SWINOMISH INDIAN TRIBAL COMMUNITY

SC² SKAGIT CLIMATE SCIENCE CONSORTIUM

SKAGIT RIVER SYSTEM COOPERATIVE

Dike Failure Scenarios

This map bundle shows the results of dike failure scenarios for Sedro-Woolley downstream to Puget Sound.

There are six dike failure scenarios, all of which were initially developed for the Draft Skagit Basin General Investigation Study (USACE, 2014). All dike failure maps are based on the river flooding simulations. Although coastal flooding could result in dike failures, the six scenarios that we are examining are unlikely to be affected by coastal floods. This set includes an overview map of this area and zoomed-in map areas for Lafayette Road, Above BNSF Bridge, Below I-5 Bridge, Below Mount Vernon flood wall, Above Division Bridge, and North Fork Fir Island. Full context for these maps can be found in the full *Understanding Current and Future Skagit Flood Risk Through New Modeling Capabilities* report and specific details on the hydraulic model that created these maps can be found in Appendix A. Animations for select locations can be found at the Skagit Climate Science Consortium website.

These maps are products of the hydraulic model detailed in Appendix A. They are provided without any warranty of performance or fitness for a particular purpose. They should not be depended upon as a sole source of information as they illustrate potential scales of flooding rather than exact locations and do not account for real-time changes like erosion, dike failures, larger than modeled events, or other factors. Maps should be used at your own risk.

What Is Included in This Appendix

This appendix contains map bundles for Upriver Flooding (Marblemount to Sedro-Woolley), Lower River Flooding (Sedro-Woolley to Skagit, Padilla and Samish bays), Coastal Flooding, and Dike Failure Scenarios.

Each of these map bundles has a map showing results for the entire map bundle area and then more zoomed in maps for key population centers. Maps include: flood depths, flood hazard (depth and velocity), and duration. For dike failure scenarios, a depth difference map is also included.

FLOOD FREQUENCIES

Floods are described in terms of "flood frequencies"; in this report we provide results for the 10–, 25–, 100– year events. As described in the report, this terminology can be confusing because it makes it sound like a flood event will only happen once in a given timeframe. In fact, the "10–year event" is a shorthand way to describe a flood event that has a 10% probability (or 1 in 10 chance) of occurring in any given year. Similarly, a 25–year event has a 4% chance of occurring in any given year, and a 100–year flood event has a 1% chance of occurring in any given year.

CLIMATE CHANGE

Climate change is projected to result in larger and more frequent floods. For example, models project that today's 1% annual chance event will become about a 4–5% chance event by midcentury. To help the reader understand how flood risk is changing, this report uses the common terminology of 10–, 25–, and 100–year flood frequencies combined with different timeframes: historic, 2040s and 2080s.

FLOOD DEPTH MAPS

Flood depth maps show the depth and extent of flooding for specific locations and events.

DEPTH–VELOCITY HAZARD MAPS

Depth-velocity hazard maps show the danger posed by flood waters. Based on both water depth and velocity, the maps show the likely risk for children, adults, vehicles, and structures. These maps do not include secondary hazards such as erosion, avulsion, landslides or debris flows.

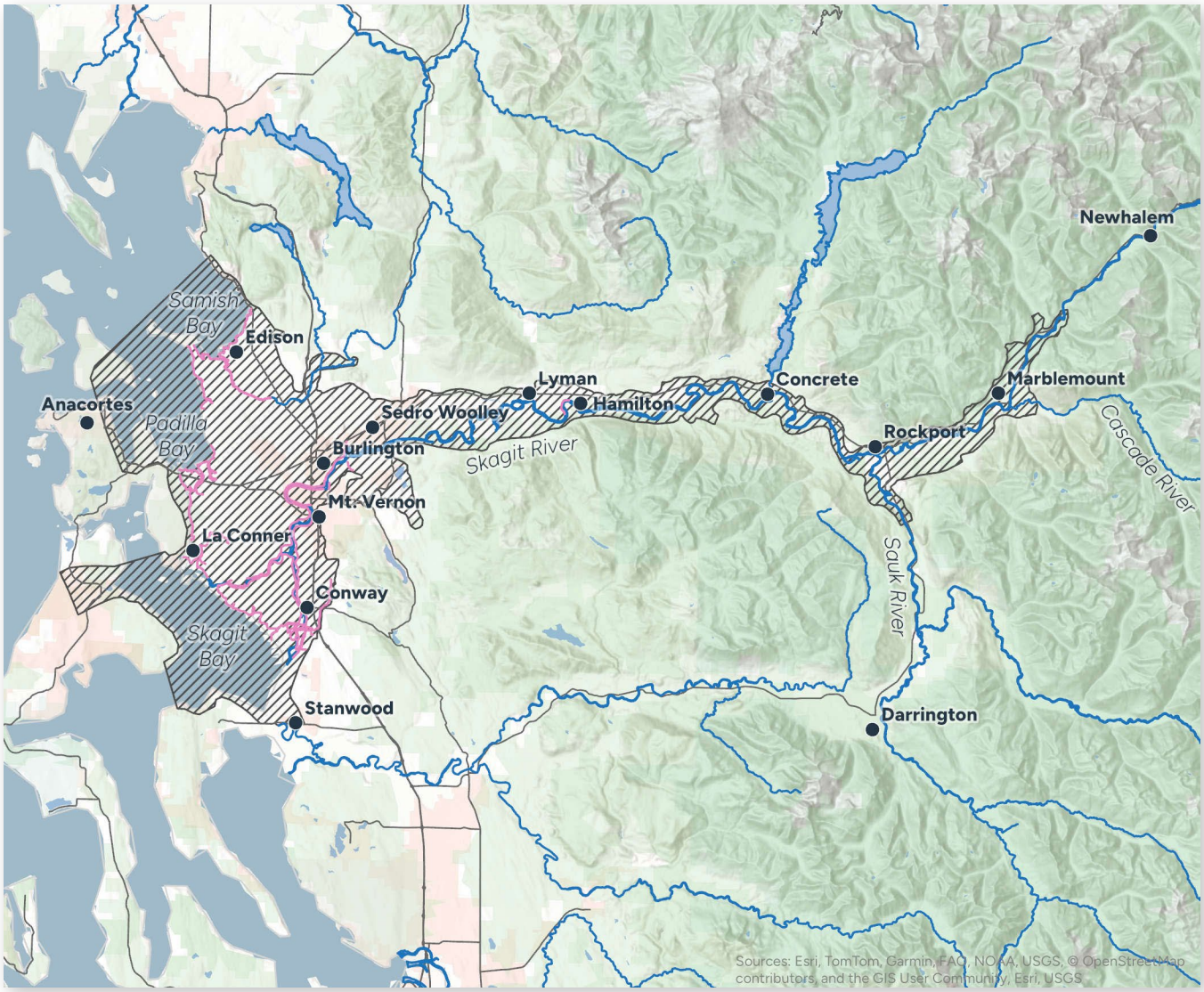
DURATION MAPS

Duration maps show the amount of time a location is flooded. This can be important for understanding the impacts on buildings, roads, dikes, emergency response, livestock, and many other important aspects of flood risk.

Disclaimer

These maps are products of the hydraulic model detailed in Appendix A. They are provided without any warranty of performance or fitness for a particular purpose. They should not be depended upon as a sole source of information as they illustrate potential scales of flooding rather than exact locations and do not account for real-time changes like erosion, dike failures, events that are larger than those modeled, or other factors. Maps should be used at your own risk. A reference section at the end contains data sources for map products.

Skagit River System Overview



Hydraulic Model Domain

Maps included in Appendix B are products of the 2–D hydraulic model described in Appendix A. This map shows the model domain. The hatching shows that the model extends into Skagit, Padilla and Samish Bays in order to simulate coastal flooding. Water flowing into the model domain during flood events – from the Baker River, Upper Skagit River, Sauk River, and many smaller tributaries – are all included, even though the hydraulic model simulations are confined to the Skagit River floodplains.

