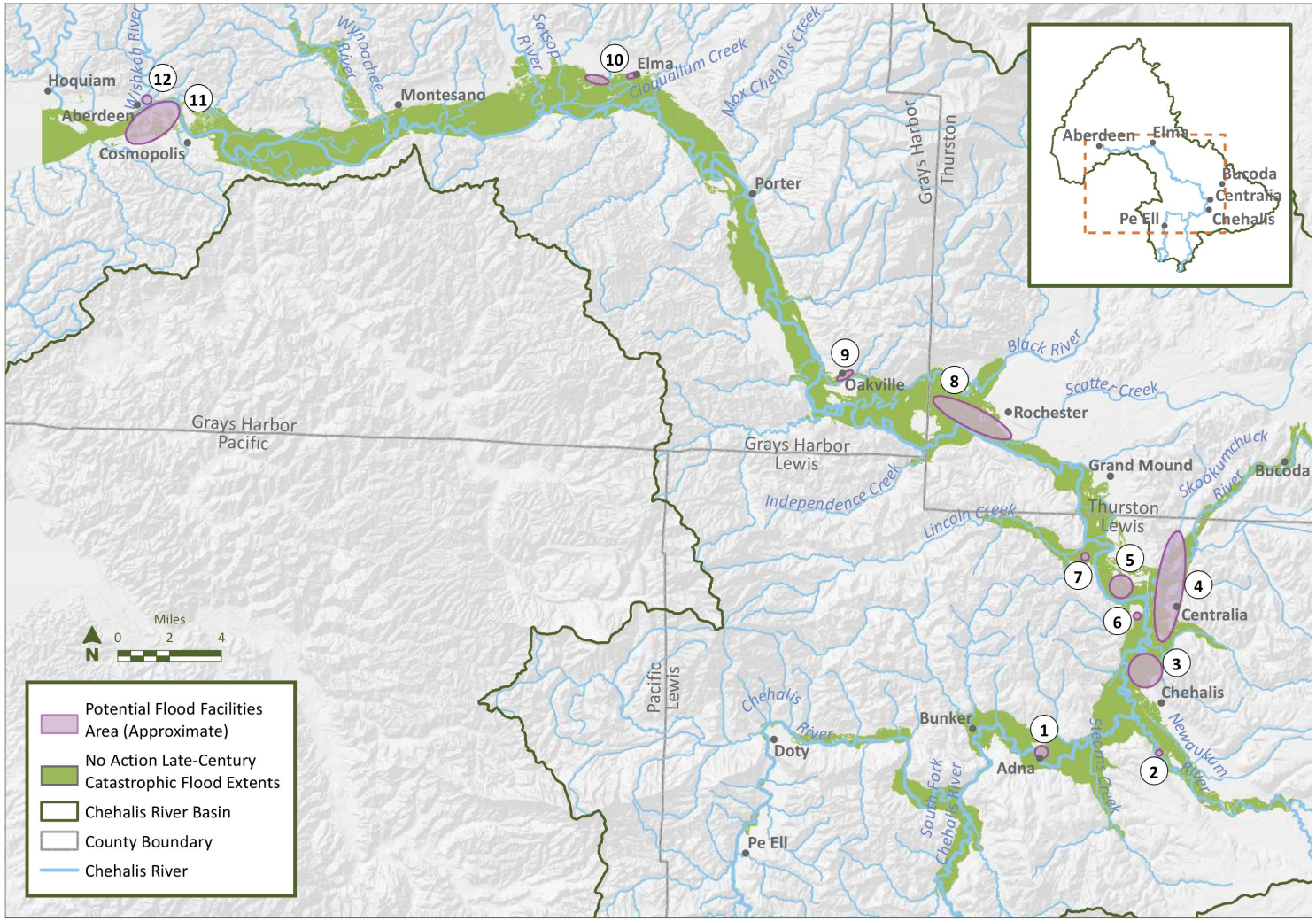
[1] "Valuable" structures include schools, residences, and businesses. Structures that are considered "not valuable" include garages, sheds, park shelters, carports, and other similar structures.

Table 1 and Figure 1 identify the 12 example areas selected for consideration, organized from upstream to downstream. The narrative that follows describes the issues that need to be addressed to reduce flood damages for each area. All the potential options in Table 1 could be combined with relocating or floodproofing existing structures. Population growth in the modeled 100-year floodplain could accommodate between 407 and 914 new residential and commercial/industrial structures in this area. These structures would be distributed throughout all three counties in the modeled 100-year floodplain, with the highest portion of this development expected in Lewis County. This is expected to be enough for current and projected population growth (Anchor QEA 2016).

Table 1
Example Areas to Consider for Local Flood Protection Facilities

LOCATION	DESCRIPTION AND NUMBER OF STRUCTURES IN MODELED 2080 FLOODPLAIN	POSSIBLE SOLUTIONS AND TECHNICAL CONSIDERATIONS
1. Adna	Concentration of residences and high school **Structures = 83**	Drainage solution implemented in 2013; potential levee or road raise to further protect Adna
2. Lower Newaukum	Moderate number of residences near Stan Hedwall Park **Structures = 20**	May be too few structures for levee
3. Airport Levee and Chehalis	Airport levee and I-5, commercial district of Chehalis. **Structures = 215**	Possible raise of levee, I-5, or floodwalls; combine with other actions such as raising local roads
4. Centralia	Majority of Centralia east of I-5, flooding from Skookumchuck in north half; from Salzer/Chehalis in south half **Structures = 3,484**	Possible new, raised, or setback Skookumchuck levees; possible extension of Long Road levee to protect South Centralia; possible road raises to protect downtown
5. West Centralia	Centralia west of I-5 **Structures = 508**	Potential new levee similar to segment proposed by Corps studies; combine with other actions such as removing fill, raising roads, or widening bridges
6. Military Road	Residential **Structures = 34**	Potential road raise
7. Galvin	Concentration of residences **Structures = 87**	Possible road raise; could also consider flood storage
8. Independence Road and north floodplain	Right bank floodplain of Chehalis River, nearly 40% of river flow goes north towards Black River; numerous residences, Chehalis Reservation **Structures = 306**	Possible causeway or road raises
9. Oakville	South part of town **Structures = 172**	Possible levee and pump station
10. Elma	South Elma along north side of Highway 12; water flows over Highway 12 to low spot **Structures = 148 structures**	Possible raise of Highway 12, levee and pump station
11. South Aberdeen Levee Area	Area protected by levee still experiences tidal, local, and tributary flooding **Structures = 1,203**	Possible pump station and raise of levee; removal of fill on riverward side of levee for flood storage
12. East Aberdeen	Tidal flooding near Wishkah River in commercial area; not protected by North Shore Levee **Structures = 4**	Possible pump station and fill removal to increase flood storage; floodproofing

Figure 1
Potential Flood Facilities Areas



1. Adna

A levee improvement and drainage project was implemented in Adna in 2013 to reduce road inundation and improve drainage. This area is within the modeled 2080 catastrophic floodplain and is predicted to have between 1 and 6 feet of flooding in the modeled late-century catastrophic flood. Additional facilities could be considered, such as a larger flood protection levee or road raise to serve as a levee (possibly combined with a pump station), to protect the high school and 80 or more other structures. However, it is likely that a levee would cause increased flooding to individual structures upstream or downstream, so mitigating measures such as floodproofing or relocating structures would need to occur. If a levee was not desired, then consideration of structure relocation or floodproofing would apply to 80 or more structures including the high school in Adna. It is possible that potential nearby flood storage areas could be considered in combination with a levee improvement. For example, areas behind the existing railroad grades could be reconnected, but these would not provide sufficient storage to reduce flooding in Adna (WSE and Anchor QEA 2020). Reconnecting adjacent upstream wetland areas may not provide additional flood storage because estimated flood depths from the 2080 catastrophic flood modeling are already 20 feet or more in those wetland areas. A levee or road raise combined with structure floodproofing or relocations in areas not protected could be the most promising option.

2. Lower Newaukum

This area south of Stan Hedwall Park has a moderate number of residences in the floodplain (approximately 20 structures). The Lower Newaukum is within the 2080 catastrophic floodplain (exacerbated by the Chehalis River backwatering up the Newaukum River). The density and number of structures may be too limited to consider a levee. The modeled depths of flooding for the 2080 catastrophic flood in this area are generally about 1 foot, so floodproofing could be the primary measure employed here. Most of this portion of the Lower Newaukum is not in the current FEMA 100-year floodplain. Floodproofing combined with an ASRP restoration project could also be the most promising option.

3. Airport Levee and City of Chehalis

The airport levee, I-5, and portions of the city of Chehalis directly east of I-5 are currently within the FEMA 100-year floodplain and are also modeled to be within the 2080 catastrophic floodplain. There are more than 200 structures in the immediate area and critical infrastructure that would be flooded in the modeled 2080 catastrophic flood event, although most of these structures currently are within the FEMA floodplain. Modeled flooding depths range from 6 to more than 10 feet in the modeled 2080 catastrophic flood event. Raising the airport levee has been previously evaluated in combination with levees and floodwalls along I-5. Levees of this scale would cause both upstream and downstream effects on flood elevations (up to 2 feet), so additional measures would need to be considered, such as relocating or floodproofing of structures that would experience increased flooding. Other measures such as raising roads within the city of Chehalis would also need to be considered, which could also have effects on flood elevations.

