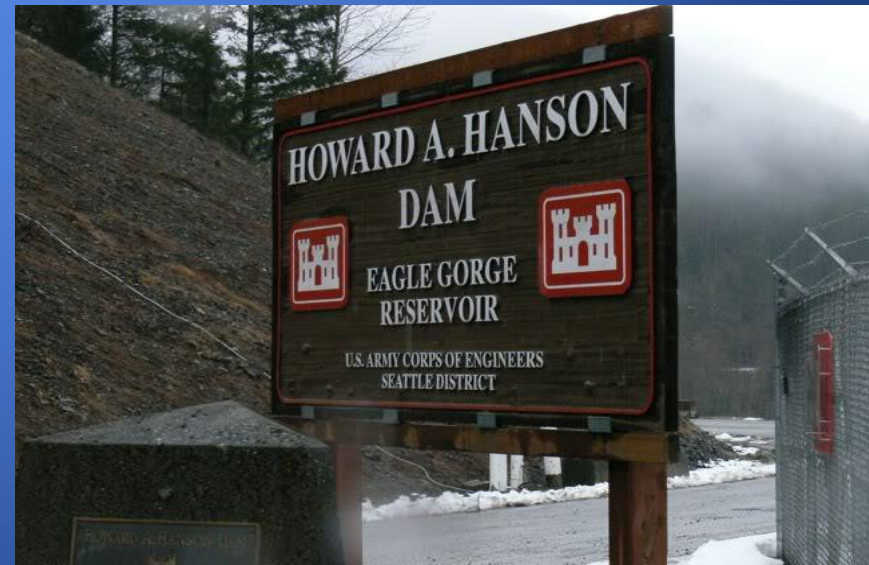


The Howard Hanson Dam & Green River Valley Flood Analysis



Washington State Department of Transportation

**Richard C. Daniels, Diana McGuerty, and Oai Tang,
The WSDOT GIS EOC Team**



Problems & Issues

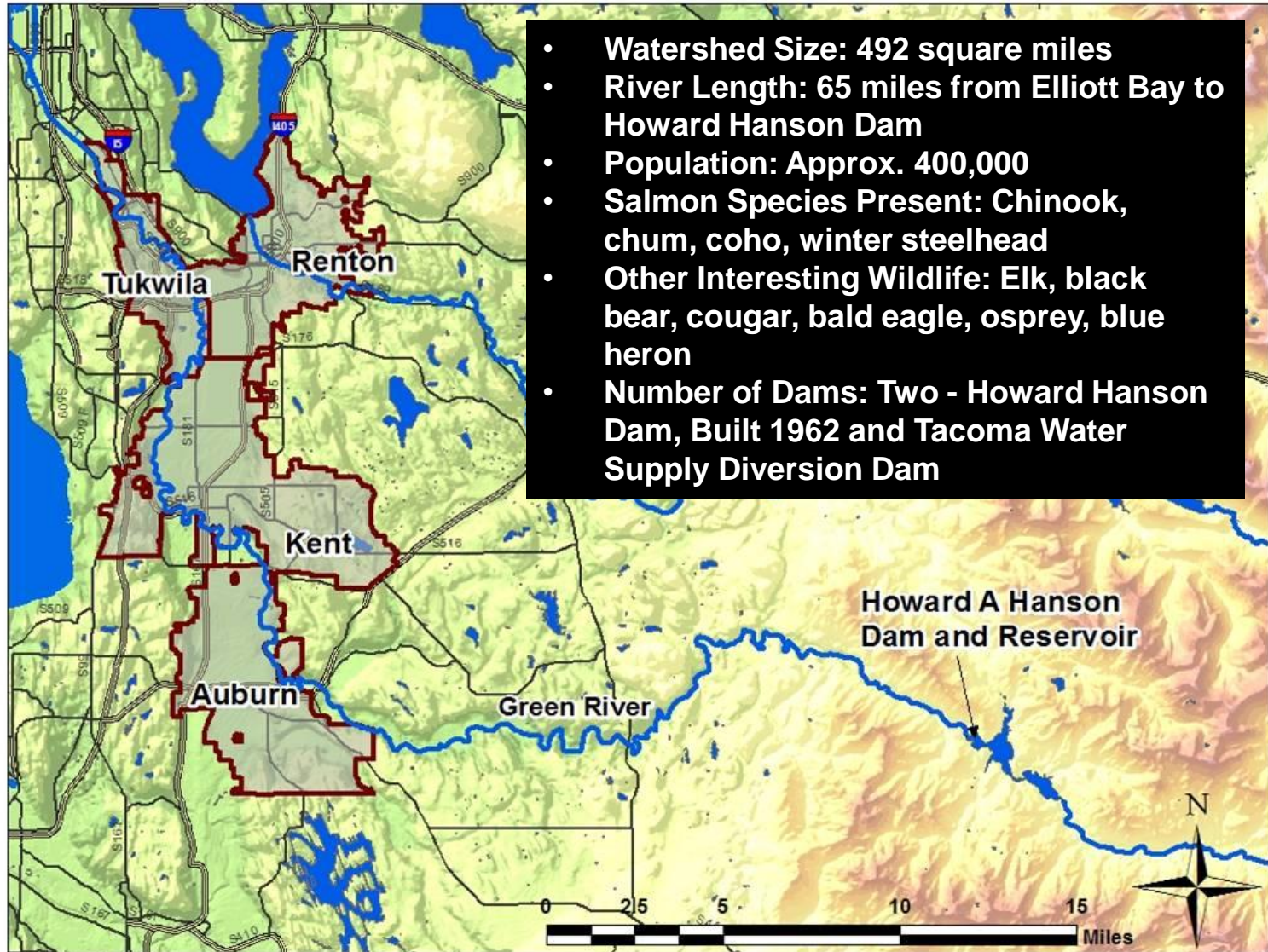
- Risk is due to high rates of water seeping through an earthen bank that forms the right-shoulder of the dam. Seepage increase occurred after record high water in January 2009.
 - Record water level reached = 1,189 feet
 - Maximum pool level = 1,206 feet
- Army Corps of Engineers has placed restrictions on the pool elevation of 1,165 feet until repairs are completed, this may take as long as three years (2012).
- With the restricted pool elevation, downstream communities face the highest risk of flooding since 1961.
- **EMD Issued Directive on September 14th** for all State Agencies conduct risk assessments to determine possible impact on State Infrastructure and services within in the Green River Valley.

