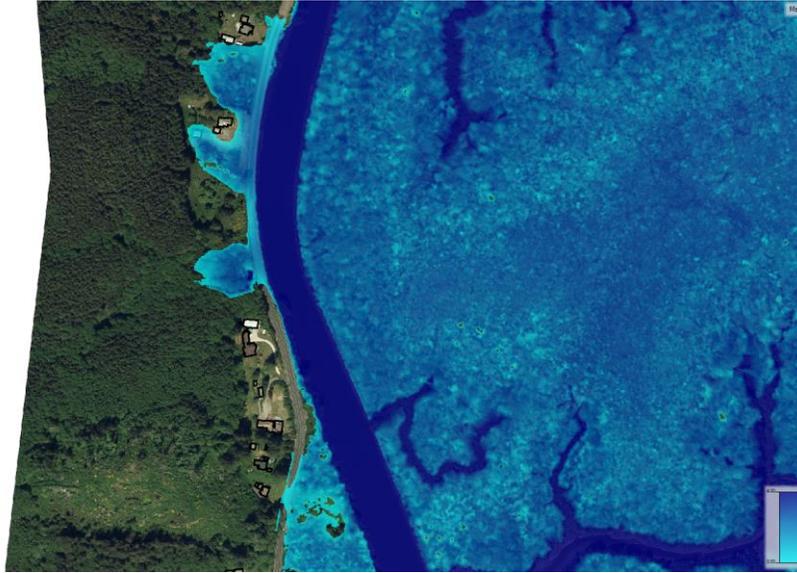


# Study Area #1 – Ellison Dip (M.P. 3.8)

Includes two potential flood locations

<b>Road Flooding Information:</b> Length of Road Flooded in 100-year Flood –1,200 feet Maximum depth – 4.9 feet	<b>Cost of Road Closures<sup>1</sup>:</b> \$322,000	<b>Est. Cost to Correct:</b> \$1,250,000 to \$1,800,000+
	<small><sup>1</sup>Estimated net present value of cost of road flooding over a 50-year life cycle (assuming this was the only location of Wishkah Road flooding)</small>	



<b>Flood Observations:</b> Minimum Road Elevation: 10.8 feet January 2015 Water Level: 12.8 feet December 2015 Water Level: 13.0 feet January 2009 Water Level: 15.2 feet	<b>Flood Simulation Statistics:</b>		
	<b>100-year Event</b> Max Level: 16.0 feet Duration: 36 Hours	<b>10-year Event</b> Max Level: 14.0 feet Duration: 18.5 Hours	<b>2-year Event</b> Max Level: 11.9 feet Duration: 5.8 Hours

## Potential Project Alternatives

Flood reduction alternatives considered for this location include:

1. A floodwall along the east side of Wishkah Road,
2. Relocating Wishkah Road farther to the west at a higher elevation, or
3. Raising the road using walls and light-weight fill

A preliminary estimate for construction of a floodwall can be obtained from the estimated cost of the Baretich Road flood wall which is expected to cost about \$2,000 per lineal foot. Assuming the floodwall at this location would need to be 1,200 feet long the estimated cost would be \$2,400,000, plus costs for design, environmental documentation, and permitting. Additional costs would be incurred if there are wetland impacts and associated mitigation, culvert replacements, or property acquisition associated with the project.

A second option considered at this location would be to construct a new road to the west, either in front of or behind the existing homes. The new road would need to be elevated above the 100-year flood (estimated elevation 15.6 feet NAVD) and would need to be up to 1/3 of a mile long. To construct a new road would require easements or property acquisition which could be very expensive. There would also likely be significant permitting effort as it appears that there may be wetland and/or stream channel impacts. It is estimated that permitting costs for a realigned road could be as high as \$100,000 and mitigation and monitoring costs could easily exceed \$100,000, depending on the extend of impact. The existing Wishkah Road would also need to be removed as mitigation, and additional mitigation may also be required. Overall a new road alignment at this location is expected to cost at least \$1,800,000.