4. Centralia

A significant portion of Centralia east of I-5 that is not within the current FEMA 100-year floodplain is modeled to be within the 2080 catastrophic floodplain, with depths ranging from 1 to 5 feet. There are nearly 3,500 structures within the example area identified in Figure 1. Providing levees or floodwalls were considered previously in combination with raising or adding levees along the Skookumchuck River and Salzer Creek to protect Centralia. These previously considered measures would have upstream and downstream impacts on flood elevations, so additional measures would also need to be considered, such as relocating or floodproofing structures that could experience increased flooding. Other measures such as raising roads within Centralia would also need to be considered. Some additional flood storage could also be achieved if the existing levees along the Skookumchuck River could be set back to increase capacity along the Lower Skookumchuck River, or some flood storage could be achieved farther upstream on Salzer Creek, but this would not significantly reduce flood flows or water levels (WSE and Anchor QEA 2020).

The Corps (2003, 2012) studies also included consideration of additional flood storage in Skookumchuck Dam through raising the dam. Without raising the dam height, operating the dam to provide flood storage would reduce flow augmentation during summer months, but trading water supply storage for flood storage could be considered because the dam owner's water supply needs are reduced with the phased closure of the Centralia Steam Generating Plant. A combination of new levee segments, flood storage within the existing Skookumchuck Dam, setback and raising of the Skookumchuck levees, and relocation or floodproofing of structures could be a promising option.

5. West Centralia

Parts of Centralia west of I-5 west of Fort Borst Park are modeled to be within the 2080 catastrophic floodplain with depths ranging from 1 to 3 feet, whereas only part of this area is within the current FEMA 100-year floodplain. There are approximately 500 structures within the example area identified in Figure 1. In addition, there are several areas that are currently undeveloped but are within the city limits or Urban Growth Area of the City of Centralia and could be subject to future development. A levee was proposed for this area as part of the Corps studies (2003, 2012) but was not analyzed by itself for benefits and impacts. The previously considered combined levee and floodwall project could have upstream and downstream impacts on flood elevations. It is likely that additional measures would also need to be considered, such as relocating or floodproofing structures that could experience increased flooding. Other measures could also be considered, such as removing fill, raising roads, or widening bridges.

6. Military Road

Parts of Centralia west of I-5 and south of Mellen Street are modeled to be within the 2080 catastrophic floodplain with depths ranging from 1 to 10 feet, and are also within the current FEMA 100-year floodplain. There are approximately 30 structures within the example area identified in Figure 1. Options

that could be considered include raising the road, floodproofing, or relocating structures out of the floodplain. The hospitals to the north are not modeled to be within the 2080 catastrophic floodplain.

7. Galvin

The Galvin area west of the Chehalis River has a moderate number of residences (approximately 80 structures) and is within the current FEMA 100-year floodplain. It is predicted to be within the 2080 catastrophic floodplain with modeled depths of flooding from 1 to 6 feet. Options that could be considered include raising the road, floodproofing, or relocating structures out of the floodplain. Existing oxbows and wetland areas adjacent to Galvin are modeled to have substantial depths of flooding during the 2080 catastrophic flooding, so reconnections may not provide additional flood storage. However, there may be opportunities for some flood storage in the Lincoln Creek valley. Oxbows and wetlands in the mainstem floodplain could be an opportunity for restoration associated with the ASRP; similarly, opportunities for restoration or flood storage in the Lincoln Creek valley could be associated with the ASRP.

8. Independence Road and North Floodplain Area

The floodplain north of the Chehalis River, in the unincorporated Grays Harbor County area north of Independence Road area and a large portion of the Confederated Tribes of the Chehalis Reservation, has multiple areas that are both within the current FEMA 100-year floodplain and are modeled to be within the 2080 catastrophic floodplain. Modeled future, late-century depths range from 1 to 6 feet. Some localized actions such as raising Anderson Road have already been taken to ensure access to the Chehalis Tribal government buildings (which are mostly out of the floodplain). Development is relatively sparse but the area is large, so there are more than 300 structures as well as infrastructure within the example area identified in Figure 1. Options that could be considered include raising other roads (causeway or other type of raise), floodproofing, or relocating structures. This floodplain area also provides multiple opportunities for restoration associated with the ASRP.

9. Oakville

The south part of Oakville has a moderate number of structures (more than 170 structures). Portions of this area are within the current FEMA 100-year floodplain, but additional areas are predicted to be within the 2080 catastrophic floodplain with modeled depths of future flooding from 1 to 3 feet in the late-century 100-year event. A project was completed to address flooding from Roundtree Creek, but this does not address flooding from the Chehalis River. Options that could be considered include a localized levee (potentially with a pump station), floodproofing, and relocating structures out of the floodplain.

10. Elma

Portions of south and west Elma (approximately 150 structures) receive flooding from overtopping of Highway 12. Portions of this area are within the current FEMA 100-year floodplain, but additional areas currently in the 500-year floodplain are predicted to be within the 2080 catastrophic floodplain with

modeled depths from 1 to 4 feet. Options that could be considered include raising Highway 12, or a localized levee (potentially within a pump station), floodproofing, or relocating structures out of the floodplain. This area could also be an opportunity for restoration associated with the ASRP.

11. South Aberdeen Levee Area

The South Aberdeen Levee currently protects approximately 1,200 structures from primarily tidal flooding. This area is currently within the FEMA 100-year floodplain. There are localized internal drainage issues in this area from precipitation and stormwater runoff, and with potential 2080 sea level rise these problems are likely to worsen. This levee is currently being evaluated for recertification and some improvements are likely to be required. Other options that could be considered include pump stations, removal of fill outside of the levee (and potentially some areas within the levee, which could be an opportunity for restoration associated with the ASRP) to increase capacity of the river, floodproofing, or relocating structures out of the floodplain.

12. East Aberdeen

A commercial area (approximately four structures) that would not be protected by the proposed North Shore Levee and its Western Extension could be provided protection from potential 2080 sea level rise. Options that could be considered include pump stations, floodproofing, or relocating structures, and fill removal. This area could also be an opportunity for potential shoreline restoration associated with the ASRP.

Considerations

These example areas to be considered for local flood protection facilities highlight that there are a wide range of intensities of development throughout the basin, where differing types of local flood protection facilities could be considered. In most situations, installing or raising a levee could cause increased flood elevations to upstream or downstream areas. This indicates that a combination of actions is likely required at any given priority area. In addition, there are very limited opportunities for setting back existing levees because most levees currently only protect relatively small areas of intensive development. In most of these example areas, the scale of flood facilities should be considered in combination with the potential need to floodproof, remove, or relocate structures that either would not be protected or could have increased flooding.

References

Abbe, T., B. Anderson, C. Carlstad, D.L. Devier, K. Fetherston, S. Dickerson-Lange, L. Embertson, S. Higgins, S. Katz, L. Lestelle, K.K. Machata, M. Nelson, J. O'Neal, K. Patrick, M. Reinhart, C. Riordan, M. Stepp, P. Trotter, and R. Ventres-Pake, 2016. *Preliminary Scientific Assessment of a Restorative Flood Protection Approach for the Upper Chehalis River Watershed*. Prepared by Natural Systems Design. September 26, 2016 (Draft).

Abbe, T., C. Carlstad, D.L. Devier, S. Dickerson-Lange, J. Jay, M. Nelson, L. Embertson, S. Higgins, S. Katz, B. Keller, and K. Fetherston, 2020. *Chehalis Basin Strategy Restorative Flood Protection Advanced Feasibility Evaluation for the North and South Forks of the Newaukum River, Washington*. Prepared for Washington State Department of Ecology. Prepared by Natural Systems Design. January 2020.

Anchor QEA (Anchor QEA, LLC), 2016. Appendix L: Build Out Analysis. *Chehalis Basin Strategy Final Programmatic EIS*. Prepared for the Washington Department of Ecology. June 29, 2016.

Corps (U.S. Army Corps of Engineers), 2003. *Centralia Flood Damage Reduction Project, Chehalis River, Washington*. Seattle District.

Corps, 2012. *Centralia Flood Risk Management Project, Chehalis River, Washington*. Draft Close-out Report, January 2012. Seattle District.

Ecology (Washington State Department of Ecology), 2017. *Chehalis Basin Strategy Final Programmatic EIS*. June 2017. Accessed at: http://chehalisbasinstrategy.com/programmatic-eis/.

GDS Associates, Inc. 2020. *Economic Damage Mapping within the Late-Century Catastrophic Floodplain.* Prepared for the Chehalis Basin Strategy. August 2020.

HDR and WSE (HDR, Inc., and Watershed Science and Engineering, Inc.), 2014. *Scenario of Small Flood Damage Reduction Projects*. Prepared for the Chehalis Basin Workgroup.

Lewis County, 2016. GIS layer of revetments and dikes. Provided for the Chehalis Basin Strategy. November 2016.

Ruckelshaus (William D. Ruckelshaus Center), 2012. *Chehalis Basin Flood Hazard Mitigation Alternatives Report*. Prepared for the State of Washington.

WSDOT (Washington State Department of Transportation), 2014. *Chehalis River Basin I-5 Flood Protection near Centralia and Chehalis*. Final November 26, 2014.

WSE (Watershed Science and Engineering), 2020. Memorandum to: Andrea McNamara-Doyle, Office of Chehalis Basin. Regarding: Additional Near-term and Long-term Hydrologic and Hydraulic Modeling Options. November 2020, in progress.

WSE (Watershed Science and Engineering) and Anchor QEA, 2020. Memorandum to: Andrea McNamara-Doyle, Office of Chehalis Basin. Regarding: Local Actions Program Near-term Technical Analyses for Office of Chehalis Basin: Summary and Evaluation of Options for Increasing Floodplain Storage. October 2020, in progress.