Note - The dam is not in danger of failing

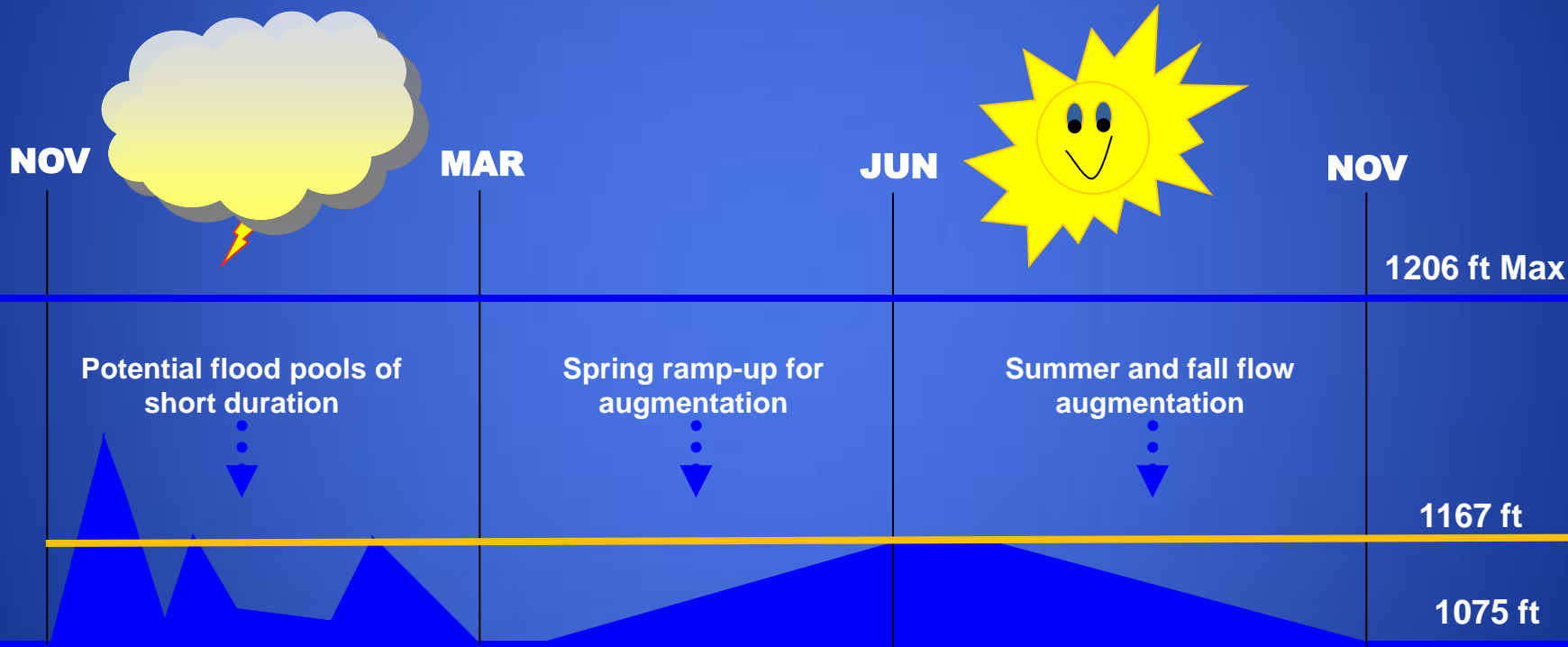
WSDOT EOC, brought together a small portion of the EOC GIS Team to gather the data on HHD and conduct the impact analysis for the Department.

- Joe Schmit acted as liaison between Executives and other agencies to find out requirements**
- Rich Daniels put together the imagery received from various sources and did the spatial/3D analysis to reconfigure the LIDAR, TINS, and other formats to determine elevation data**
- Oai Tang put together the specialized information needed by maintenance- such as pits/quarries, culverts, storm water, facilities, fuel & equipment storage**
- Diane McGuerty gathered data from the FEMA, State EOC, King CO, NW Region and other specialty offices. Data includes imagery, survey data, CAD drawings, detours, geocoding & device locations**

Green River Valley Watershed



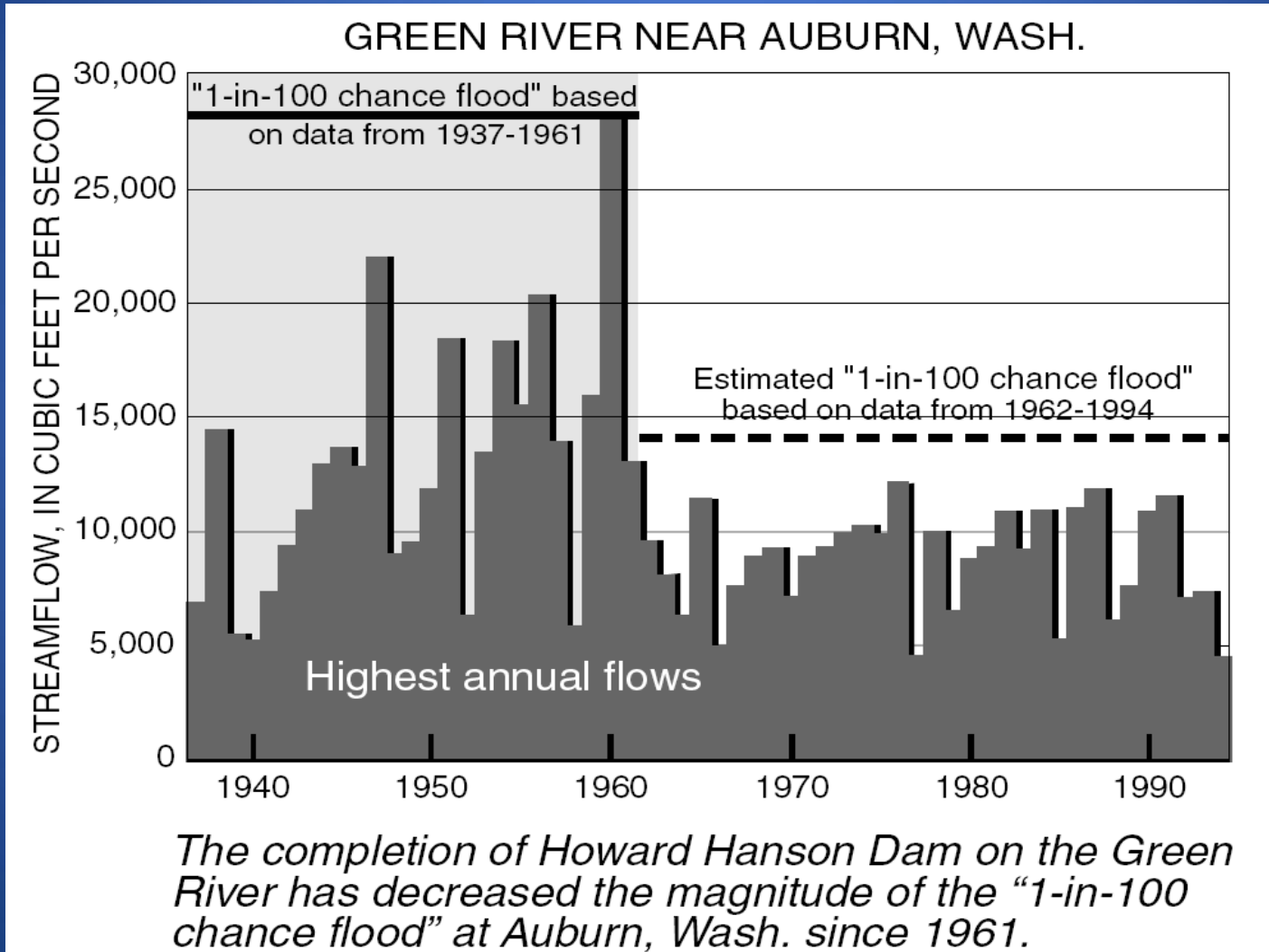
Normal Green River Flow Pattern at Howard Hanson Dam



Pool elevation in feet above sea level

Why is this a Problem?