- Cities
- Major Roads
- Rivers
- Dike or Coastal Dike
- 2D Model Domain

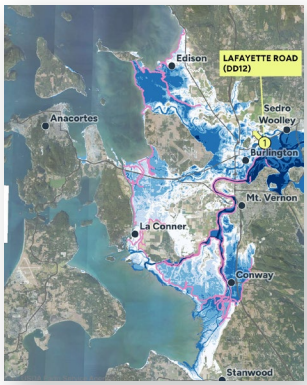
0 2.5 5 10 Miles

How to Read Dike Failure Scenario Maps

What These Maps Show

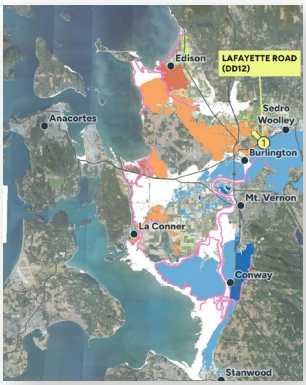
For all maps, the background is based on aerial imagery (USDA 2023). Structures are shown as orange rectangles (Microsoft 2022). Pink lines, if present, show dike or coastal dike locations (Skagit County 2022), and dark gray lines show major transportation routes (WSDOT 2008, Skagit County 2019). Dark blue lines show rivers on the overview maps.

FLOOD DEPTH MAPS



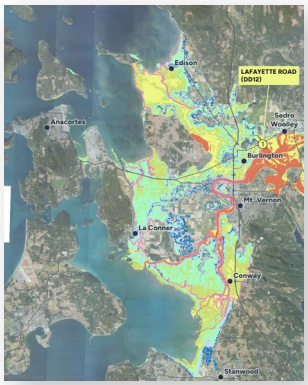
These maps show flood depths for each dike failure scenario. Maps highlight the location of the assumed failure with a green numbered circle. A green arrow shows the direction of the failure (right bank or left bank). Maps show the depth of flooding in shades of blue, where darker blue indicates deeper water and lighter blue indicates shallower water. Dikes or coastal dikes are shown in pink.

DEPTH DIFFERENCE MAPS



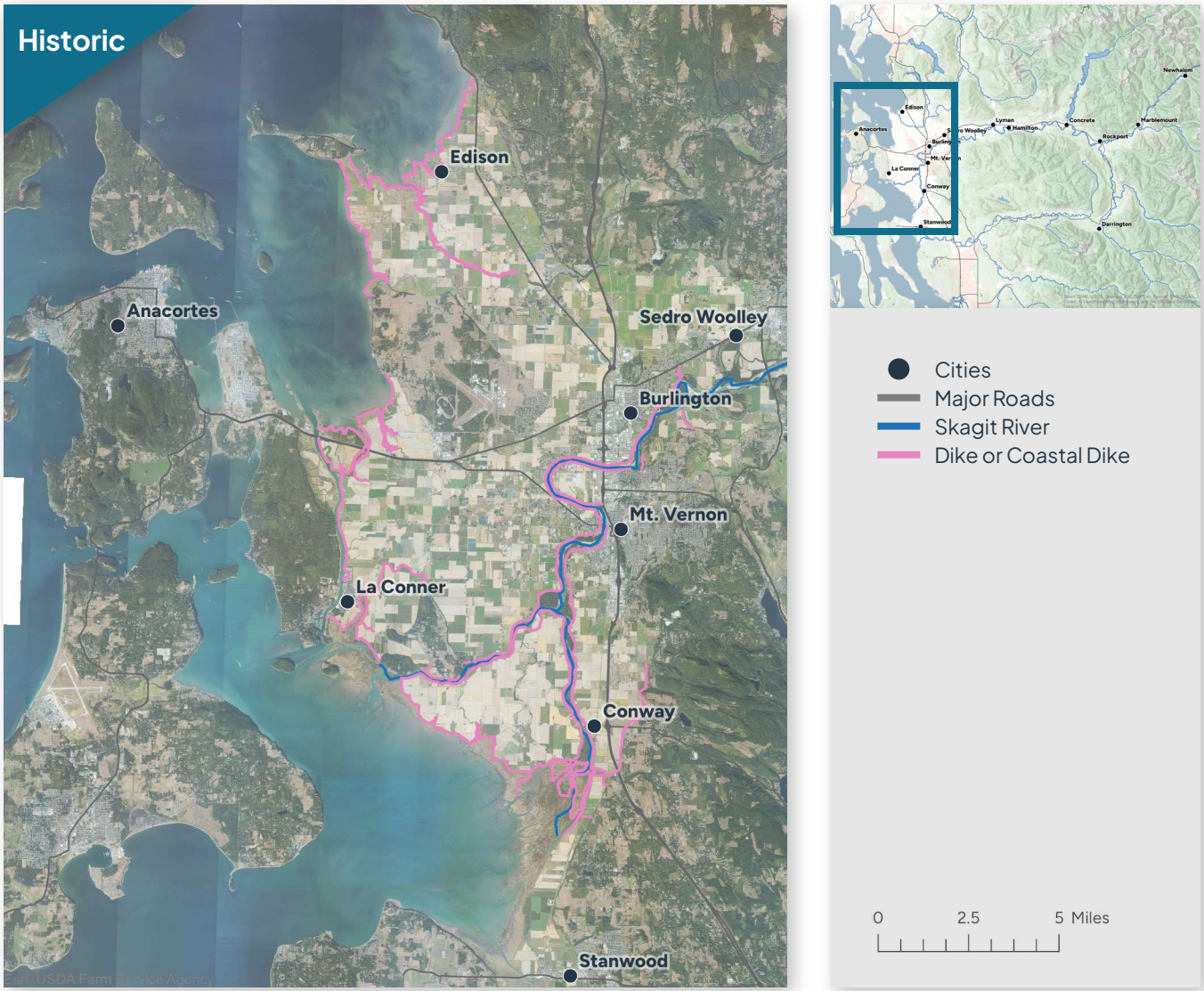
These maps show the difference in flood depth for a dike failure during the historic 100-year flood, relative to the "no failure" scenario. Differences are shown in shades of red when the dike failure flood depth is greater than the no failure scenario and shades of blue when the dike failure flood depth is less. White denotes areas with no change in flood depths between the failure and no failure scenarios. Light green shading highlights areas that are flooded in the dike failure scenario but not in the no failure scenario.

DEPTH-VELOCITY HAZARD MAPS



These maps show depth-velocity hazards for a historic 100-year event associated with a dike failure scenario. The hazard classifications shown in the key were assigned based on a standard international practice (AIDR, 2017) and grouped into six hazard ratings. The hazard mapping is based on clearwater hazards and does not account for secondary hazards such as geomorphic hazards (e.g., erosion, avulsion, debris flows, alluvial fan, etc.). Colors show when water poses a risk to children, adults, vehicles, and structures due to depth, velocity or a combination of the two, where darker blue indicates lower hazard classifications and yellows/oranges indicate the highest hazard classifications.