The third option would include raising the roadway within the current roadway prism. To accomplish this, mechanically stabilized earth (MSE) retaining walls on either side of the roadway would be installed and light-weight fill placed between the walls. Most of the soils in the Wishkah River Flood plain are soft and likely cannot support the necessary fill to raise the roadway. Walls, light-weight fill and a new pavement surface would likely cost between \$850 and \$1,250 per lineal foot of roadway, for an estimated range in costs for this option of \$1,000,000 - \$1,500,000.

These costs do not include design, permitting and other soft costs. A 25% contingency should be added to cover such costs and current project unknowns, putting the range at \$1,250,000 to \$1,800,000. Additional costs would be incurred if there are wetland impacts and associated mitigation, culvert replacements, or property acquisition associated with the project.

## Study Area #2 – Near Leutz Road (M.P. 4.0 and 4.4)

Includes two potential flood locations (not included in original project scope)

### Road Flooding Information:

Length of Road Flooded in 100-year Flood – 1,200 feet  
Maximum depth – 5.6 feet

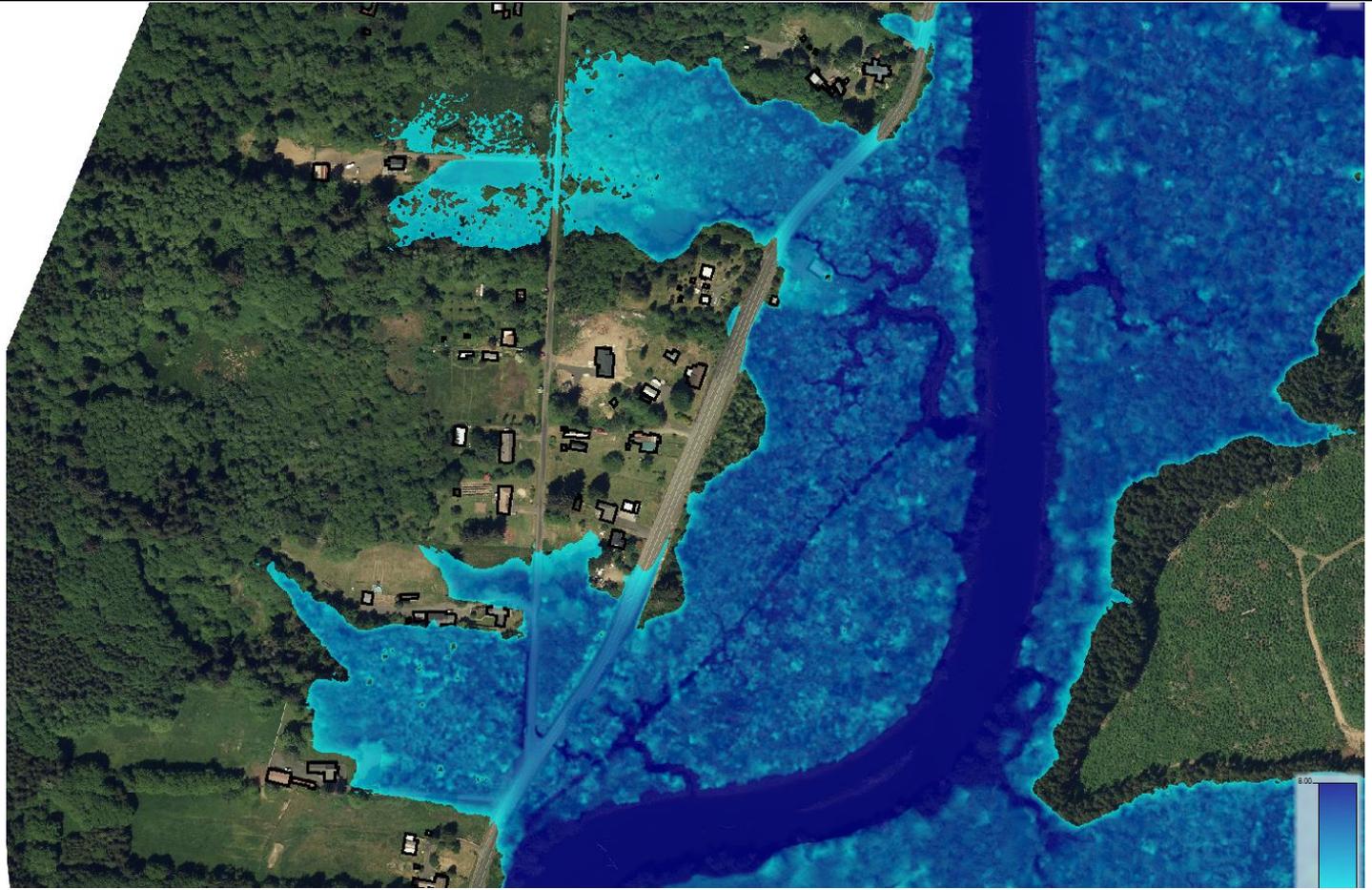
### Cost of Road Closures<sup>1</sup>:

\$250,000

### Est. Cost to Correct:

\$2,500,000

<sup>1</sup>Estimated net present value of cost of road flooding over a 50-year life cycle (assuming this was the only location of Wishkah Road flooding)



### Flood Observations:

Minimum Road Elevation: 10.4 feet  
January 2015 Water Level: 13.0 feet  
December 2015 Water Level: 13.2 feet  
January 2009 Water Level: 15.5 feet

### Flood Simulation Statistics:

#### 100-year Event

Max Level: 16.3 feet  
Duration: 42 Hours

#### 10-year Event

Max Level: 14.3feet  
Duration: 24 Hours

#### 2-year Event

Max Level: 12.2 feet  
Duration: 7.25 Hours

## Potential Project Alternatives

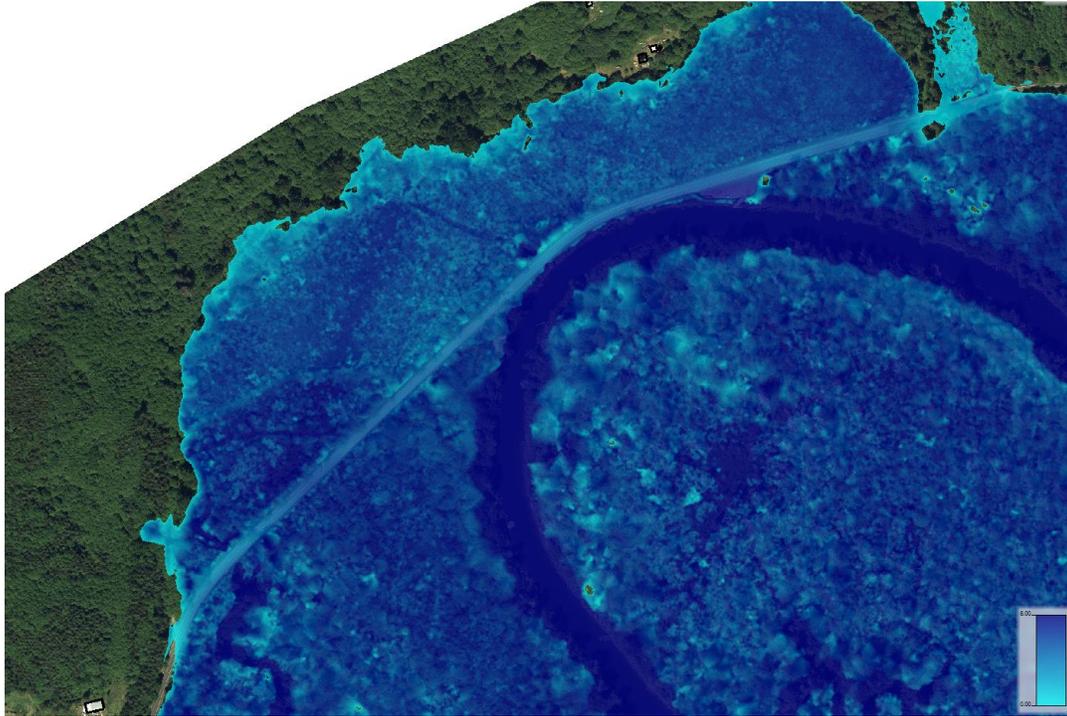
Simulated flooding in a 100-year flood is projected to be up to 5.6 feet deep and up to 1,200 feet long at these two locations near Leutz Road. Flood reduction alternatives at these locations would likely include raising the road on Mechanically Stabilized Earth (MSE) fills as these would require the least property and have the least impact on adjacent properties (albeit at a higher cost than traditional fill with sloping sides). Raising Wishkah Road by 6 feet or more would require the road be brought up to current safety standards including shoulders, guardrails and other features. In addition to the road raise there are two streams in this project area that would need to be passed under the road fill, and these passages would need to be designed according to current WDFW fish passage guidelines which would require either very large culverts or perhaps a bridge. Permitting and environmental documentation requirements associated with the stream crossings could easily cost \$100,000 or more. It is estimated that a project to raise the Wishkah Road and provide fish passable culverts for the two streams would cost at least \$2,000,000. Adding a 25% contingency to cover unforeseen issues, puts the estimated cost of improvements at this site at \$2,500,000.