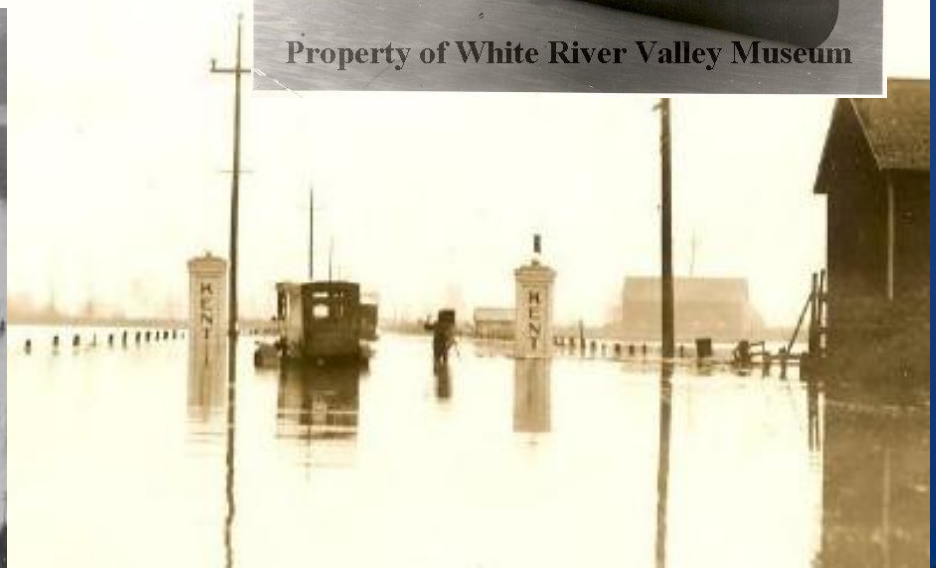
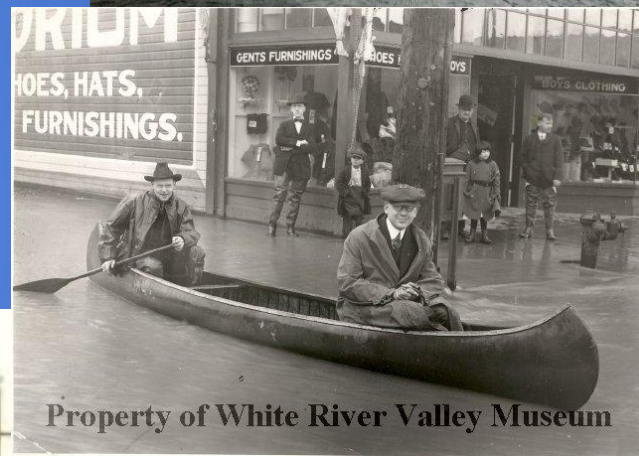
Green River Valley Highest Annual Flows 1937-1994



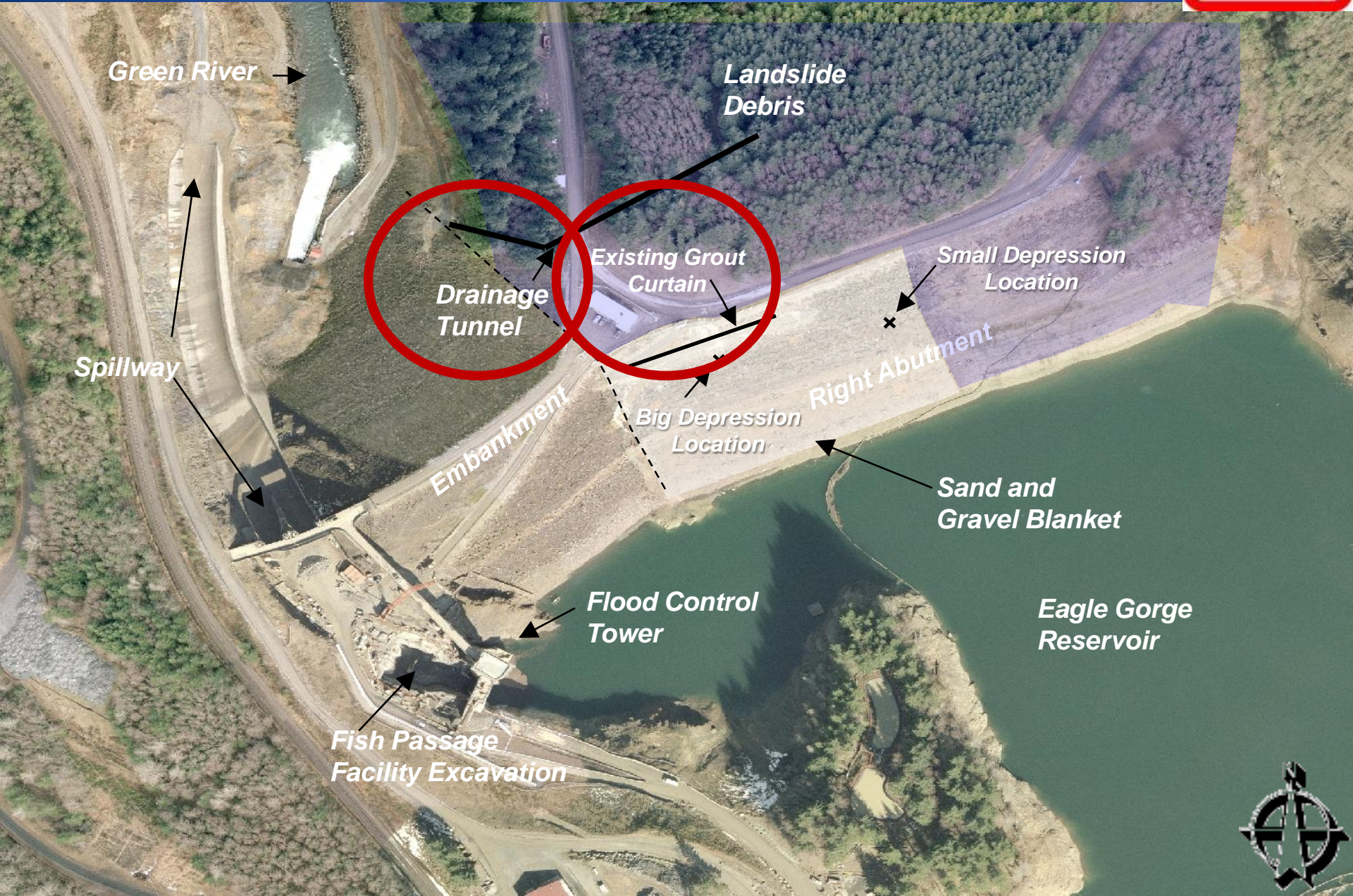
The last major flood in 1959 reached a water level of 69.7 ft at Auburn. Flood stage is 61.7 ft