APPENDIX A
EXISTING FLOOD PROTECTION FACILITIES AND PREVIOUSLY CONSIDERED FLOOD PROJECTS

Table A-1
Existing Flood Protection Facilities

FACILITY	TYPE	LOCATION	NOTES
Airport Levee	Levee	Airport Road	Protects the Chehalis Airport currently at less than 100-year protection (~465 acres protected)
Airport Pump Station	Pump station	Airport Road	Helps reduce internal drainage within airport levee system
Fairground Levee	Levee	Southwest Washington Fairgrounds	Protects the fairgrounds from Salzer Creek flooding (~90 acres protected)
Long Road Levee	Levee	Centralia	Protects a residential neighborhood in Centralia (~121 acres protected)
Skookumchuck Levees	Levee	Lower Skookumchuck River	Protects residential and commercial areas of Centralia (~220 acres protected)
Chehalis River Levee	Levee	Centralia west of I-5	Protects portions of Centralia directly west of I-5 (~26 acres protected)
Skookumchuck Dam	Dam	Skookumchuck River RM 22.2	Provides water supply; only incidental flood reduction benefits
Wynoochee Dam	Dam	Wynoochee River RM 50	Provides water supply, hydropower, and some flood reduction benefits
South Aberdeen Levee	Levee	South Aberdeen	Protects residential and commercial areas of Aberdeen from tidal flooding (~1,295 acres protected)
Pacific Ocean Levee	Levee	Hoquiam	Protects industrial areas of Hoquiam (~61 acres protected)
Pacific Ocean Levee 2	Levee	Hoquiam	Protects industrial areas of Hoquiam (~41 acres protected)
Pacific Ocean Levee 3	Levee	Hoquiam	Protects disposal site on Rennie Island (~76 acres protected)
Hoquiam River Levee	Levee	Hoquiam	Protects residential and commercial areas of Hoquiam (~520 acres protected)
Little Hoquiam River Levee	Levee	Hoquiam	Protects residential and commercial areas of Hoquiam (~118 acres protected)

FACILITY	TYPE	LOCATION	NOTES
Wishkah Floodwall	Floodwall	Wishkah Road	Protects residential areas of Aberdeen
North Shore Levee and West Extension	Levee	Aberdeen and Hoquiam	Designed and funding requested to protect residential, commercial, and industrial areas of Aberdeen and Hoquiam (~700 acres to be protected)
Pump Stations in Aberdeen	Pump station/ tide gate	Aberdeen	Helps reduce localized stormwater flooding during periods of high tides
Pump Stations in Hoquiam	Pump station/ tide gate	Hoquiam	Helps reduce localized stormwater flooding during periods of high tides

RM: river mile

Figure A-1
Existing Local Flood Protection Facilities

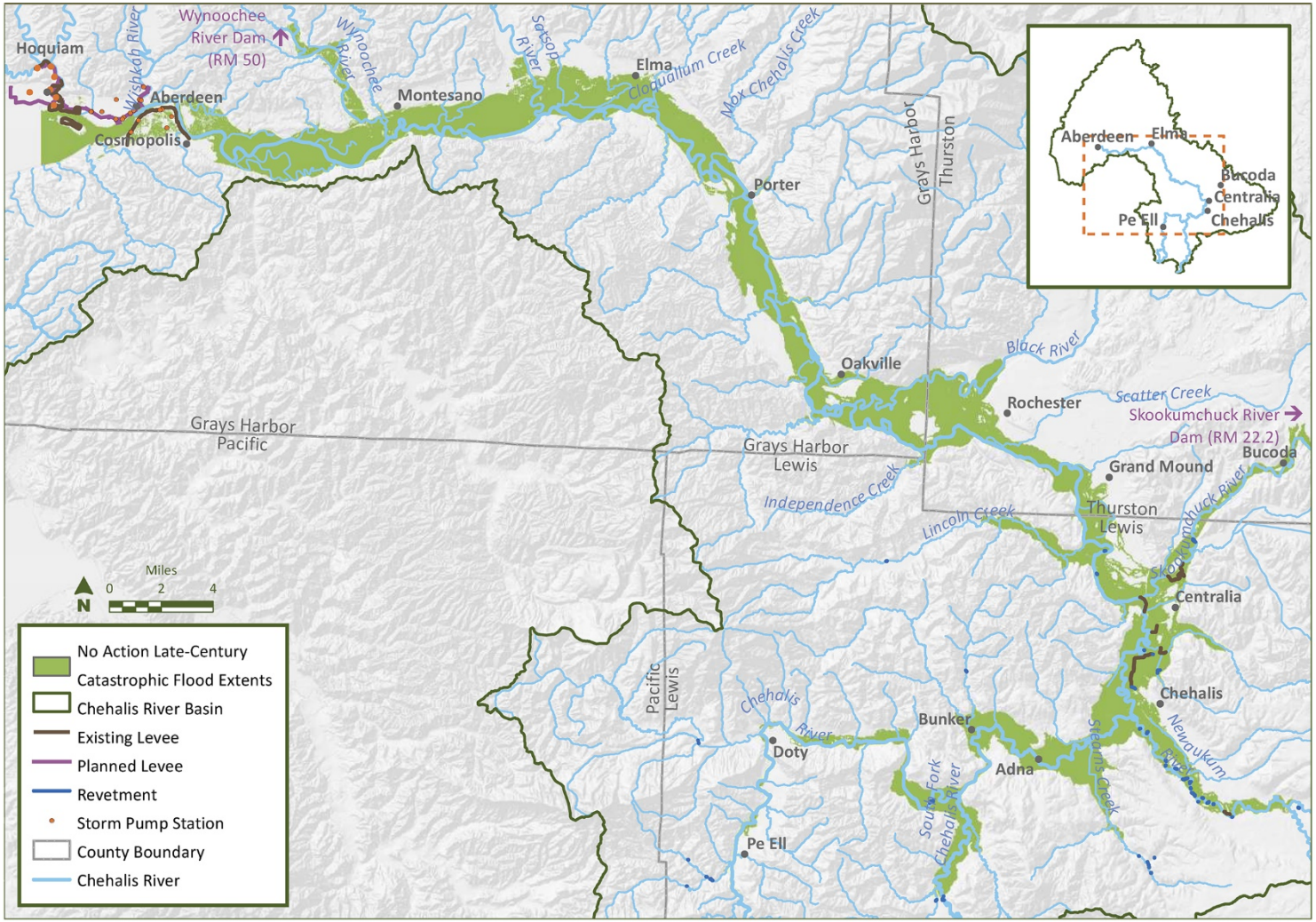


Table A-2
Previously Considered Flood Protection Facilities or Projects

ID	FACILITY TYPE	LOCATION	PROPOSED ACTION	FLOOD ISSUE ADDRESSED AND WHERE	WAS IT IMPLEMENTED?	NOTES
1	Study for solutions	Newaukum River at I-5	Study to look at causes and solutions	Backwater on Newaukum River due to I-5 and city bridge cause flooding	No	
2	Study for solutions	City of Napavine Kirkland Road and Rush Road	Study to look at causes and solutions	Flooding of Rush Road and Kirkland Road	No	Also another project to evaluate culvert replacements; current areas zoned with potential for future development within floodplain
3	Not identified	Port of Chehalis Port Offices	Identify flood protection measures	Protection of office buildings	Not known	
	Not identified	Port of Chehalis McBride Court	Identify flood protection measures	Protection of office buildings	Not known	
4	Floodplain storage	Stan Hedwall Park	Reconnect existing side channels and add restoration features more than 40 acres	Flood storage potential	No	
5	Realignment of Creek	Stan Hedwall park	Realign Dillenbaugh Creek through Stan Hedwall Park	Avoids I-5 and multiple other railroad/road crossings that cause backwater	No	A detailed feasibility evaluation was completed on this project
6	Raise I-5	13th Street to Mellen	Raise I-5 on fill	Protection of I-5 and properties to the east	No	Very high cost compared to benefits
	Raise I-5	13th Street to Mellen	Raise I-5 on viaduct	Protection of I-5 only	No	Very high cost compared to benefits; increased flooding in Chehalis
	Relocate I-5	13th Street to Mellen	Relocate I-5	Protection of I-5 only	No	Very high cost compared to benefits

ID	FACILITY TYPE	LOCATION	PROPOSED ACTION	FLOOD ISSUE ADDRESSED AND WHERE	WAS IT IMPLEMENTED?	NOTES
	Express lanes on I-5	13th Street to Mellen	Add express lanes for added capacity and emergency bypass of flooding	Protection of I-5 only	No	High cost compared to benefits; adverse impacts to residents and businesses
	Bypass lanes on I-5	13th Street to Mellen	Add bypass lanes for emergency bypass of flooding	Protection of I-5 only	No	High cost compared to benefits; adverse impacts to residents and businesses
	Levees, floodwalls	13th Street to Mellen	Levees and floodwalls to protect I-5	Protection of I-5 and portions of Chehalis	No	Raises flood elevations upstream and downstream west of I-5
7	Oxbow reconnection	RM 78 Chehalis River	Reconnect oxbow with mainstem	Flood storage potential	No	
8	Raise bridges	Mellen Street, SR 6, Galvin, Sickman-Ford	Raise bridges and reduce constrictions of floodway	No significant benefit (Ruckelshaus 2012)	No	May raise flood elevations downstream
9	Temporary road structure	Main Street Chehalis	Temporary flood protection structure along main street	Keeps access between I-5 and downtown open	No	A detailed feasibility evaluation was completed on this project
10	Floodplain capacity/ storage	Chehalis WWTP	Remove former WWTP and fill and restore floodplain and shoreline; partly trade-off for fill in other locations	Flood storage potential	In progress	Completing designs
11	Levee improvement	Chehalis Airport	Raise existing levee to 3 feet above 100-year	Protect airport and associated businesses	Part of SEPA Draft EIS	If implemented separately from FRE, additional features such as I-5 levees would be needed; raises flood elevations upstream and downstream of project
12	N/A	National Avenue at Coal Creek	Reduce localized flooding	National Avenue	Not known	
13	Pump station	Airport levee	Improve pump station	Reduce internal ponding	Not known	