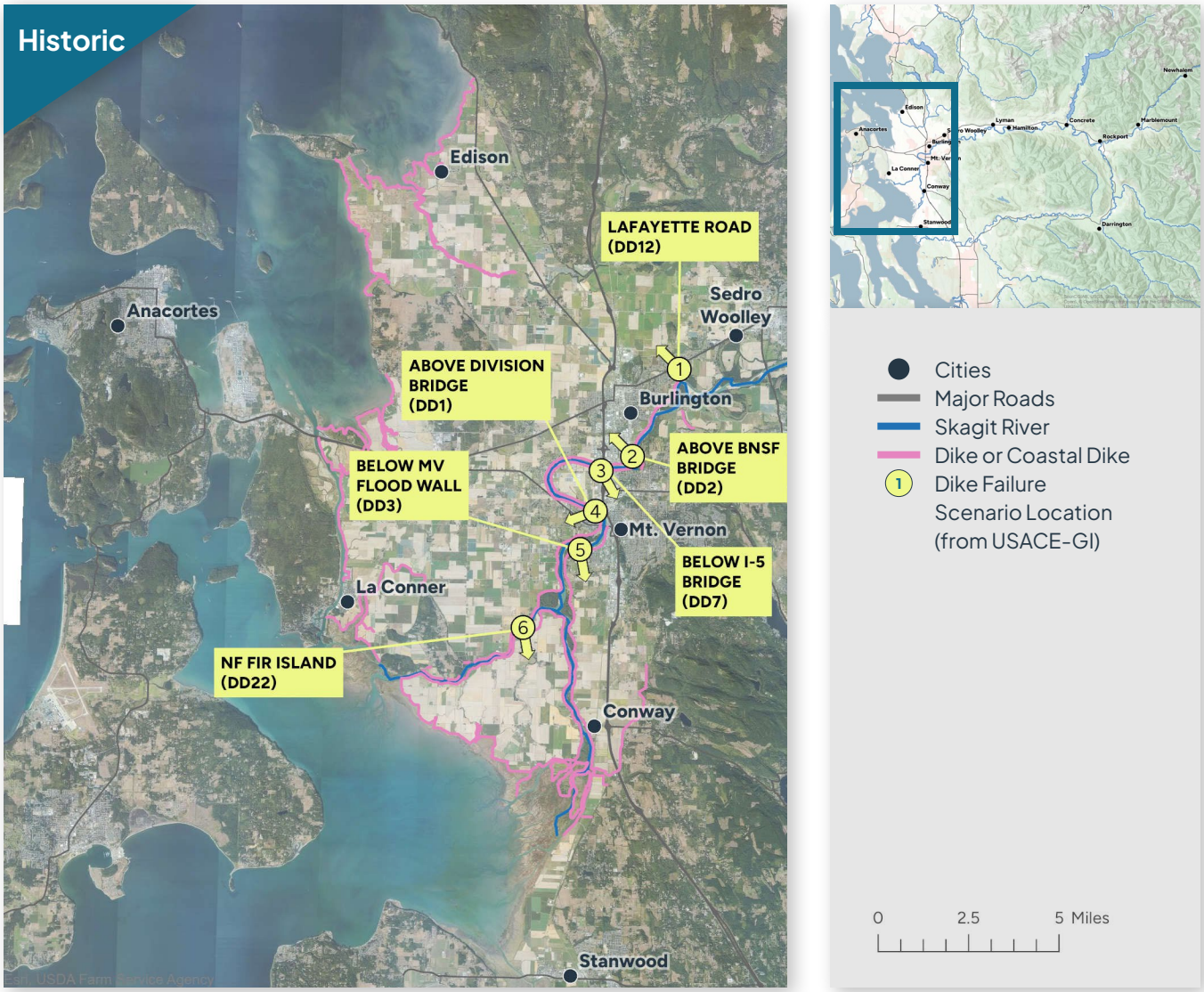
Overview Map



LIKELIHOOD OF A DIKE FAILURE IN A 100-YEAR HISTORIC OR FUTURE FLOOD EVENT

Flood maps, including those shown above, are often based on simulations in which all infrastructure – including dikes and coastal dikes – remains intact. Flood waters can overtop structures in these simulations, but they do not cause failures. In reality, dikes can fail even when they are not overtopped, and dike failure is a risk during Skagit floods. Understanding how flooding might evolve under different dike failure scenarios is an important part of evaluating flood risks. This map bundle provides six examples of failure scenarios in different parts of the lower Skagit system to explore how significantly a failure can affect flood depths and depth-velocity hazards.

Failure Locations (from USACE-GI)



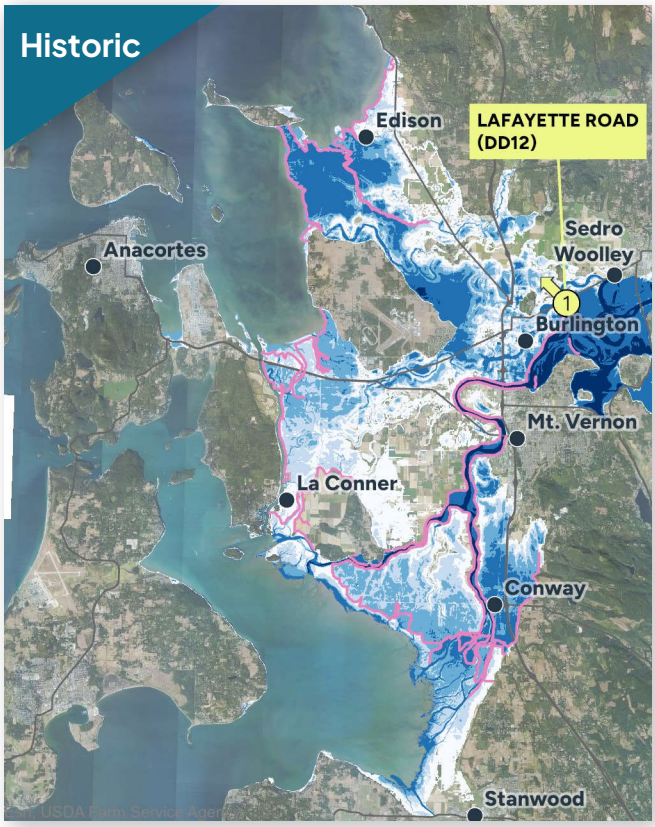
SIX SELECTED DIKE FAILURE SCENARIOS

This map shows the location of the six dike failure scenarios used to develop the depth, depth difference and depth-velocity hazard map products. The arrows show the direction (right bank or left bank) of the failure. The locations of these selected failures are not meant to imply that failures could only occur in these locations nor that they will necessarily occur in these locations. The locations were chosen to be representative of the consequences of failures at different locations along the river and occurring on different sides of the river. The six scenarios were selected for the Draft Skagit Basin General Investigation Study (USACE, 2014).

DIKE FAILURE SCENARIOS

Lafayette Road

FLOOD DEPTH



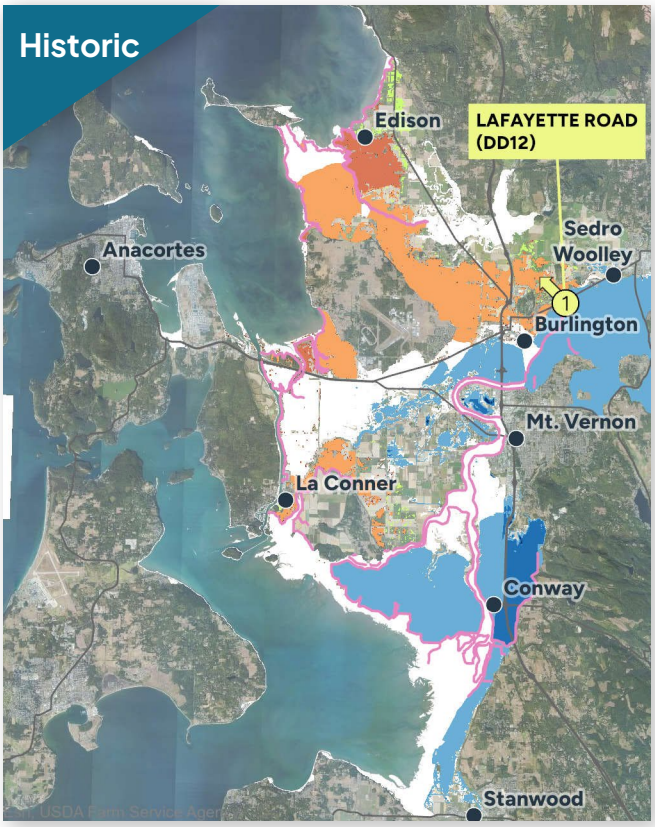
Flood Depth (ft)
- 0–1.5
- 1.5–3
- 3–5
- 5–15
- >15

0 2.5 5 Miles

Dike or Coastal Dike

1 Dike Failure Scenario Location (from USACE-GI)

DEPTH DIFFERENCE



Depth Difference (ft)
- -5 - -2
- -2 - -1
- -1 - 0
- 0
- 0 - 1
- 1 - 2
- 2 - 5
- 5–10