Prior to 1961

- Prior to 1961 the Green River was expected to overflow its banks nearly every winter. The entire valley from Boeing Field to Auburn would be underwater,
- Kent was only negotiable by boat. Livestock would be drowned, chickens and cats were marooned in the trees, and Longacres Race Track in Renton (south of I-405) would be two or three feet under water.



Howard Hanson Dam



Drainage Tunnel

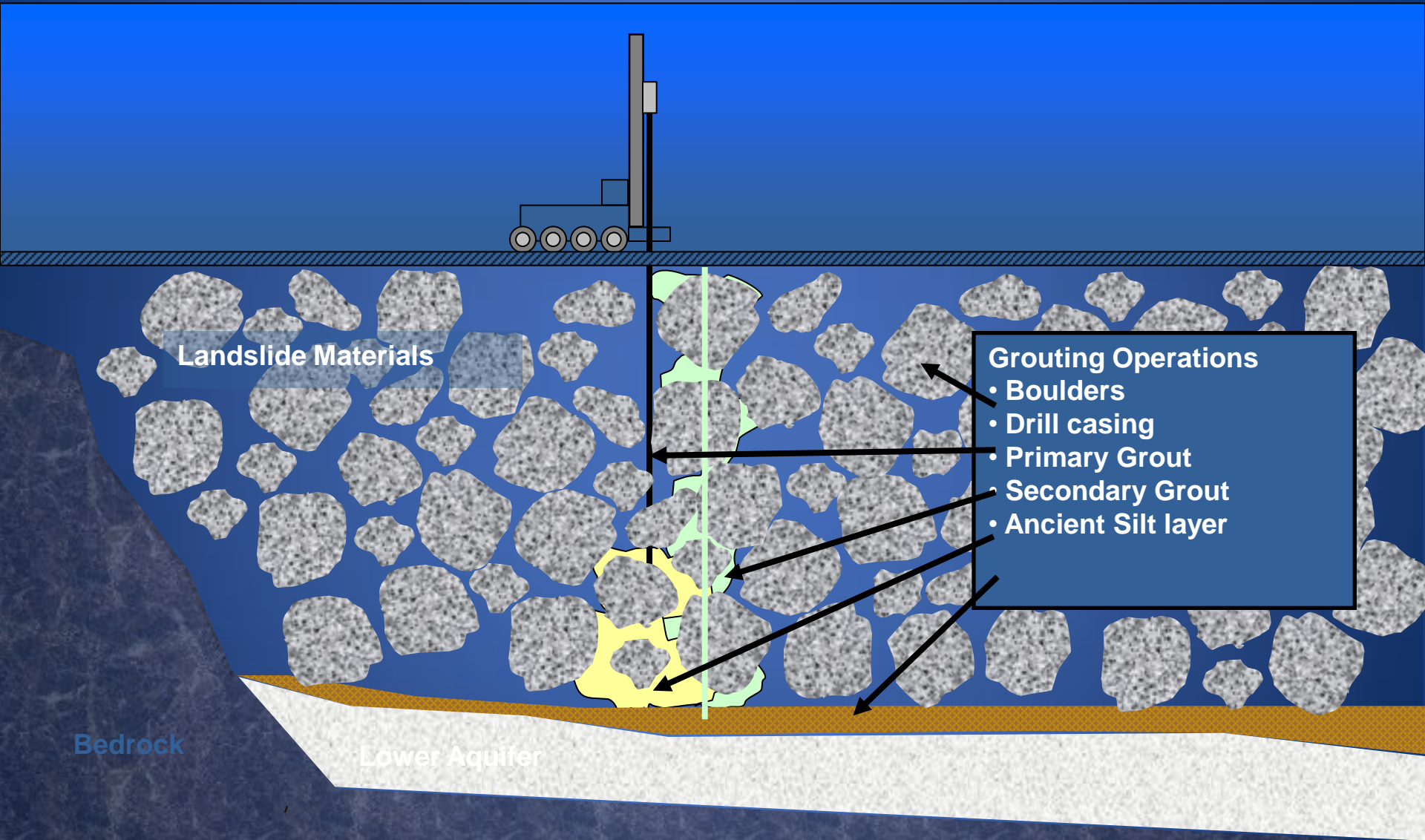


Drainage Tunnel Improvement Construction



09/17/2009

Grout Curtain Construction



Grout Curtain Construction



U.S. Corp of Engineers Flood Scenarios

Scenarios A25, A50, and A100 provide the best low, moderate, and high scenarios

Run Name	Peak Flow at Auburn gage (cfs)	Discharge (cfs)	Notes:
A25	13,900	8,800	No levee breach, a pool restriction of 1165 and 4% annual chance exceedance inflow to Howard Hanson Dam.
C100	17,600	11,000	No levee breach, a pool restriction of 1185 and 1% annual chance exceedance inflow to Howard Hanson Dam.
A50	19,500	13,500	No levee breach, a pool restriction of 1165 and 2% annual chance exceedance inflow to Howard Hanson Dam.
A100	25,000	19,200	No levee breach, a pool restriction of 1165 and 1% annual chance exceedance inflow to Howard Hanson Dam.
A100B	25,000	19,200	Includes levee breach, a pool restriction of 1165 feet, and 1% annual chance exceedance inflow to Howard Hanson Dam.