ID	FACILITY TYPE	LOCATION	PROPOSED ACTION	FLOOD ISSUE ADDRESSED AND WHERE	WAS IT IMPLEMENTED?	NOTES
14	Streambank and floodplain restoration	Salzer Creek Lower Mile	Excavate wetland area, and regrade banks of Salzer Creek	Increase capacity	No	A detailed feasibility evaluation was completed for this project
15	Levee/dike improvements	Salzer Creek/ Fairgrounds area	Improve existing levee	Fairgrounds flooded and high flood elevations (+8 feet) maintained in fairgrounds	No	
16	Levees, floodwalls	Chehalis River, Dillenbaugh and Salzer creeks, Skookumchuck River	Levees and floodwalls to protect I-5, Centralia, Chehalis	Protection of I-5, downtown Chehalis, Centralia, NE Centralia	No	Significantly raises flood elevations upstream and downstream
17	Floodplain storage	Salzer Creek at Centralia Alpha Road	Realign stream and install large woody debris, excavate wetland and install riparian vegetation	Flood storage potential	Yes	
18	Floodplain storage	RM 68 Oxbow on Chehalis	Reconnect oxbow with mainstem Chehalis	Flood storage potential	No	
19	Critical infrastructure: Hospital	Hospital on Cooks Hill Road	None proposed	All access routes to hospital flooded	No	Flooding problem area for critical infrastructure
20	Riprap bank protection for exposed sewer line	840 feet upstream of Chehalis Skookumchuck River Confluence	Two alternatives: 1) additional riprap and bank protection for exposed lines; or 2) relocation of pipe	Sewer mains along the Chehalis River were exposed after the 2007 flood	Yes, initial was implemented ion May 2008.	After riprap placement in May 2008, erosion continues upstream and downstream of riprap
21	Dredging	Chehalis River between Mellen Street and Lincoln Creek		No significant benefit (Ruckelshaus 2012)	No	May raise flood elevations downstream, large impacts to river, may require frequent maintenance
22	Oxbow reconnection	WDFW pheasant farm	Excavate side channels and enhance wetlands	Flood storage potential	No	

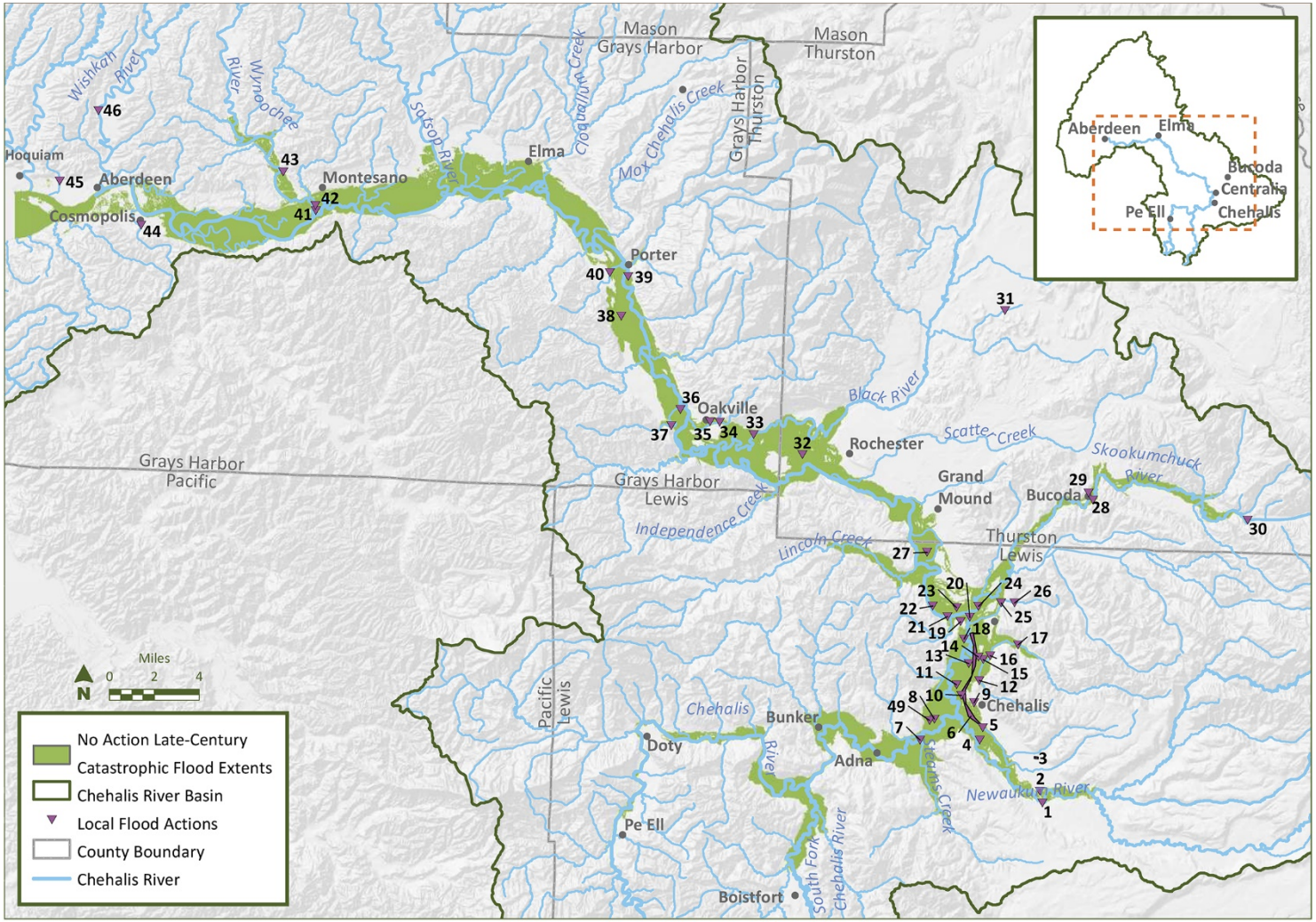
ID	FACILITY TYPE	LOCATION	PROPOSED ACTION	FLOOD ISSUE ADDRESSED AND WHERE	WAS IT IMPLEMENTED?	NOTES
23	Levee	West of I-5 in Centralia	Levee to protect portions of Centralia west of I-5	Protect residential and commercial areas of Centralia	No	
24	Reconfigure and improve Skookumchuck levees	Skookumchuck River, RM 0-4	Improve or relocate levees	Possible reduced flood elevations in Centralia	No	May raise flood elevations upstream and downstream
25, 26	Floodplain storage areas on China Creek	China Creek, between East 6th Street and N Gold Street	Berm and flood storage area	Flood storage at 2-year event in floodplain area. Additional storage planned for 25-year event. No benefit to Chehalis River flows or water levels.	In progress	
27	Relocation	WWTP on Goodrich Road	Relocate critical infrastructure out of floodplain	Centralia WWTP moved to Goodrich Road	Yes	
28	High-flow bypass	Relict channel around Bucoda	Excavate relict channel as a high-flow bypass on Skookumchuck	Alleviate downtown flooding	No	
29	Road raise	Main Street in Bucoda	Install culvert/bridge at the intersection and raise Main Street to allow access during high flows	Skookumchuck River overflows and closes intersection of 11th Street and Main Street, blocking access from the adjacent neighborhood to the highway	No	A detailed feasibility evaluation of this project was completed
30	Dam storage	Skookumchuck Dam	Use dam as flood storage	Flooding in Centralia	No	Was studied by Corps in several iterations; concerns about seismic stability

ID	FACILITY TYPE	LOCATION	PROPOSED ACTION	FLOOD ISSUE ADDRESSED AND WHERE	WAS IT IMPLEMENTED?	NOTES
31	Floodplain storage	Allen Creek, along Case Road south of 113th avenue	Restore Allen Creek to historical alignment adding floodplain connection and storage	Flood storage potential	Not known	
32	Road raise	Moon Road on Chehalis Reservation South of Highway 12	Raise Moon Road to keep it open during moderate flooding events	Flooding in two spots on Moon Road	No	A detailed feasibility evaluation was completed on this project
33	Increase bridge capacity	Black River Bridge	Replace or modify existing bridge for more conveyance capacity	Bridge constricts flow during floods	No	A detailed feasibility evaluation was completed on this project
34	Channel realignment	Roundtree Creek Confluence with Harris Creek in Oakville	Restore Roundtree Creek to its original alignment	Harris Creek floods the city of Oakville	Yes	Project complete
35	Study for solutions	Southeast Oakville	Study to look at causes and solutions	Flooding likely from Harris Creek, Black River, and Unnamed Tributary	Partially	Harris and Roundtree creek culverts replaced
36	Oxbow reconnection	RM 43 Chehalis River	Reconnect oxbow with mainstem and install restoration	Flood storage potential	Not known	
	Streambank protection	City of Elma WWTP outfall	Relocate WWTP outfall and install streambank protection	Streambank at outfall is eroding	Yes	
37, 38	Bridge capacity	South Bank Road (Wakefield Road between mileposts 8.2 and 16.9	Install a bridge to allow floodwaters to flow under road and not wash out roadway	Road is flooded or washed out	No	
39	Oxbow reconnection	RM 36 Chehalis River	Reconnect oxbow with mainstem and install restoration	Flood storage potential	Yes	Chehalis Tribe restoration