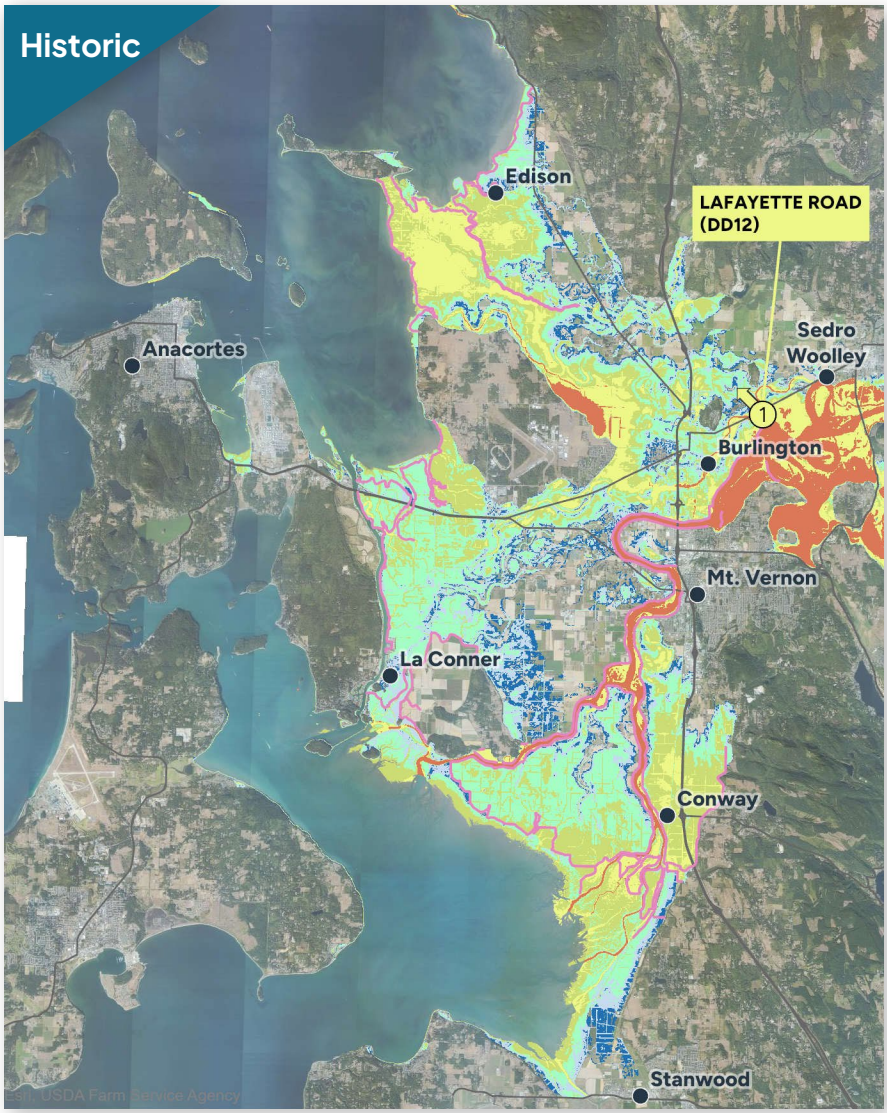
Additional flooding from dike failure

Dike or Coastal Dike

1 Dike Failure Scenario Location (from USACE-GI)

Lafayette Road

DEPTH-VELOCITY HAZARD



Descriptions for Flood Hazard Rating Mapping (AIDR, 2017)

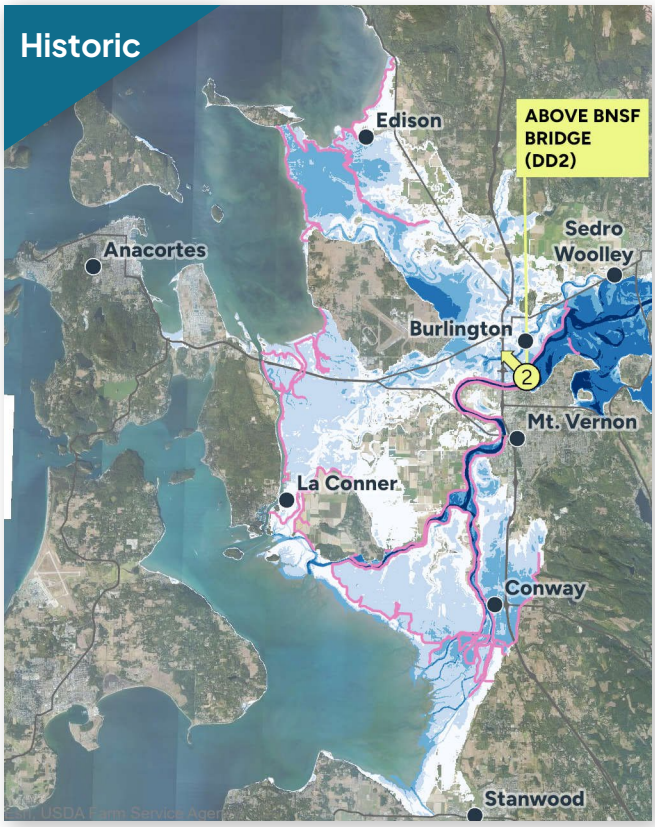
- Generally safe for vehicles, people, and buildings
- Unsafe for small vehicles
- Unsafe for vehicles, children, and the elderly
- Unsafe for vehicles and people
- Unsafe for vehicles and people. All building types vulnerable to structural damage.
- Unsafe for vehicles and people. All building types considered vulnerable to failure.
- Dike or Coastal Dike
- (1) Dike Failure Scenario Location (from USACE-GI)