COE Flood Scenarios

Based on pre 1961 data:

A25 is approximately the 2-year flood

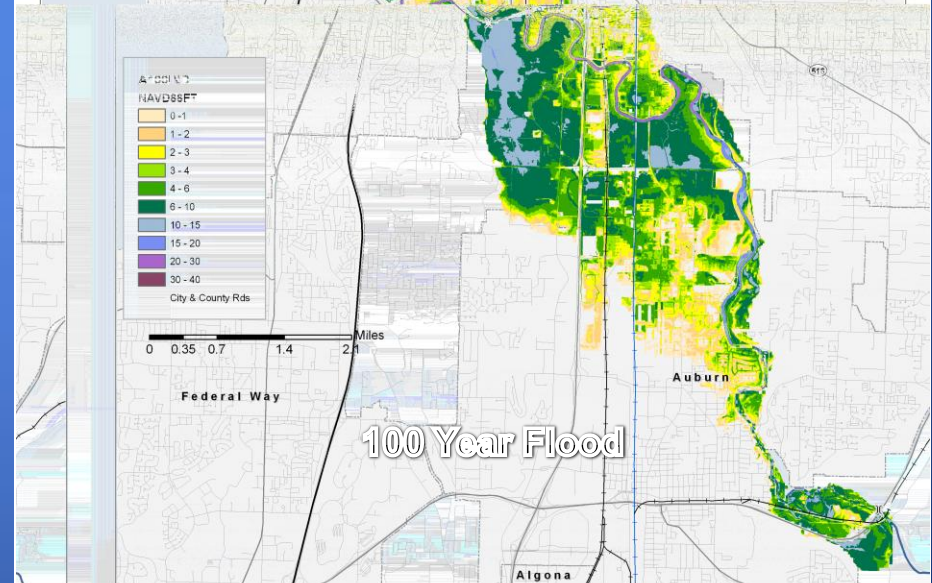
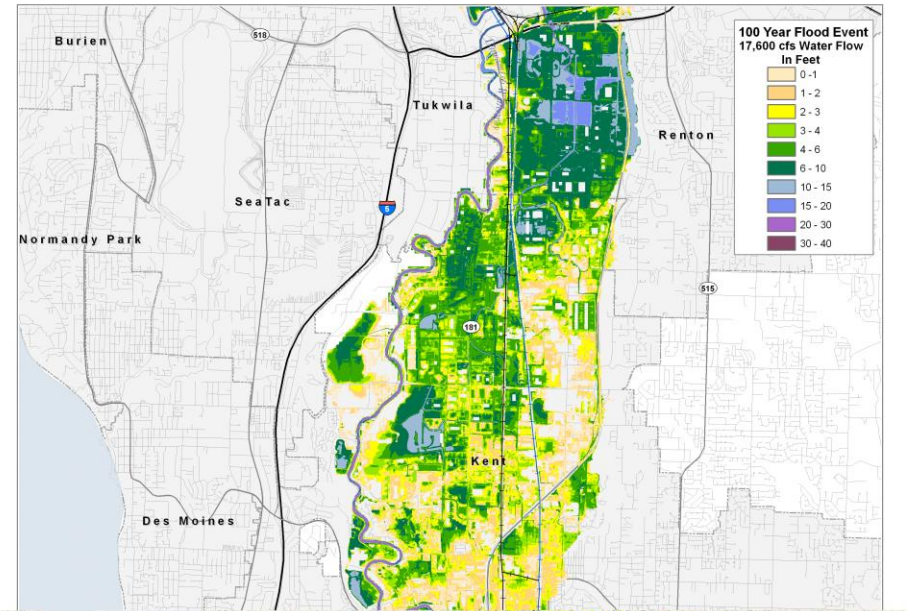
C100 is approximately the 7-year flood

A50 is approximately the 10-year flood

A100 is approximately the 100-year flood

C100 Chosen as the 'base line' flood for impact analysis by the State Emergency Management Division.

Howard Hanson Dam, 25,000 cfs Flood Scenario (A100)
Washington State Highway Potential Closure Planning



01-405

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NOTE:
Standardized event data may vary or be updated as a user's data base changes depending on the study, project or other activities.
Please ensure that you are utilizing the most current map product for operational decision making.

Potential Flooding Area from SR 18 t

- All Risk Bridge Structures
- Arterial
- Freight Rail Lines
- U.S. Interstate
- U.S. Highway
- State Route
- Major Levee
- River/Stream
- County Line



WSDOT Flood Impact Assessment Procedure

- 1. Created 'Foot Print' of C100 flood area & a LIDAR water depth grid derived from FEMA flood models**
- 2. Identified assets that may be at risk by determining if they fell within the C100 flood foot print.**
- 3. Identified the risk to infrastructure for each asset type**
- 4. For items that could be damaged or "lost" if inundated we determined the expected depth of water**
- 5. Lastly, methods to mitigate the risk were identified (e.g., sand bagging, elevating, tie down, or relocating).**

ArcGIS Impact Model – Used to Identify Features that fell Within the C100 Flood Foot Print.

The image displays the ArcGIS software interface and a workflow diagram. The ArcMap window shows a map of a city area with various layers and toolboxes. The workflow diagram, titled "Clip Inventory with Mask", illustrates the process of identifying features within a flood footprint.

ArcMap Interface:

- Layers Panel:** Shows layers including ITS_Devices, C100 Flood Mask, C100 Depth Grid (Value: High: 11709, Low: -3623), C100IND (NAVD88FT), and Bing Maps - Roads.
- Toolbox:** Lists various tool categories such as ArcToolbox, 3D Analyst Tools, Analysis Tools, Cartography Tools, Conversion Tools, Coverage Tools, Data Interoperability Tools, Data Management Tools, Geocoding Tools, Geostatistical Analyst Tools, Linear Referencing Tools, Network Analyst Tools, Samples, Spatial Analyst Tools, Spatial Statistics Tools, WSDOT EOC Toolbox, Calc Evacuation Population, Calculate Population Statistics, Clip & Resample Population, Create Mask from Raster, Intersect Polygons with Routes, Merge Features, Clip Inventory with Mask, Summary Statistics, and Transfer Raster Values for a Polyline.

Clip Inventory with Mask Workflow Diagram:

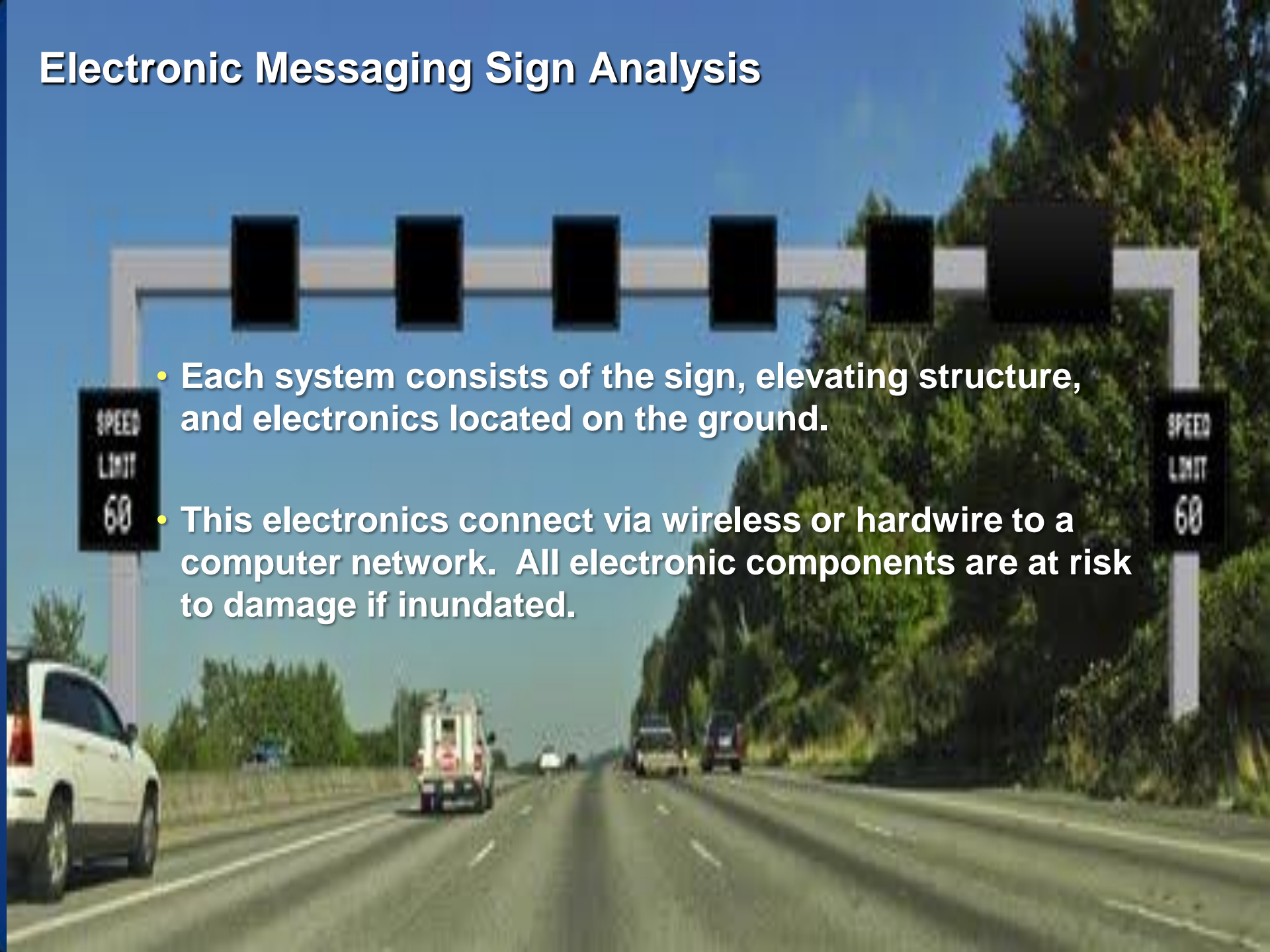
```
graph TD; P1((P)) --> InventoryItem((Inventory Item)); P2((P)) --> C100Flood((C100 Flood)); InventoryItem --> Clip[Clip]; C100Flood --> Clip; Clip --> InventoryClip((Inventory_Clip.shp)); InventoryClip --> SurfaceSpot[Surface Spot]; C100DepthGrid((C100 Depth Grid)) --> SurfaceSpot; SurfaceSpot --> OutputFeature((Output Feature)); P3((P)) --> OutputFeature;
```

The diagram shows the following steps:

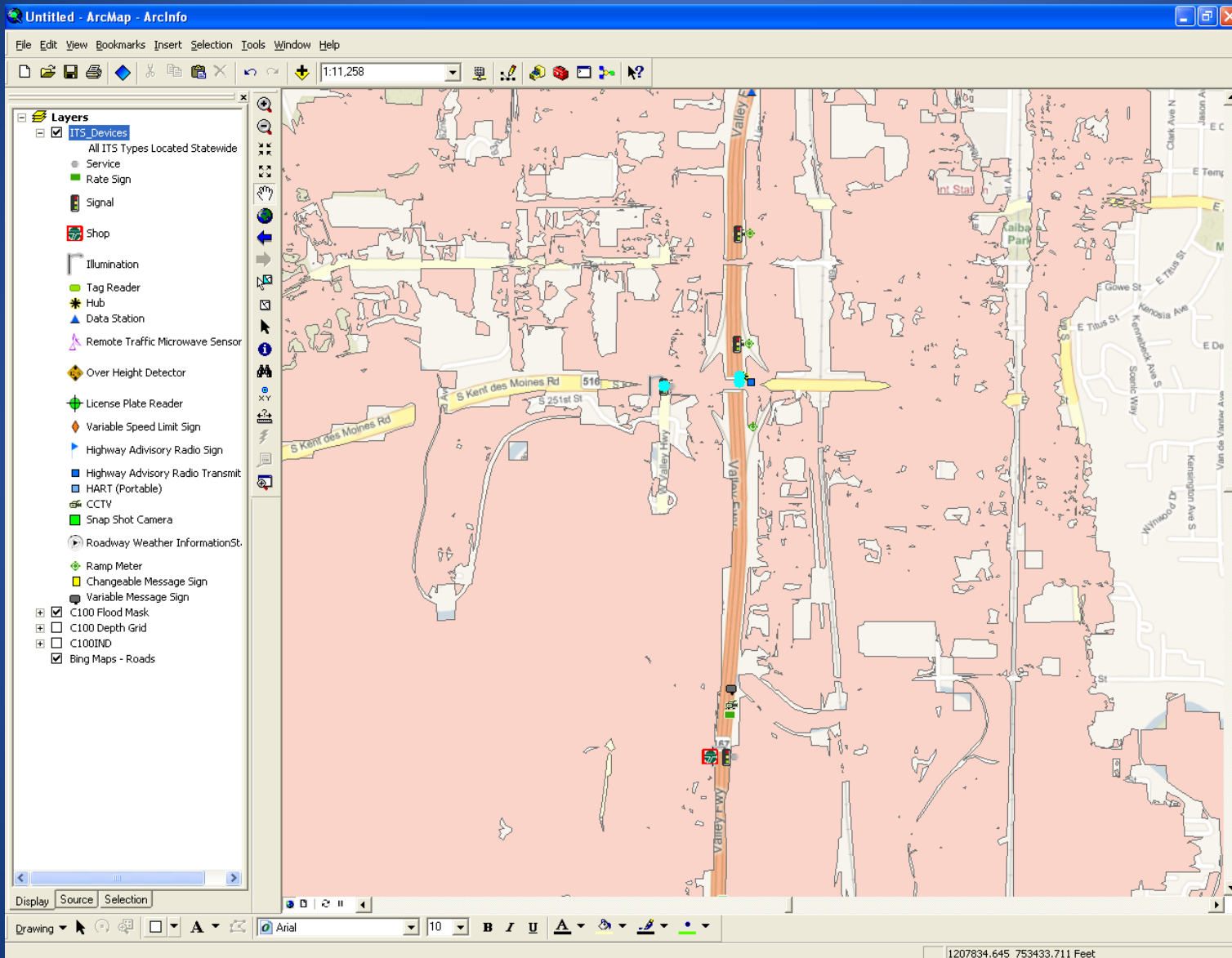
- Input: Inventory Item (P) and C100 Flood (P).
- Process: Clip (using a hammer icon).
- Output: Inventory_Clip.shp (P).
- Input: Inventory_Clip.shp (P) and C100 Depth Grid (P).
- Process: Surface Spot (using a hammer icon).
- Output: Output Feature (P).