An alternative to raising the road over both of these flooding locations might be to raise Wishkah Road and Leutz Road at just the south location and then use Leutz Road as a detour to travel further up the Wishkah valley. This detour alternative would reduce the cost of Wishkah Road improvements but might require additional safety or other improvements to Leutz Road, which have not yet been estimated.

# Study Area #3 - Long Swamp (M.P. 4.6 - 5.3)

Deepest flooding over greatest length of road

<b>Road Flooding Information:</b> Length of Road Flooded in 100-year Flood – 3,550 feet Maximum depth – 5.9 feet	<b>Cost of Road Closures<sup>1</sup>:</b> \$500,000	<b>Est. Cost to Correct:</b> \$2,250,000 to \$12,000,000
	<sup>1</sup> Estimated net present value of cost of road flooding over a 50-year life cycle (assuming this was the only location of Wishkah Road flooding)	



<b>Flood Observations:</b> Minimum Road Elevation: 11.7 feet January 2015 Water Level: 13.8 feet December 2015 Water Level: 14.2 feet January 2009 Water Level: 16.9 feet	<b>Flood Simulation Statistics:</b>		
	<b>100-year Event</b> Max Level: 17.6 feet Duration: 48 Hours	<b>10-year Event</b> Max Level: 15.5 feet Duration: 30 Hours	<b>2-year Event</b> Max Level: 13.5 feet Duration: 9.5 Hours

## Potential Project Alternatives

The Long Swamp location has the deepest and longest section of roadway flooding of any of the sites investigated. Observed flooding in January 2015 was about 2.75 feet deep. Flooding in a 100-year flood is projected to be up to 6 feet deep and extend up to 3,550 feet along Wishkah Road. Flood reduction alternatives considered include raising Wishkah Road by up to 6 feet and adding a floodwall along approximately 1,100 feet of the Wishkah River where the road is very close to the river. The raised road might be constructed on Mechanically Stabilized Earth fills to minimize wetland impacts although MSE fills would be higher cost than traditional sloping earth fills. It is not clear whether the additional weight due to a road fill of 6 feet or more could be accomplished without significant geotechnical stabilization of the road grade. Based on recent projects near this location it is expected that wetland loss would need to be mitigated at a ratio of 4:1 (i.e. 4 acres of wetland would need to be created for every 1 acre of fill) and the estimated cost for wetland creation could be \$500,000 to \$1,000,000 per acre with property acquisition. A traditional road fill, assuming wetland presence along the length of the improvement and an average height of 4 feet and 2:1 side slopes along the entire 3,500 foot length of road (minus the floodwall section), could require up to 2.2 acres of wetland fill. Given the mitigation ratio and cost described above, wetland mitigation alone could approach \$8,000,000. With the fill and flood wall, this project could cost more than \$12,000,000.