0 2.5 5 Miles

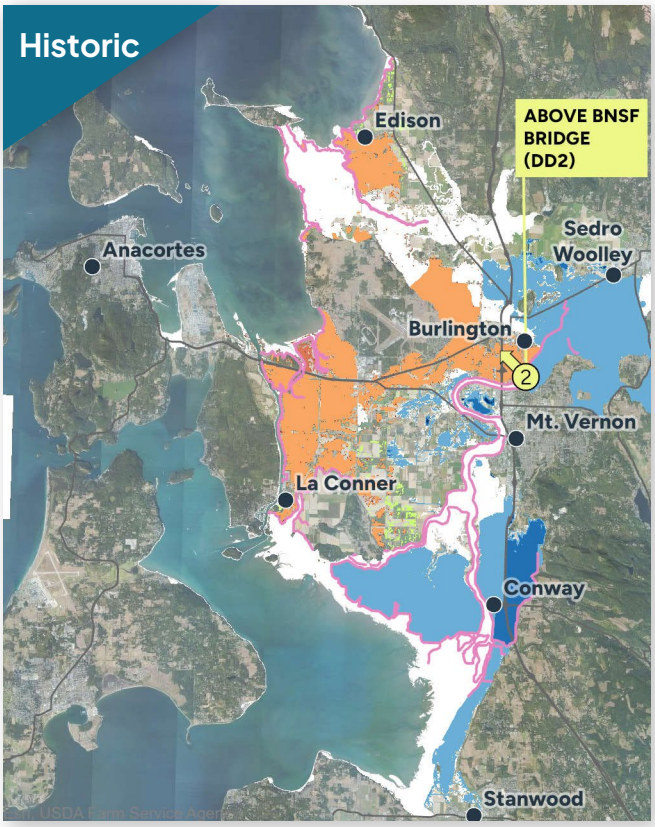
DIKE FAILURE SCENARIOS

Above BNSF Bridge

FLOOD DEPTH



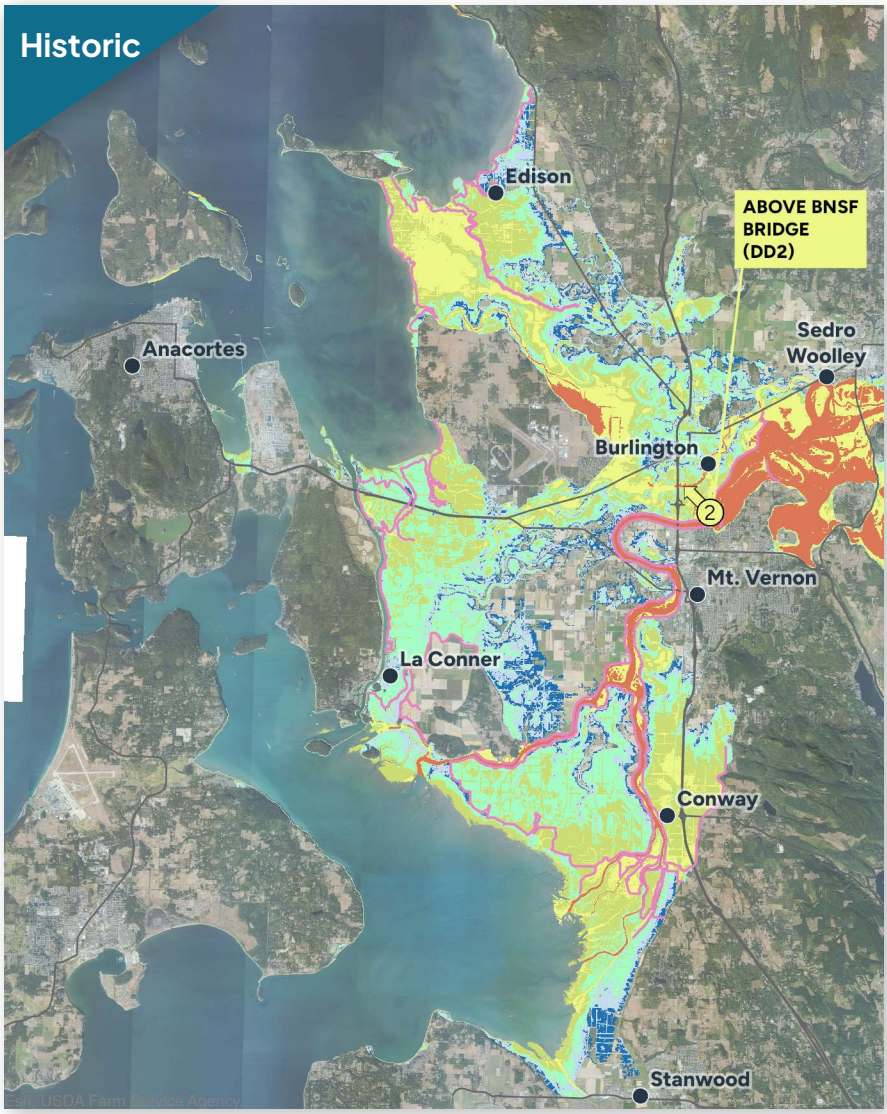
DEPTH DIFFERENCE



DIKE FAILURE SCENARIOS

Above BNSF Bridge

DEPTH-VELOCITY HAZARD



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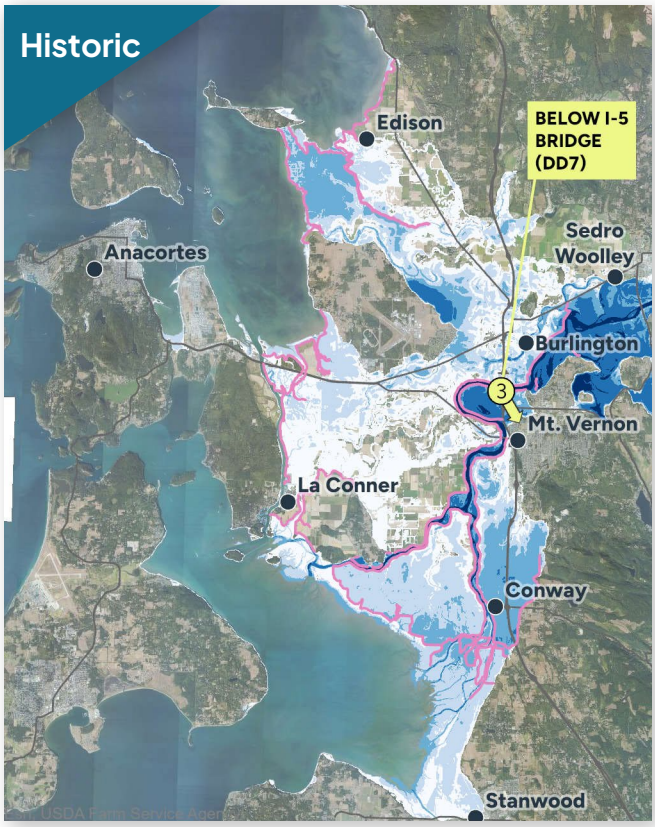
- Unsafe for vehicles and people. All building types considered vulnerable to failure.
- Dike or Coastal Dike
- (2) Dike Failure Scenario Location (from USACE-GI)

0 2.5 5 Miles

DIKE FAILURE SCENARIOS

Below I-5 Bridge

FLOOD DEPTH



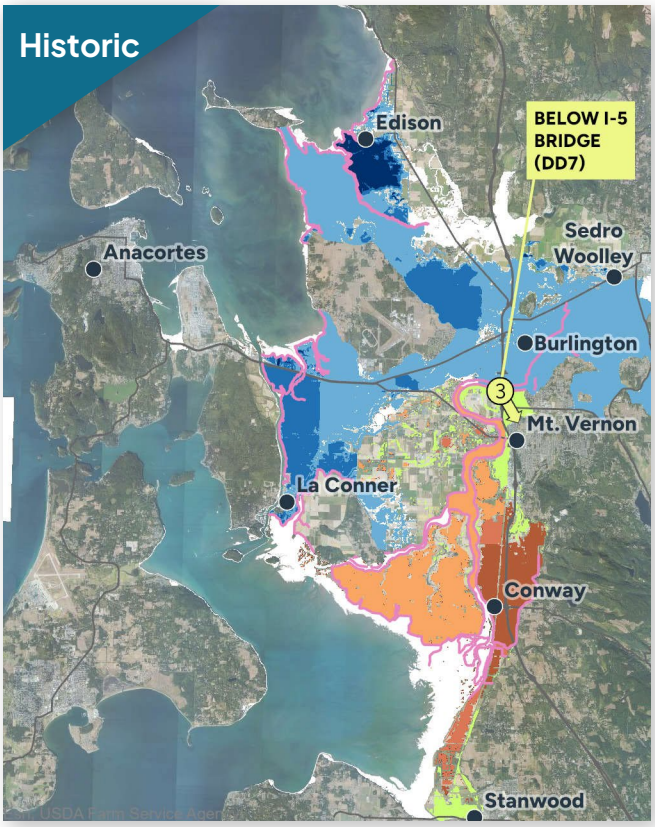
Flood Depth (ft)
- 0–1.5
- 1.5–3
- 3–5
- 5–15
- >15

0 2.5 5 Miles

Dike or Coastal Dike

3 Dike Failure Scenario Location (from USACE-GI)

DEPTH DIFFERENCE



Depth Difference (ft)
- -5 - -2
- -2 - -1
- -1 - 0
- 0
- 0 - 1
- 1 - 2
- 2 - 5
- 5–10