Electronic Messaging Sign Analysis

- Each system consists of the sign, elevating structure, and electronics located on the ground.
- This electronics connect via wireless or hardwire to a computer network. All electronic components are at risk to damage if inundated.



Step by Step Overlay for Electronic Messaging Signs



Of the 159 signs, meters, luminaries, data stations, and EM signs in the valley, 17 are subject to inundation.

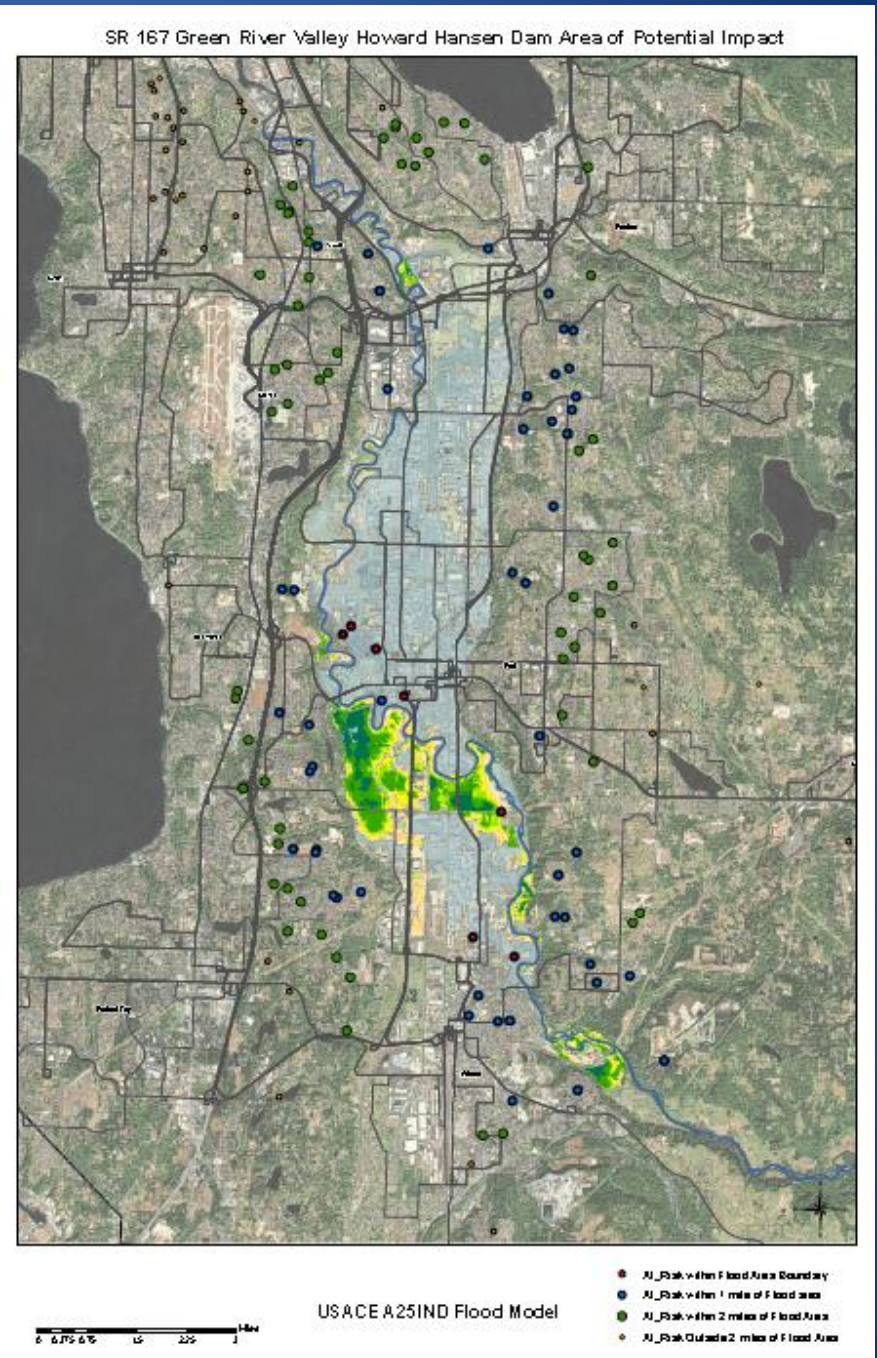
Inundation Depth & Mitigation Efforts

- The expected depth of inundation was then calculated using the model. This greatly reduced the number of features at risk since many are elevated on sign bridges or on poles.
- For the remainder, GPS crews visited and surveyed each site and options for mitigating the risk were identified and implemented.



In addition to Infrastructure, the addresses of WSDOT owned or leased facilities were Geocoding and overlaid on the the flood mask to determine if they were at risk.