Because of the high potential cost for raising this section of Wishkah Road an alternative was considered that would create a bypass route along the hillslope adjacent to the low lying area immediately west and north of the current Wishkah Road, possibly along the alignment of an existing private driveway. This alternative would require acquisition of property or an easement for the entire route and engineering and construction of approximately one mile of new roadway at the east end. Estimating the cost for such a project is not possible without additional information but it is anticipated that if an easement can be obtained this would be less costly than the road raising alternative. However, the bypass route would be more than 4,500 feet long so even at a relatively low roadway cost of \$400/LF, this option would exceed \$1,800,000. Including a 25% contingency, which may be low given the unknowns of this route, the cost is likely to be at least \$2,250,000.

# Study Area #4 - Wyman Creek (M.P. 5.8)

Additional flooding may be due to local drainage issues and beaver dams

## Road Flooding Information:

Length of Road Flooded in 100-year Flood – 1,350 feet  
 Maximum depth – 2.7 feet

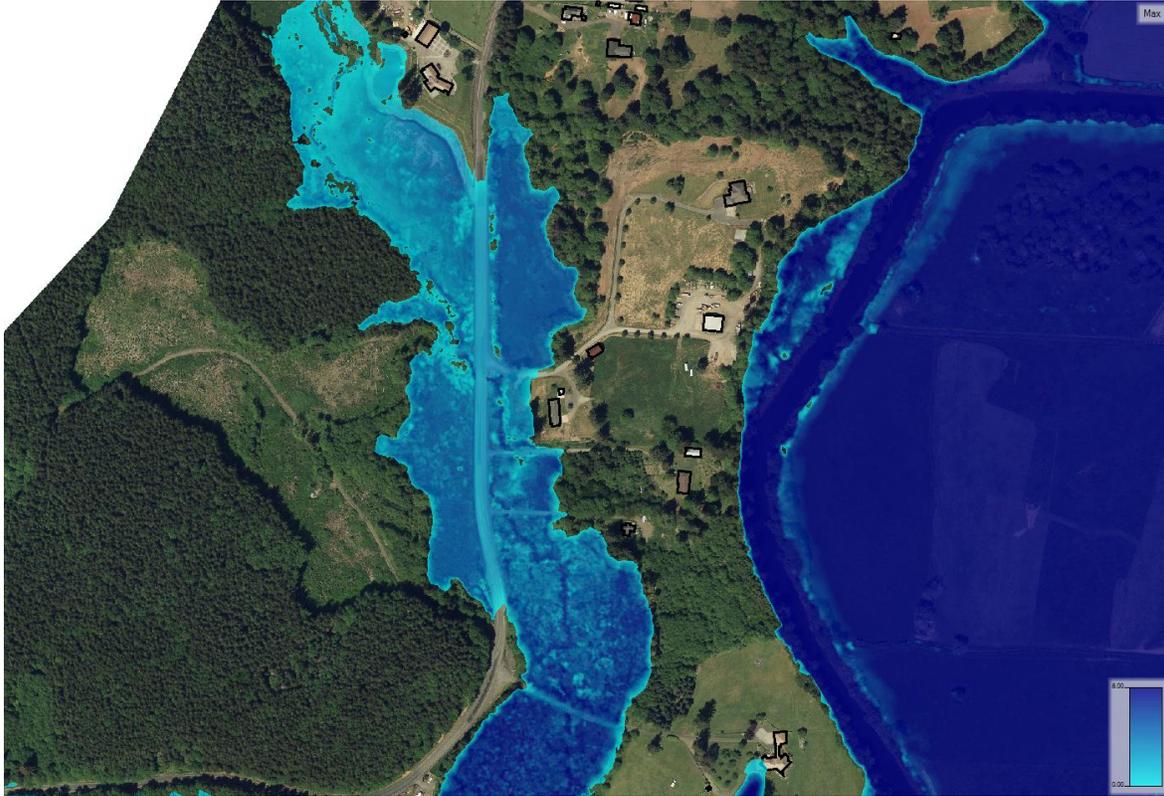
## Cost of Road Closures<sup>1</sup>:

\$163,100

## Est. Cost to Correct:

\$1,350,000+

<sup>1</sup>Estimated net present value of cost of road flooding over a 50-year life cycle (assuming this was the only location of Wishkah Road flooding)



## Flood Observations:

Minimum Road Elevation: 15.6 feet  
 January 2015 Water Level: 15.8 feet  
 December 2015 Water Level: 15.6 feet  
 January 2009 Water Level: 14.5 feet

## Flood Simulation Statistics:

100-year Event	10-year Event	2-year Event
Max Level: 18.3 feet	Max Level: 16.2 feet	Max Level: 15.6 feet
Duration: 27 Hours	Duration: 11 Hours	Duration: 0 Hours

## Potential Project Alternatives

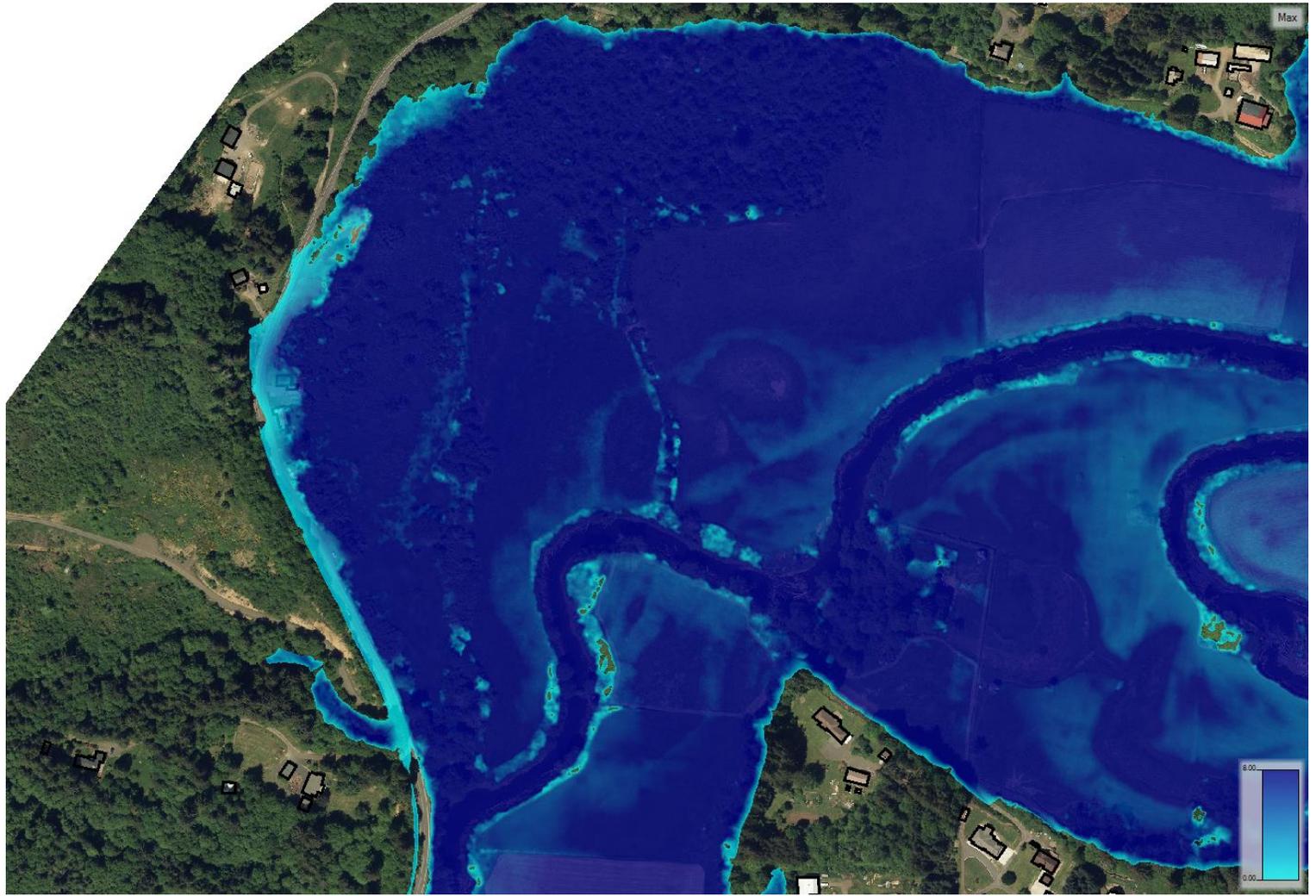
Simulated flooding near the Wyman Creek culvert crossing was not as significant as many of the other identified flood locations. Note however that the analysis only considered flooding associated with the Wishkah River and did not include detailed modeling of Wyman Creek itself. Conversation with local residents lead us to believe that frequent flooding near the Wyman Creek culvert at Wishkah Road may be occurring as a result of limited capacity in Wyman Creek and specifically as a result of beaver dams in the channel downstream of the culvert crossing. That issue has not been evaluated in this study. The least expensive alternative for eliminating flooding near Wyman Creek due to backwater from the Wishkah River would likely be to raise the road and add culvert capacity. A new culvert on Wyman Creek would need to be designed per current WDFW fish passage guidelines, meaning it would likely be significantly larger than the current culvert. Typically a wide box culvert would be the best alternative. Wishkah Road would need to be raised up to 2.7 feet over a length of approximately 1,350 feet to be above the 100-year flood level. To accomplish a road raise of 3 feet without significant wetland impacts would best be done using Mechanically Stabilized Earth fill. There may still be some wetland fill required which would necessitate mitigation, which could be costly. Permitting and environmental documentation of the project could be relatively involved due to the stream crossing and wetlands issues. It is estimated that the cost to raise 1,350 feet of roadway and replace the Wyman Creek culvert would be at least \$1,350,000, but likely higher.