Additional flooding from dike failure

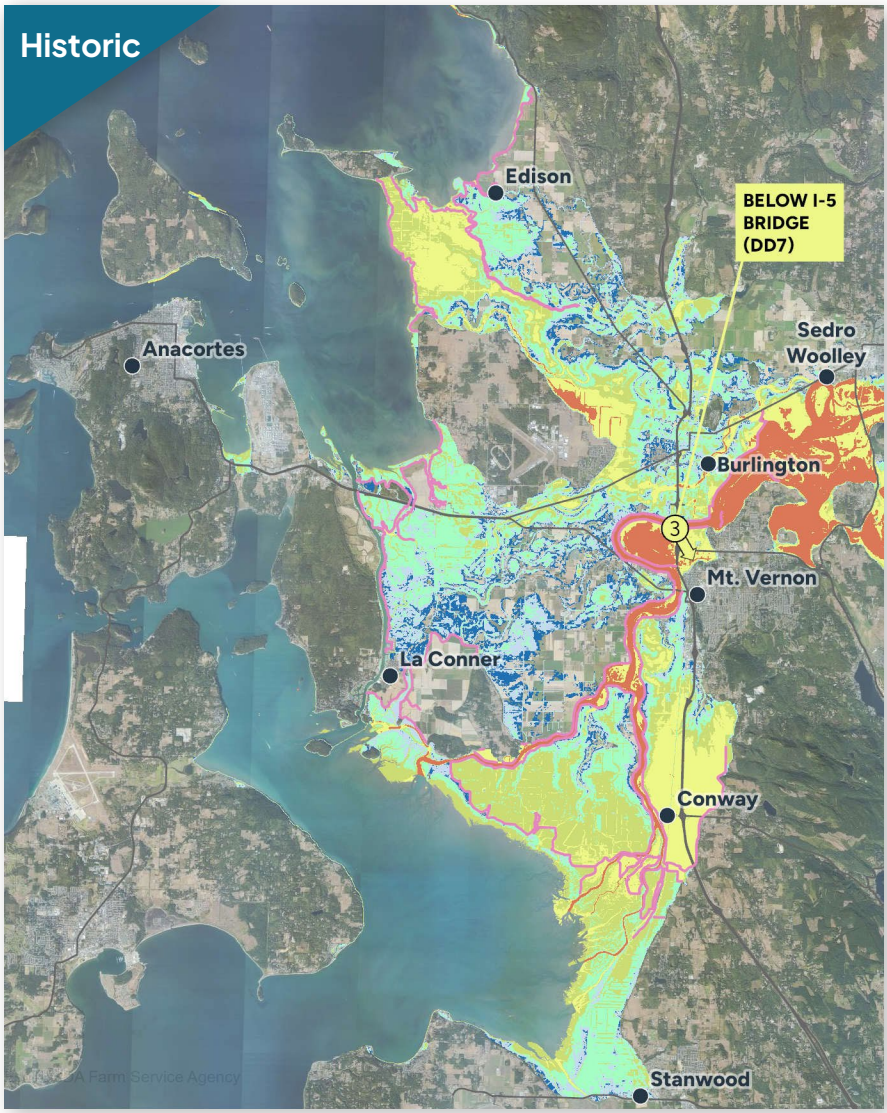
Dike or Coastal Dike

3 Dike Failure Scenario Location (from USACE-GI)

DIKE FAILURE SCENARIOS

Below I-5 Bridge

DEPTH-VELOCITY HAZARD



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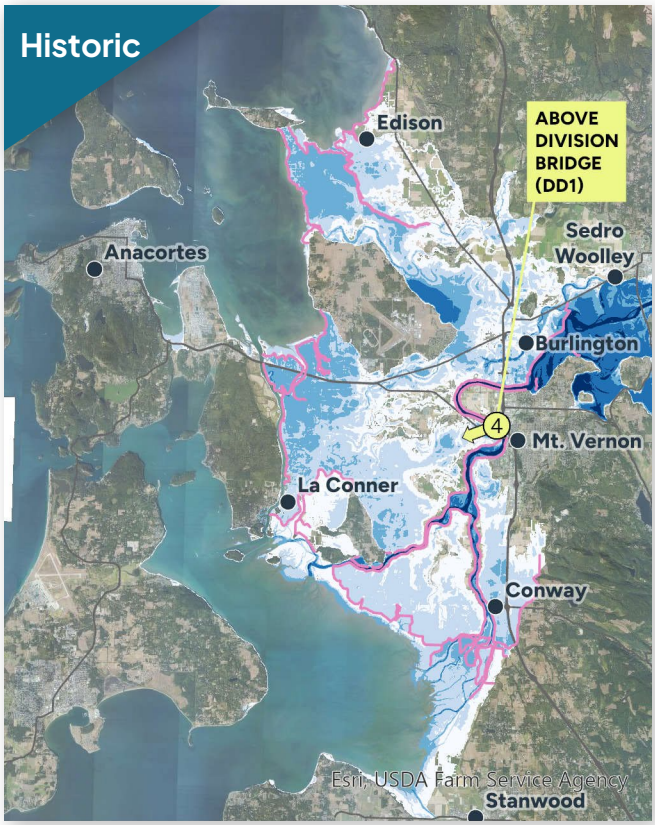
- Unsafe for vehicles and people. All building types considered vulnerable to failure.
- Dike or Coastal Dike
- (3) Dike Failure Scenario Location (from USACE-GI)

0 2.5 5 Miles

DIKE FAILURE SCENARIOS

Above Division Bridge

FLOOD DEPTH



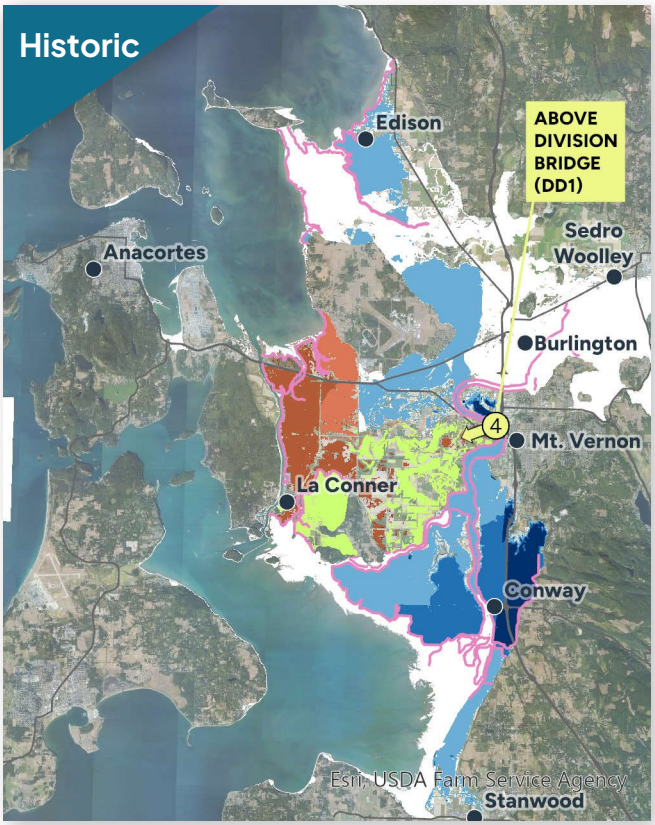
Flood Depth (ft)
- 0–1.5
- 1.5–3
- 3–5
- 5–15
- >15

0 2.5 5 Miles

Dike or Coastal Dike

4 Dike Failure Scenario Location (from USACE-GI)

DEPTH DIFFERENCE



Depth Difference (ft)
- -5 - -2
- -2 - -1
- -1 - 0
- 0
- 0 - 1
- 1 - 2
- 2 - 5
- 5–10