ID	FACILITY TYPE	LOCATION	PROPOSED ACTION	FLOOD ISSUE ADDRESSED AND WHERE	WAS IT IMPLEMENTED?	NOTES
40	Culvert replacement	South Bank Road Gaddis Creek	Widen culvert to increase flood conveyance	Backwater flooding upstream from culvert	Not known	
41	High-flow bypass	SR 107 disconnected oxbow	Restore connection to oxbow to act as overflow channel	Unspecified erosion issues in the area	Not known	
42	Bank protection measures	City of Montesano WWTP	Long-term bank protection measures	Wynoochee River migration exposing embankment of treatment plant	Partially	City installed emergency bank protection in 2007 and sheet pile in 2014
43	Road raise	Wynoochee Valley Road	Elevate portion of road near milepost 1	Flooding causes road closure	No	A detailed feasibility evaluation was completed on this project
44	Dam, tide gate, and pump station	Mill Creek, City of Cosmopolis	Replace failed dam at Mill Creek park, modify tide gate, and install pump station	Flooding of neighborhoods form Mill Creek and Chehalis backwater	Yes	Project complete
45	Tide gate and pump station	Fry Creek near Chehalis Confluence in Aberdeen	Install new tide gate and pump station to reduce flooding	High tides and flooding on the Chehalis cause neighborhood and highway flooding	Yes	
46	Road raise	Wishkah Road at Ellison Dip	Raise the grade of the road	Four areas identified by county, not specified	No	Additional study was completed on this project
	Floodwall	Wishkah Road mileposts 2.2-2.7	Construct sheet pile floodwall	Flooding of residential and commercial areas	Yes	
47	Floodway bypass	SR 6 and Scheuber Road	Floodway bypass around Chehalis/Centralia	No significant benefit (Ruckelshaus 2012)	No	Raises flood elevations downstream

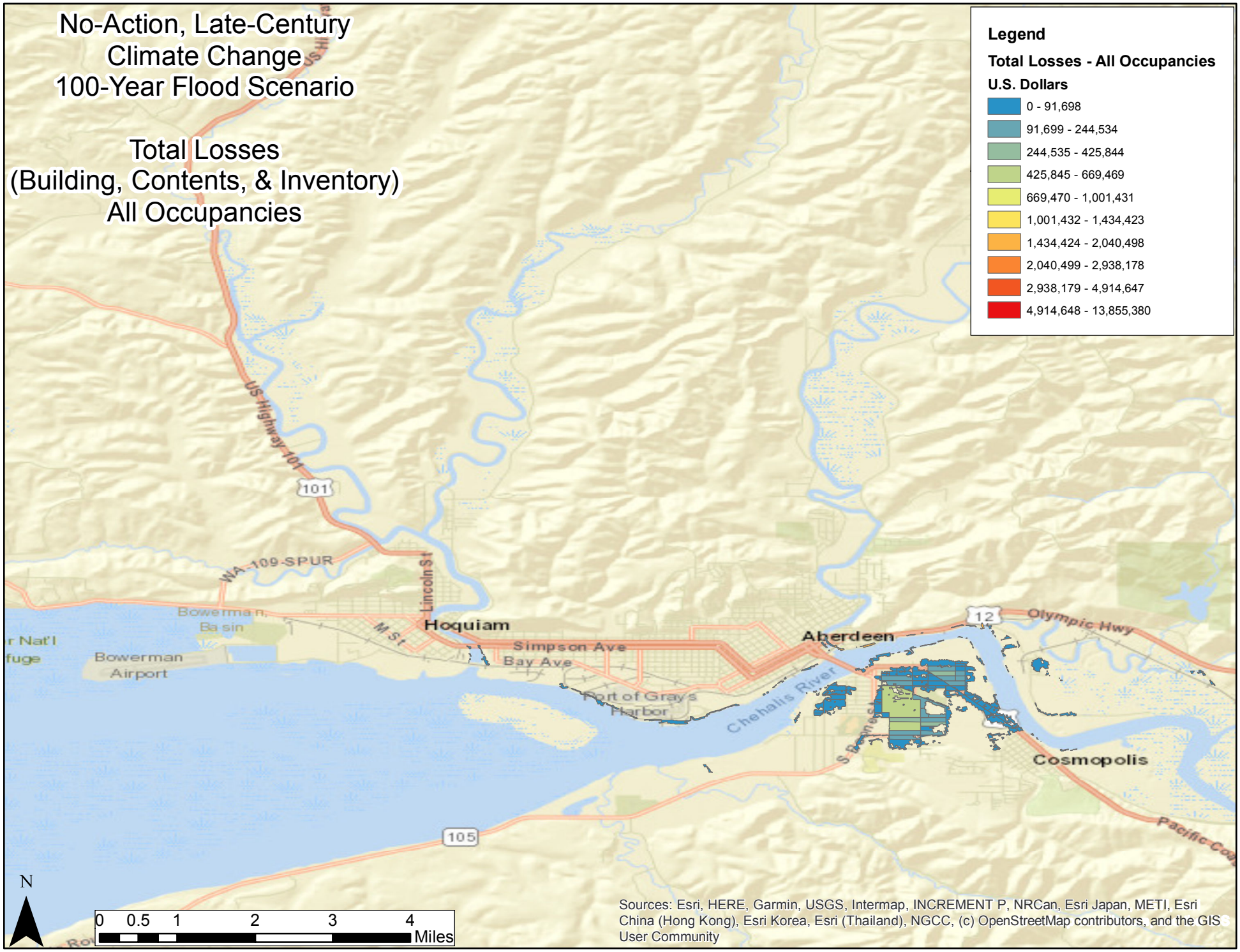
FRE: Flood Retention Expandable
SR: State Route
WWTP: Wastewater Treatment Plant

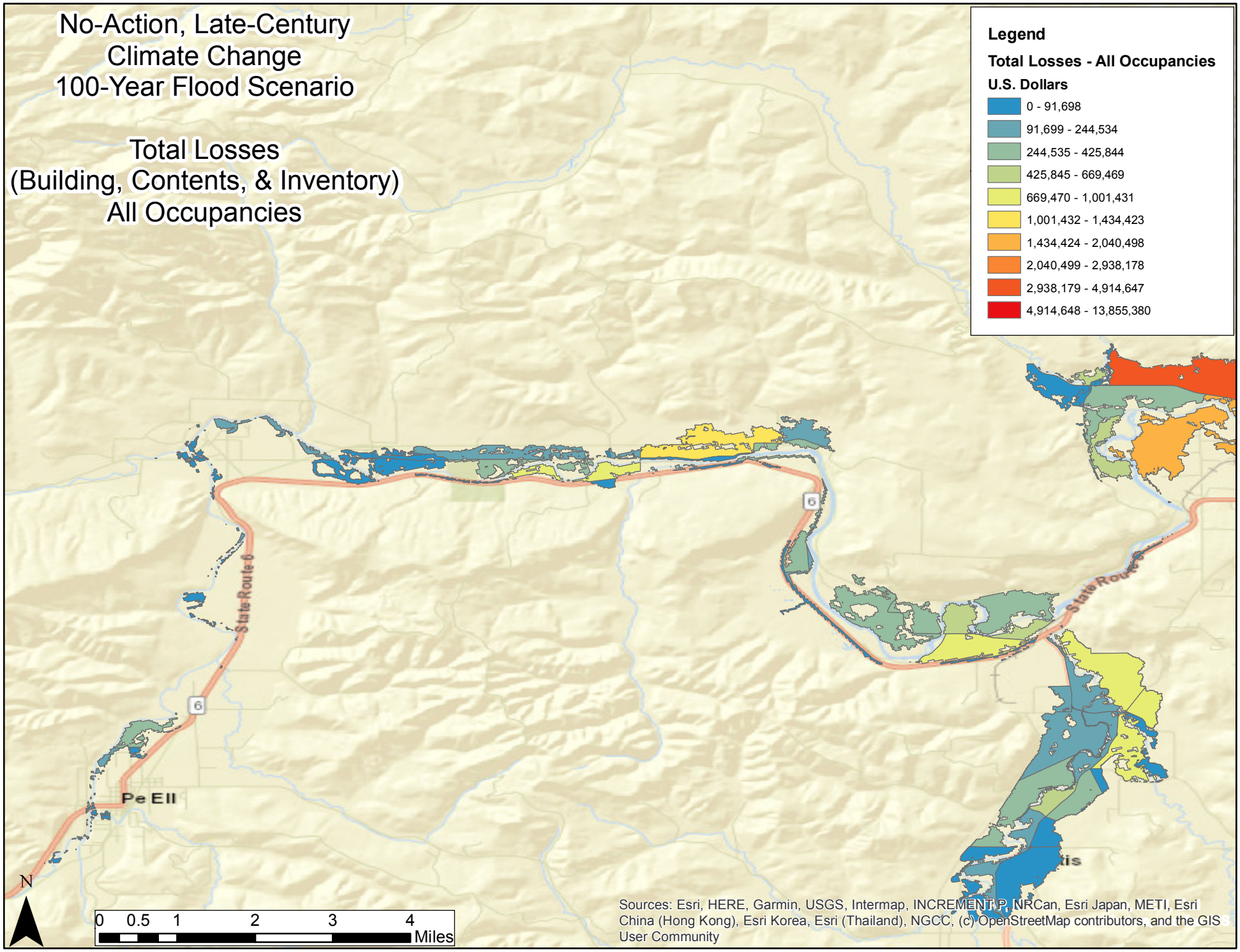
Figure A-2
Previously Identified Local Flood Actions