There are at least two private driveway crossings on Wyman Creek downstream of Wishkah Road; both would be flooded in a 100-year event. Enlarging the Wishkah Road culvert could allow higher flows to pass downstream and exacerbate flooding of these driveways. If the driveways need to be raised it the culverts under them might need to be upsized to be fish passable as well. The costs to replace culverts at the downstream driveways have not been included here. Detailed modeling of Wyman Creek would be necessary to evaluate potential flood issues and/or to design improvements at the downstream culverts.

# Study Area #5 – Miller Hill (M.P. 7.5)

Modeling and observations less certain at this location

<b>Road Flooding Information:</b> Length of Road Flooded in 100-year Flood – 1,550 feet Maximum depth – 3.1 feet	<b>Cost of Road Closures <sup>1</sup>:</b> \$126,200 <sup>1</sup>	<b>Est. Cost to Correct:</b> \$500,000 to \$1,000,000
<small><sup>1</sup>Estimated net present value of cost of road flooding over a 50-year life cycle (assuming this was the only location of Wishkah Road flooding)</small>		



<b>Flood Observations:</b> Minimum Road Elevation: 19.9 feet January 2015 Water Level: 19.9 feet December 2015 Water Level: 19.9 feet January 2009 Water Level: 22.1 feet	<b>Flood Simulation Statistics:</b>		
	<b>100-year Event</b>	<b>10-year Event</b>	<b>2-year Event</b>
	Max Level: 23.0 feet Duration: 25 Hours	Max Level: 21.0 feet Duration: 10 Hours	Max Level: 19.1 feet Duration: 0 Hours

## Potential Project Alternatives

Simulated flooding at this location is generally the shallowest of any of the flooding locations studied (except Study Area #2) and the modeling is also the most uncertain at this location because there are no photographs or high water marks for calibration of the model. Wishkah Road along this flood area is generally constructed on a fill slope along its east margin and cut into the hillslope along the west. The simplest solution to flooding in this area would likely be to shift the road slightly farther to the west, cut into the hillslope, and use the cut material to raise the road as needed. Shifting the road may require the purchase of portions of up to five properties. Assuming these could be obtained the project should be relatively straightforward to design and construct. However, additional information, including a right of way survey and geotechnical review would be required before a preliminary cost estimate can be developed for this project. An estimated range in cost for the scenario described above is \$500,000-\$1,000,000.