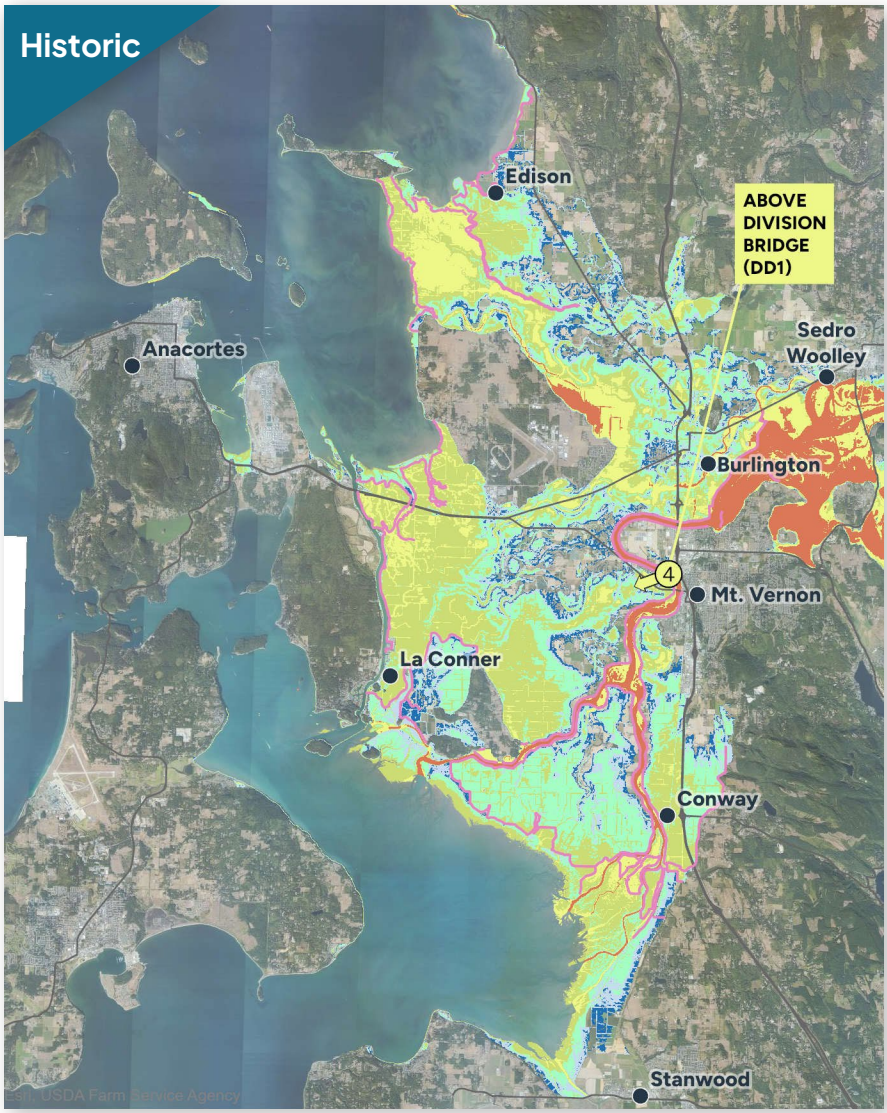
Additional flooding from dike failure

Dike or Coastal Dike

4 Dike Failure Scenario Location (from USACE-GI)

Above Division Bridge

DEPTH-VELOCITY HAZARD



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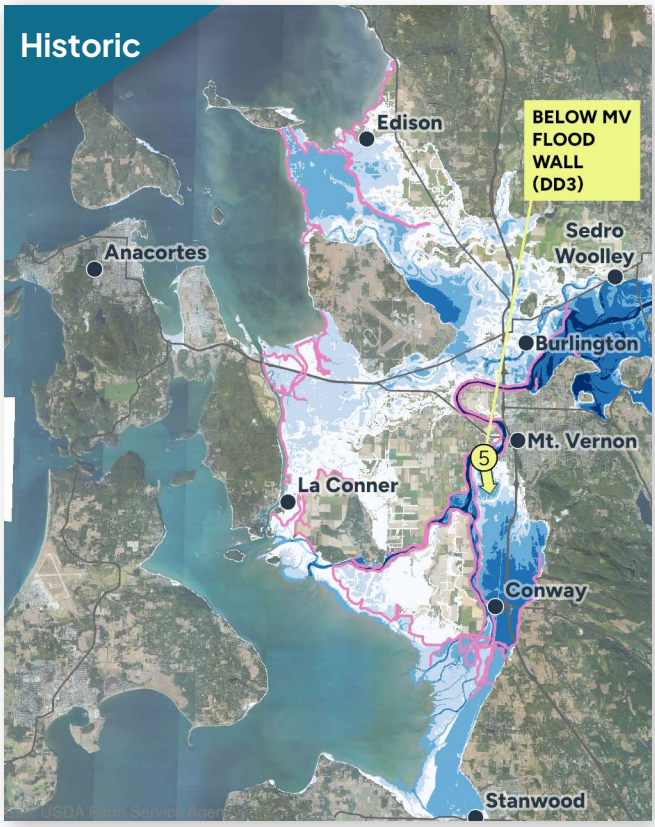
- Unsafe for vehicles and people
- Unsafe for vehicles and people. All building types vulnerable to structural damage.
- Unsafe for vehicles and people. All building types considered vulnerable to failure.
- Dike or Coastal Dike
- 4 Dike Failure Scenario Location (from USACE-GI)

0 2.5 5 Miles

DIKE FAILURE SCENARIOS

Below Mount Vernon Flood Wall

FLOOD DEPTH



Flood Depth (ft)

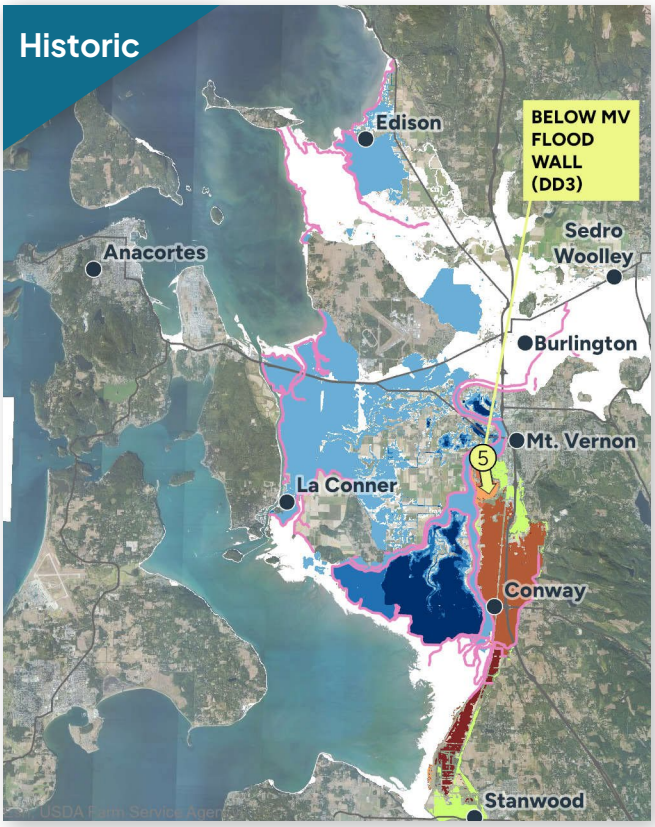
- 0–1.5
- 1.5–3
- 3–5
- 5–15
- >15

0 2.5 5 Miles

Dike or Coastal Dike

5 Dike Failure Scenario Location (from USACE-GI)

DEPTH DIFFERENCE



Depth Difference (ft)