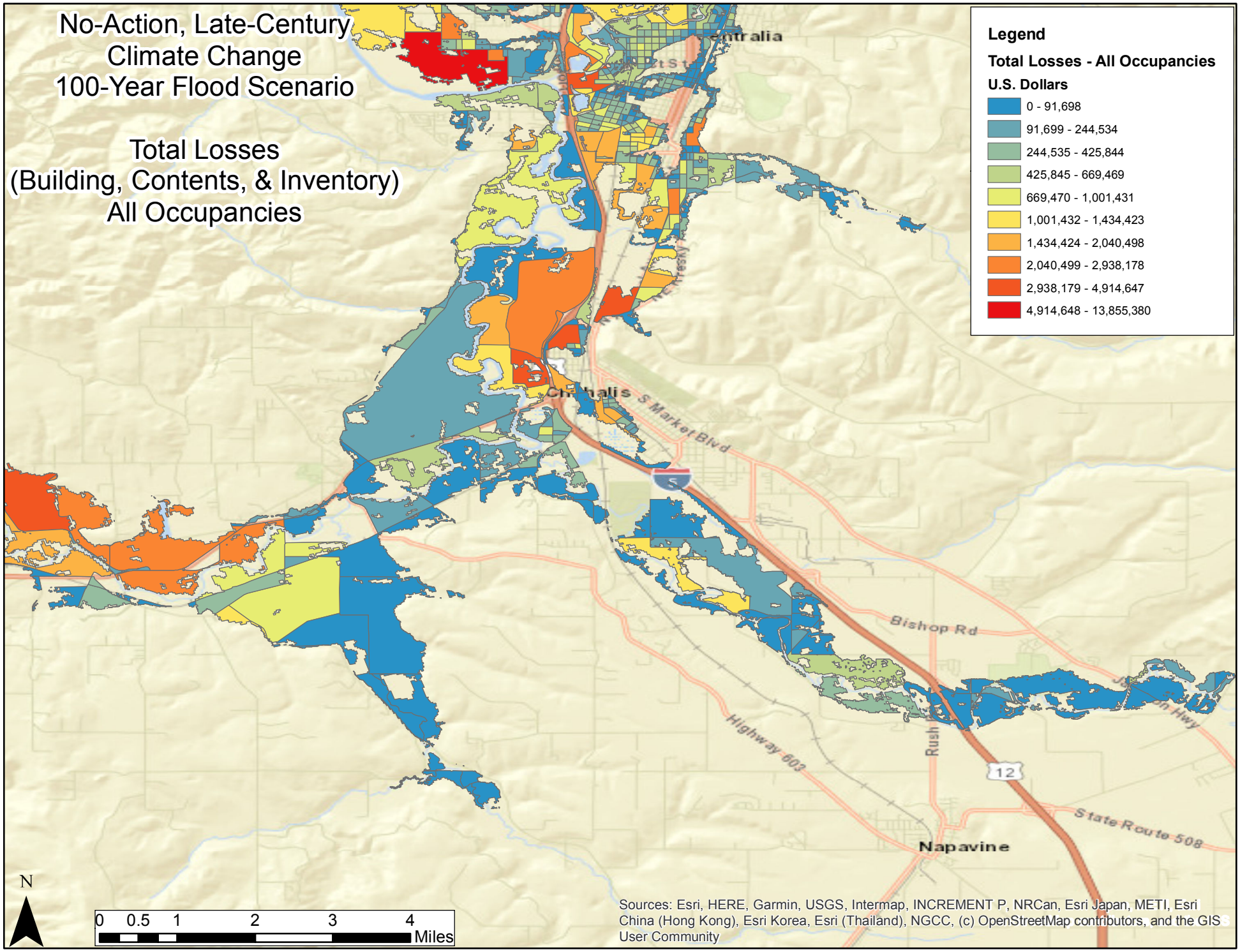


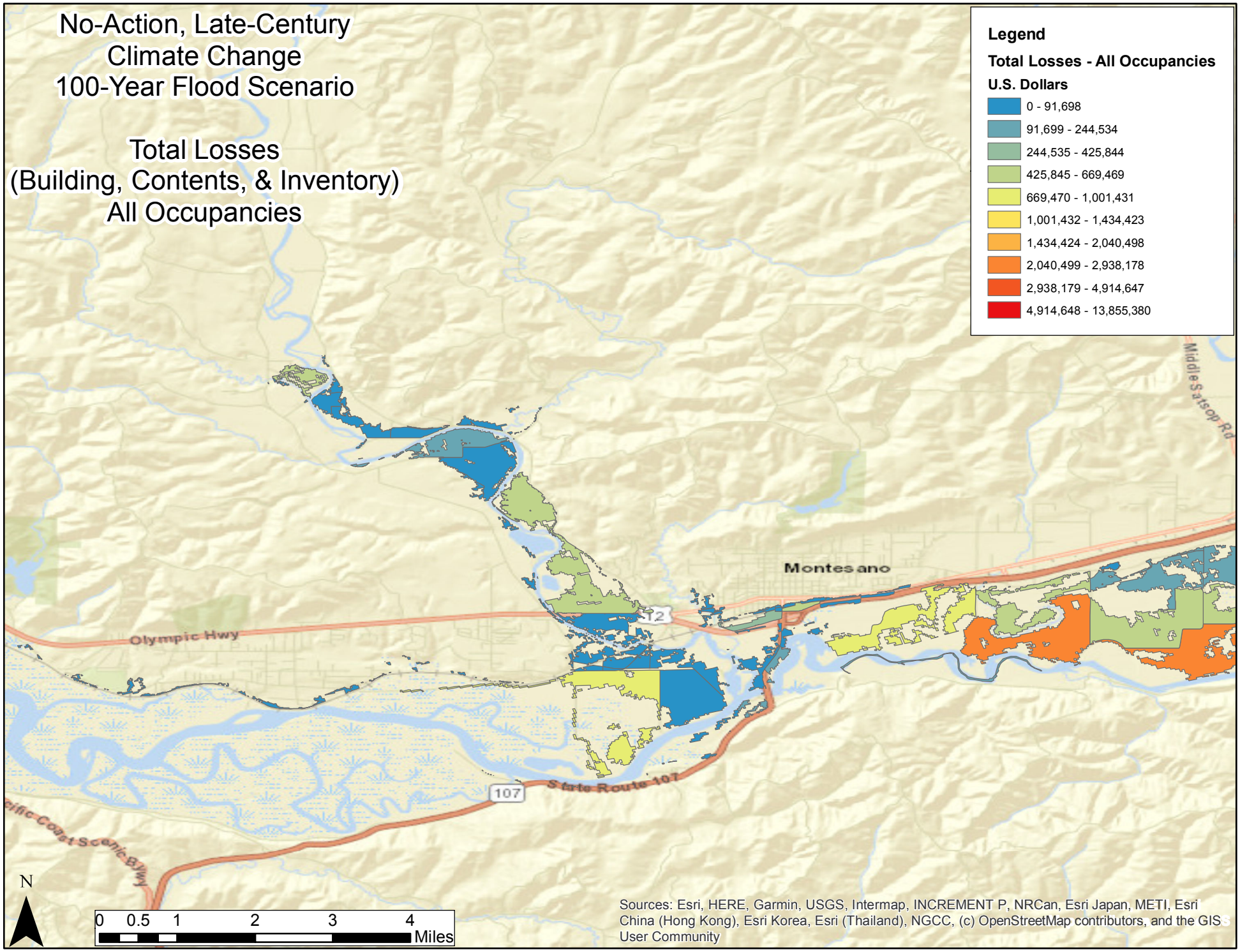
APPENDIX B
ECONOMIC DAMAGE MAPPING FOR 2080 CATASTROPHIC FLOODPLAIN

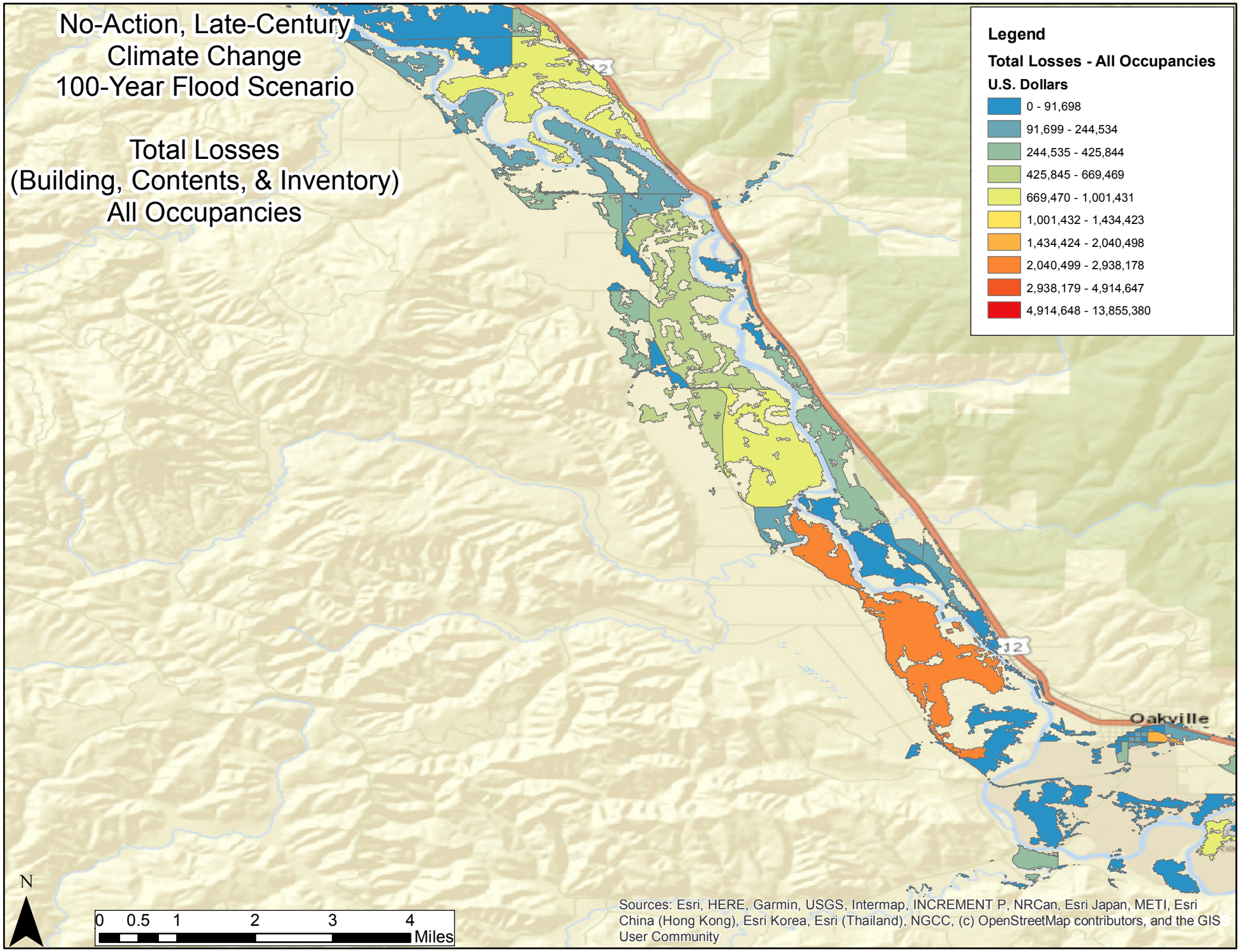
APPENDIX B
ECONOMIC DAMAGE MAPPING FOR 2080 CATASTROPHIC FLOODPLAIN

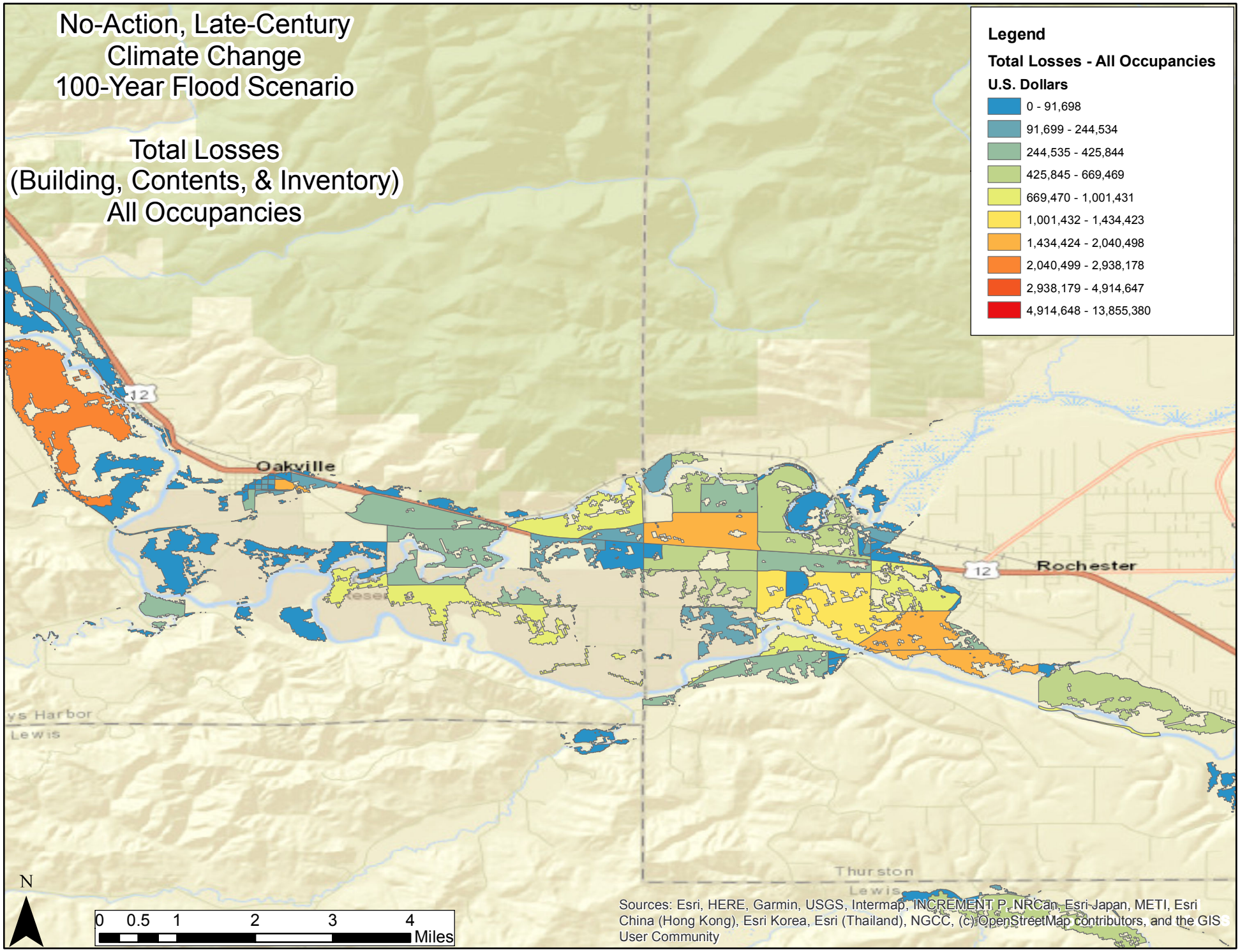

No-Action, Late-Century
Climate Change
100-Year Flood Scenario
Total Losses
(Building, Contents, & Inventory)
All Occupancies
Legend
Total Losses - All Occupancies
U.S. Dollars
0 - 91,698
91,699 - 244,534
244,535 - 425,844
425,845 - 669,469
669,470 - 1,001,431
1,001,432 - 1,434,423
1,434,424 - 2,040,498
2,040,499 - 2,938,178
2,938,179 - 4,914,647
4,914,648 - 13,855,380
US Highway 101
101
WA-109-SPUR
Lincoln St
M St
Hoquiam
Bowerman Basin
Bowerman Airport
Simpson Ave
Bay Ave
Port of Gray's Harbor
Chehalis River
Aberdeen
12
Olympic Hwy
Cosmopolis
105
N
0 0.5 1 2 3 4 Miles
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