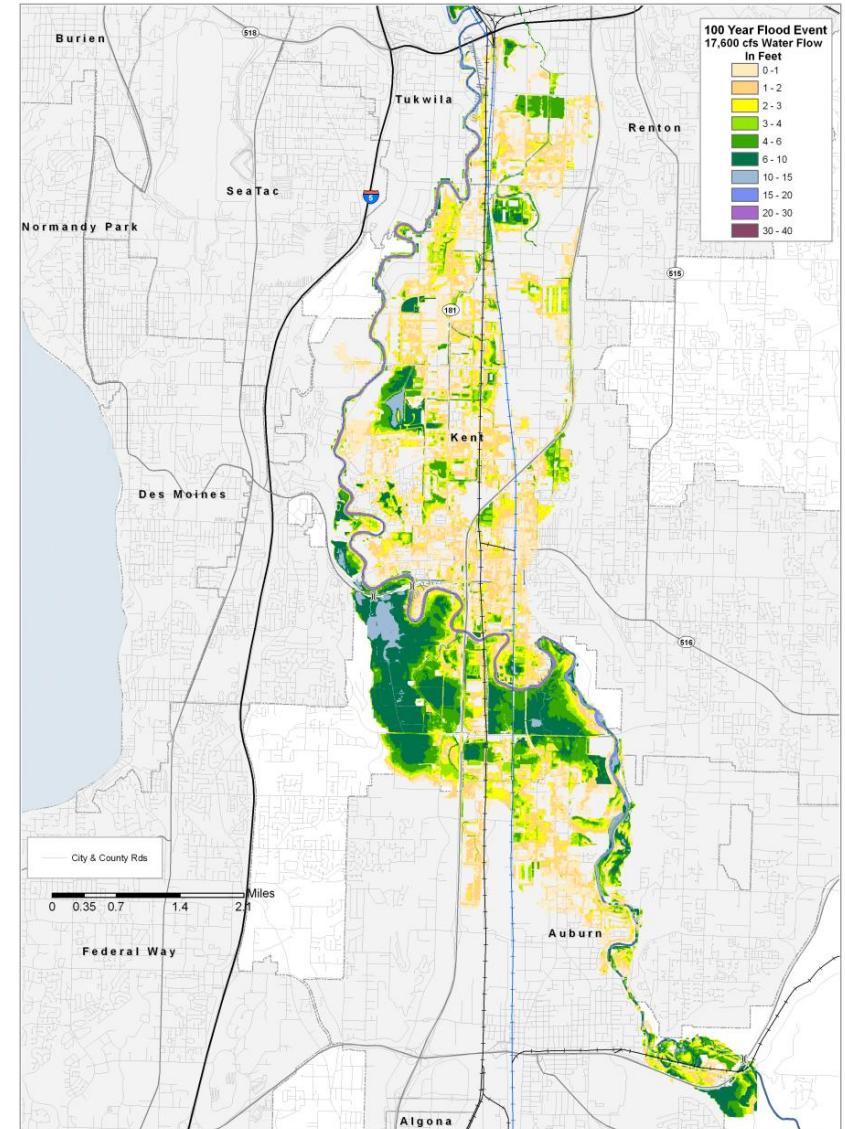
WSDOT's Kent Maintenance Facility will be subject to 3-4 ft of flooding under the C100 scenario.



Evacuation Routes

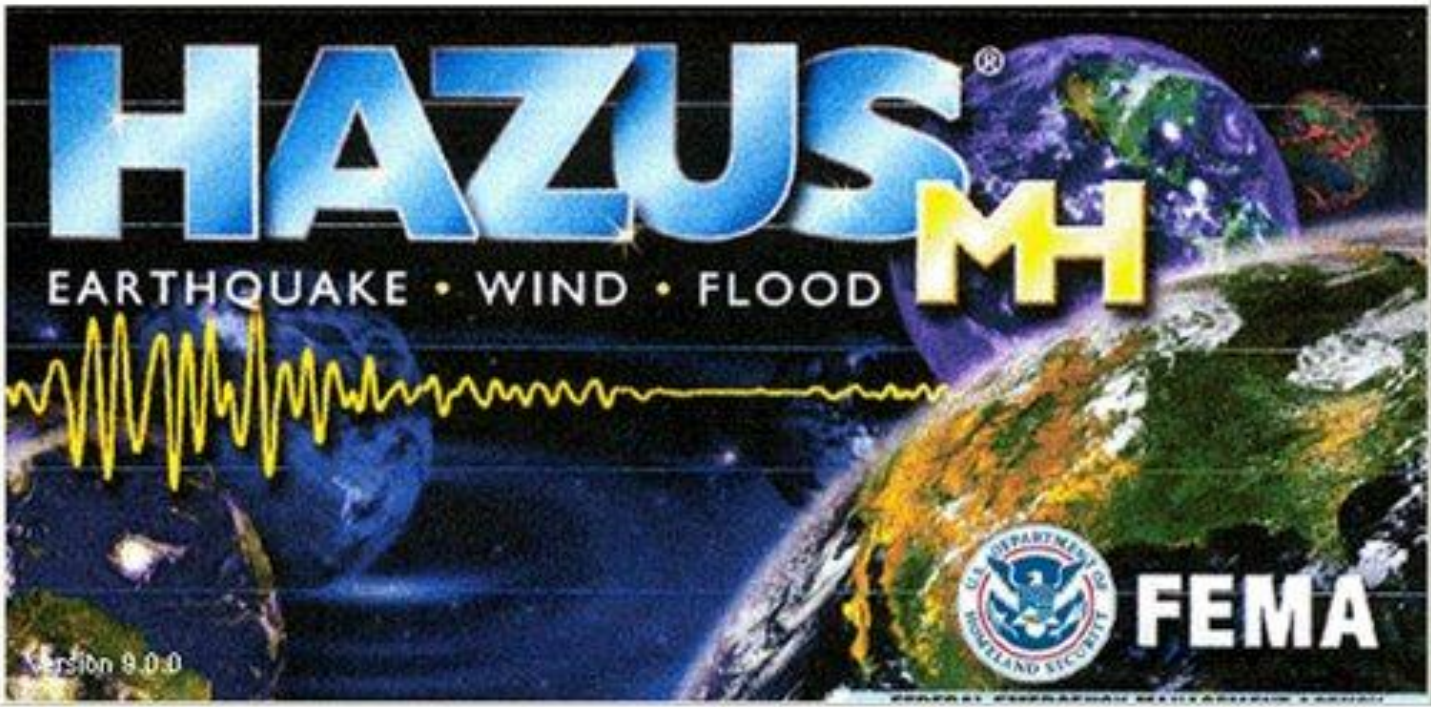
- A follow on analysis was conducted to determine the State Routes that could be flooded by the C100 Scenario
- At the height of the C100 flood the following State Routes would be partially closed:
 - SR 18
 - SR 167
 - SR 181
 - SR 516
 - And On-Ramps to I-405

Howard Hanson Dam, 17,600 cfs Flood Scenario (C100)
Washington State Highway Potential Closure Planning

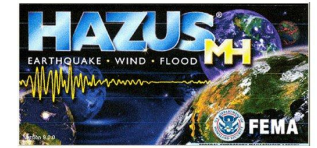


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Please ensure that you are utilizing the most current map product for operational decision making.
Washington State
Department of Transportation

Potential Flooding Area from SR 18 to I-405



Green River Temporary Measures



Locations



Hesco

Super Sacks

Sandbags

Auburn

10,500

100,000

Kent

21,000

500,000

Renton

11,000

250,000

Tukwila

10,500

9,000

100,000

King County

6,500

100,000

Seattle District

34,000

1,250,000

Totals

27,500

75,000

2,300,000

Howard Hanson Dam & Green River Valley Impact Analysis

- 1. This was the largest pre-flood impact analysis ever done in the State of Washington**
- 2. This was a joint Federal-State-Local Effort**
- 3. Every State Agency was required to:**
 - identify owned, leased, or mission critical infrastructure that was within the C100 flood zone, and**
 - Identify and implement mitigation measures for the items identified at risk**
- 4. Impacted Counties and Cities conducted the similar analyses**
- 5. Utilities and all large employers in the valley were contacted by EMD and were involved in the hazard identification process.**
- 6. In support of this effort FEMA produced new flood maps for the Valley and encouraged residence of the Green River Valley to obtain FEMA Flood Insurance.**