- -5 - -2
- -2 - -1
- -1 - 0
- 0
- 0 - 1
- 1 - 2
- 2 - 5
- 5–10

Additional flooding from dike failure

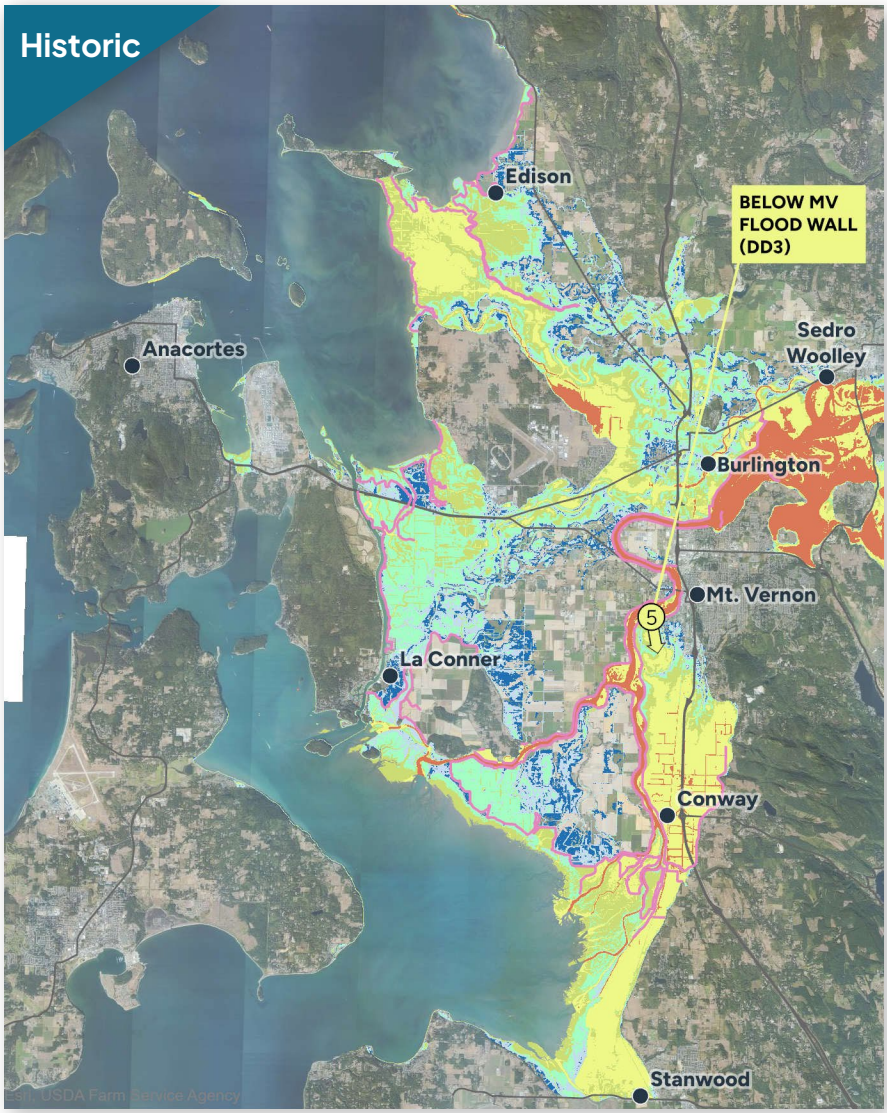
Dike or Coastal Dike

5 Dike Failure Scenario Location (from USACE-GI)

DIKE FAILURE SCENARIOS

Below Mount Vernon Flood Wall

DEPTH-VELOCITY HAZARD



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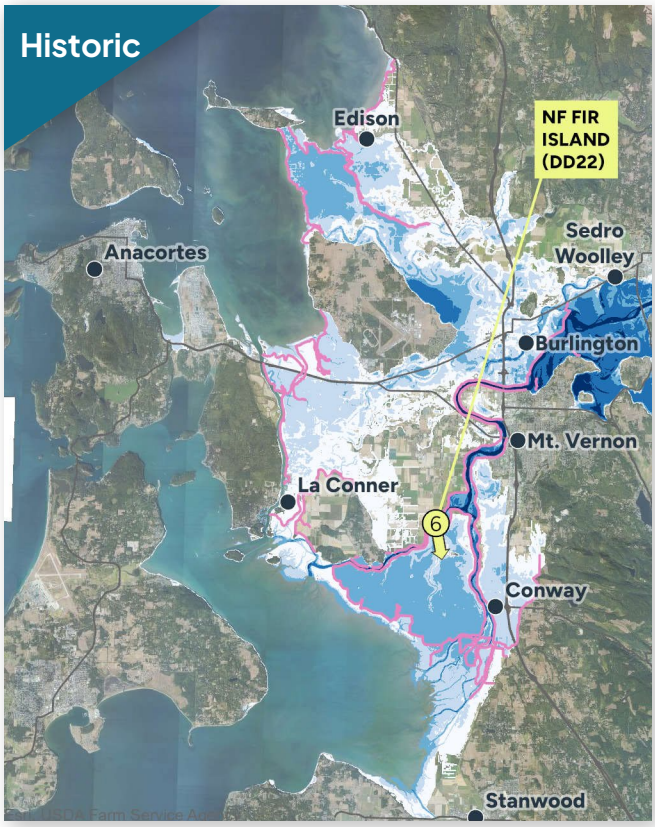
- Dike or Coastal Dike
- 5 Dike Failure Scenario Location (from USACE-GI)

0 2.5 5 Miles

NF Fir Island

FLOOD DEPTH



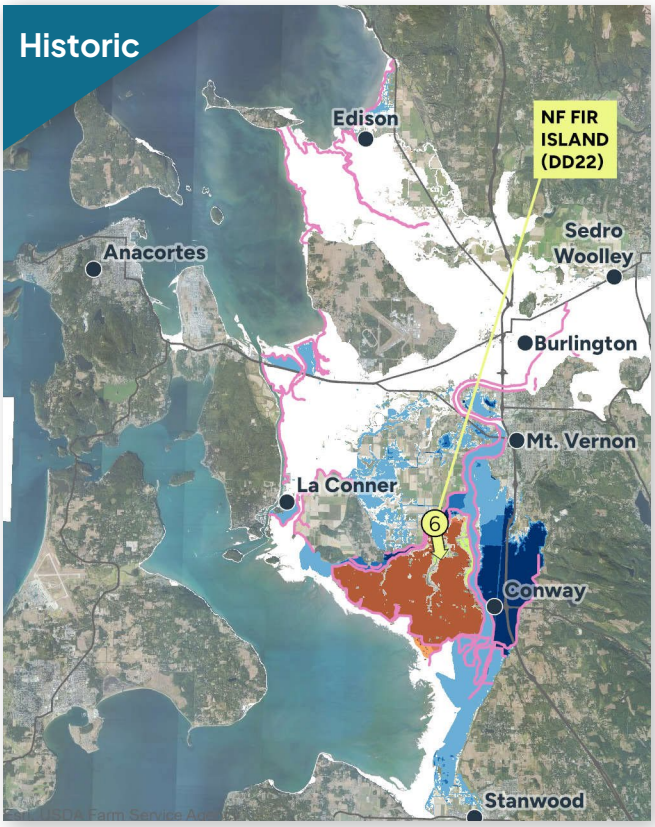
Flood Depth (ft)
- 0–1.5
- 1.5–3
- 3–5
- 5–15
- >15

0 2.5 5 Miles

Dike or Coastal Dike

6 Dike Failure Scenario Location (from USACE-GI)

DEPTH DIFFERENCE



Depth Difference (ft)
- -5 - -2
- -2 - -1
- -1 - 0
- 0
- 0 - 1
- 1 - 2
- 2 - 5
- 5–10

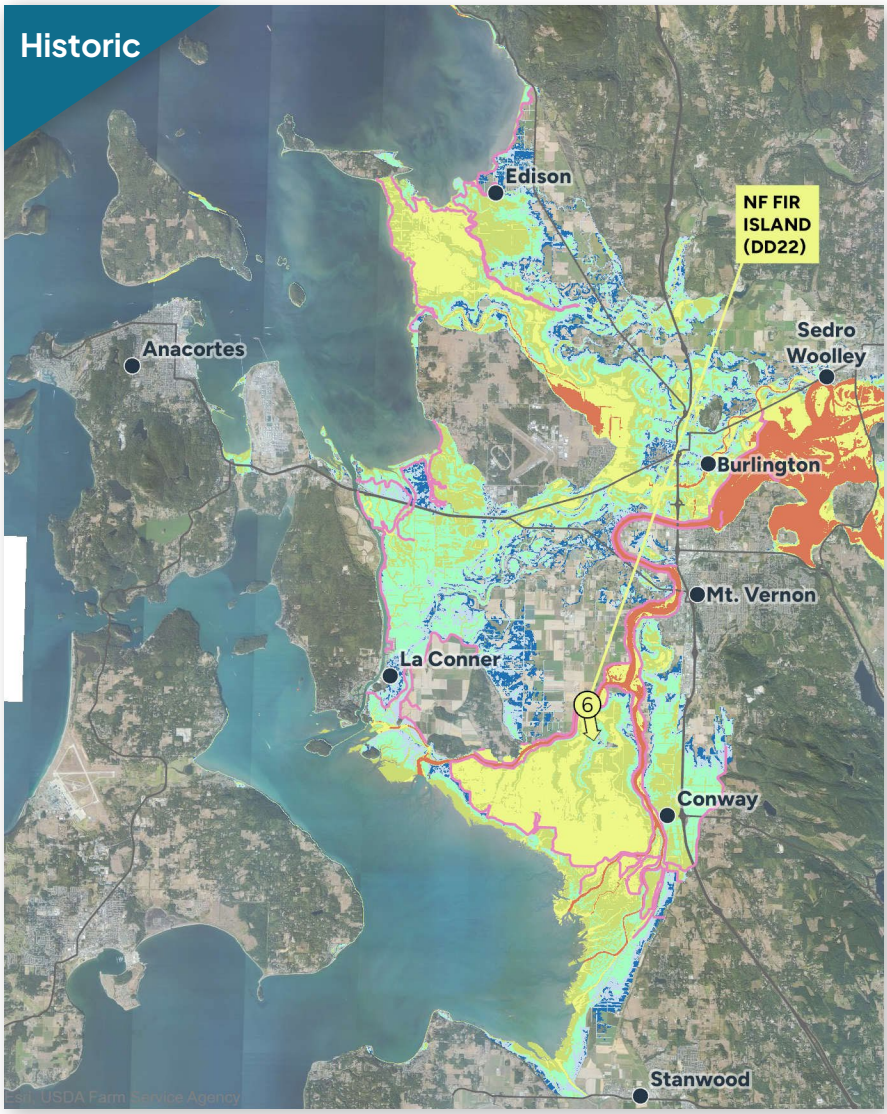
Additional flooding from dike failure

Dike or Coastal Dike

6 Dike Failure Scenario Location (from USACE-GI)

NF Fir Island

DEPTH-VELOCITY HAZARD



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0 2.5 5 Miles

References

Microsoft (2022). Building Footprints [shapefile]. File last modified 2022. https://www.arcgis.com/home/item.html?id=bb69f10baf334d4c935a0fb23d758f38

Skagit County (2022). Dikes and Levees [shapefile]. File last modified 2022.

Skagit County GIS. Road Centerline [shapefile]. File published 2019.

(USACE) U.S. Army Corps of Engineers. (2014). Skagit River Flood Risk Management General Investigation: Draft Feasibility Report and Environmental Impact Statement. Prepared for Skagit County, Washington, by the Seattle District of the U.S. Army Corps of Engineers. Available at: https://www.skagitcounty.net/Departments/PublicWorksSalmonRestoration/main.htm

(USDA) United States Department of Agriculture (2023). USDA Farm Service Agency, National Agriculture Imagery Program (NAIP) 2023 Imagery. https://nrcs.app.box.com/v/naip

Washington State Department of Transportation Cartography/GIS Section. State Routes of Washington at 1:24,000 [shapefile]. File published 2008.