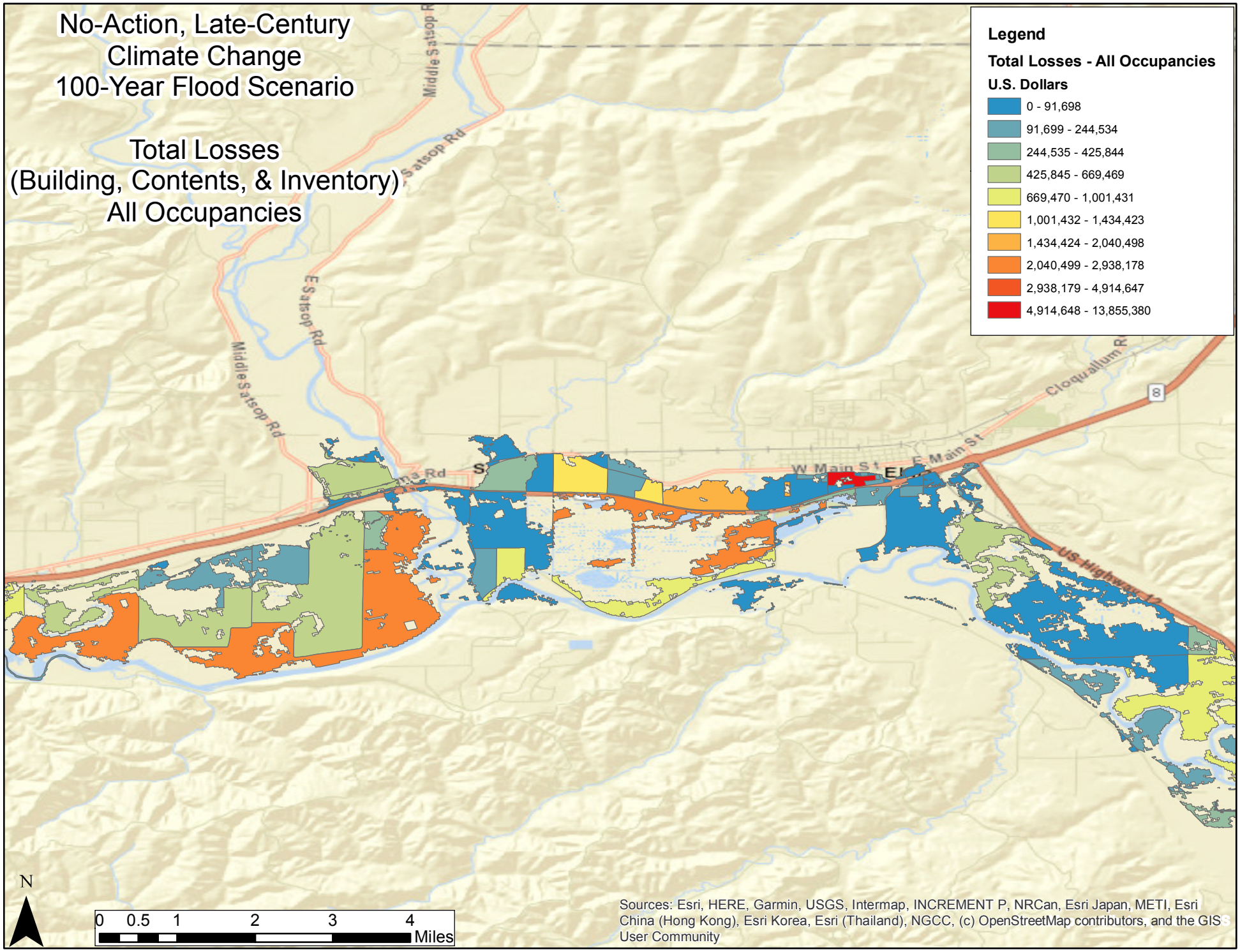

No-Action, Late-Century
Climate Change
100-Year Flood Scenario
Total Losses
(Building, Contents, & Inventory)
All Occupancies
Legend
Total Losses - All Occupancies
U.S. Dollars
0 - 91,698
91,699 - 244,534
244,535 - 425,844
425,845 - 669,469
669,470 - 1,001,431
1,001,432 - 1,434,423
1,434,424 - 2,040,498
2,040,499 - 2,938,178
2,938,179 - 4,914,647
4,914,648 - 13,855,380
State Route 6
Pe Ell
N
0 0.5 1 2 3 4
Miles
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

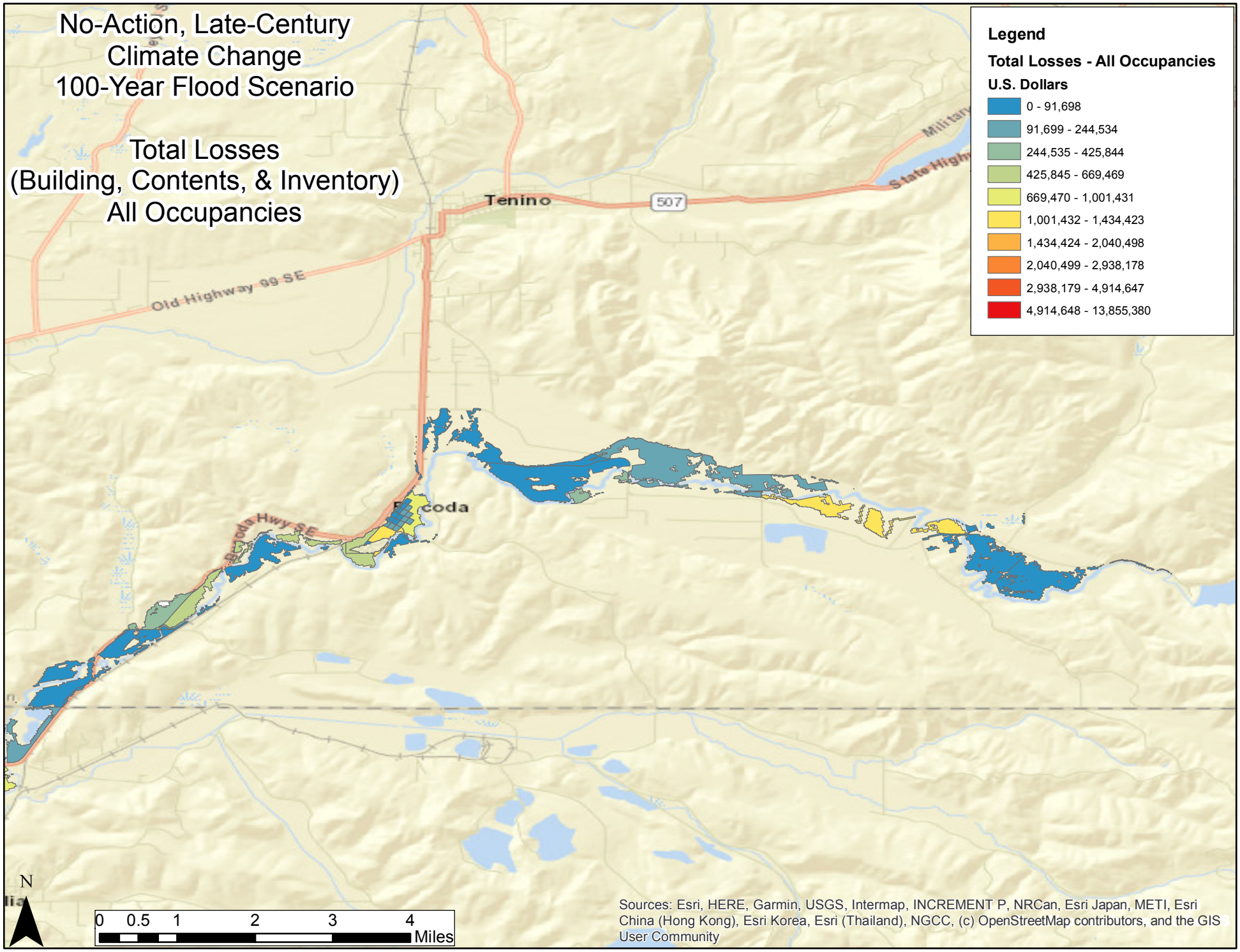

No-Action, Late-Century
Climate Change
100-Year Flood Scenario
Total Losses
(Building, Contents, & Inventory)
All Occupancies
Legend
Total Losses - All Occupancies
U.S. Dollars
0 - 91,698
91,699 - 244,534
244,535 - 425,844
425,845 - 669,469
669,470 - 1,001,431
1,001,432 - 1,434,423
1,434,424 - 2,040,498
2,040,499 - 2,938,178
2,938,179 - 4,914,647
4,914,648 - 13,855,380
Centralia
Chehalis
S Market Blvd
Bishop Rd
Highway 603
Rush
12
State Route 508
Napavine
N
0 0.5 1 2 3 4
Miles
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community


No-Action, Late-Century
Climate Change
100-Year Flood Scenario
Total Losses
(Building, Contents, & Inventory)
All Occupancies
Legend
Total Losses - All Occupancies
U.S. Dollars
0 - 91,698
91,699 - 244,534
244,535 - 425,844
425,845 - 669,469
669,470 - 1,001,431
1,001,432 - 1,434,423
1,434,424 - 2,040,498
2,040,499 - 2,938,178
2,938,179 - 4,914,647
4,914,648 - 13,855,380
Montesano
Olympic Hwy
State Route 107
107
Middle Satsop Rd
N
0 0.5 1 2 3 4
Miles
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community


No-Action, Late-Century
Climate Change
100-Year Flood Scenario
Total Losses
(Building, Contents, & Inventory)
All Occupancies
Legend
Total Losses - All Occupancies
U.S. Dollars
0 - 91,698
91,699 - 244,534
244,535 - 425,844
425,845 - 669,469
669,470 - 1,001,431
1,001,432 - 1,434,423
1,434,424 - 2,040,498
2,040,499 - 2,938,178
2,938,179 - 4,914,647
4,914,648 - 13,855,380
12
12
Oakville
N
0 0.5 1 2 3 4
Miles
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community


No-Action, Late-Century
Climate Change
100-Year Flood Scenario
Total Losses
(Building, Contents, & Inventory)
All Occupancies
Legend
Total Losses - All Occupancies
U.S. Dollars
0 - 91,698
91,699 - 244,534
244,535 - 425,844
425,845 - 669,469
669,470 - 1,001,431
1,001,432 - 1,434,423
1,434,424 - 2,040,498
2,040,499 - 2,938,178
2,938,179 - 4,914,647
4,914,648 - 13,855,380
Oakville
Rochester
12
Lewis
Thurston
N
0 0.5 1 2 3 4
Miles
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community


No-Action, Late-Century
Climate Change
100-Year Flood Scenario
Total Losses
(Building, Contents, & Inventory)
All Occupancies
Legend
Total Losses - All Occupancies
U.S. Dollars
0 - 91,698
91,699 - 244,534
244,535 - 425,844
425,845 - 669,469
669,470 - 1,001,431
1,001,432 - 1,434,423
1,434,424 - 2,040,498
2,040,499 - 2,938,178
2,938,179 - 4,914,647
4,914,648 - 13,855,380
Middle Satsop Rd
Satsop Rd
E Satsop Rd
Middle Satsop Rd
W Main St
E Main St
Cloquallum Rd
8
US Highway 12
N
0 0.5 1 2 3 4
Miles
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community


No-Action, Late-Century
Climate Change
100-Year Flood Scenario
Total Losses
(Building, Contents, & Inventory)
All Occupancies
Legend
Total Losses - All Occupancies
U.S. Dollars
0 - 91,698
91,699 - 244,534
244,535 - 425,844
425,845 - 669,469
669,470 - 1,001,431
1,001,432 - 1,434,423
1,434,424 - 2,040,498
2,040,499 - 2,938,178
2,938,179 - 4,914,647
4,914,648 - 13,855,380
Tenino
507
Old Highway 99 SE
coda
N
0 0.5 1 2 3 4
Miles
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community