NATURAL DISASTERS AND CRITICAL FACILITIES:
A GIS FRAMEWORK FOR RAPID EMERGENCY RESPONSE IN PUYALLUP, WASHINGTON

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OUTLINE

- Introduction to the City of Puyallup

- Hazards of concern for Puyallup

- Emergency Management in Puyallup and introduction to the project

- City's desired workflow in response to an emergency

- Methods and proposed work

- Summary of deliverables and measure of project success

Mount Rainier as seen from Puyallup, Washington
Image courtesy of USGS https://www.usgs.gov/media/images/mount-rainier-seen-puyallup-washington

# CITY OF PUYALLUP, WASHINGTON

- Small-medium city in the Puget Lowlands

- Located between Tacoma and Mt. Rainier, south of Seattle

- Demographics

  - 43,000 people

  - Median age 34

  - Median home price - $375,000k

  - Median household income - $73k

- Socioeconomic info

  - Washington State Fair, April and September, over 1 million visitors

  - Other major employers: Puyallup school district, local hospital, chain grocery distribution center, Comcast, Costco
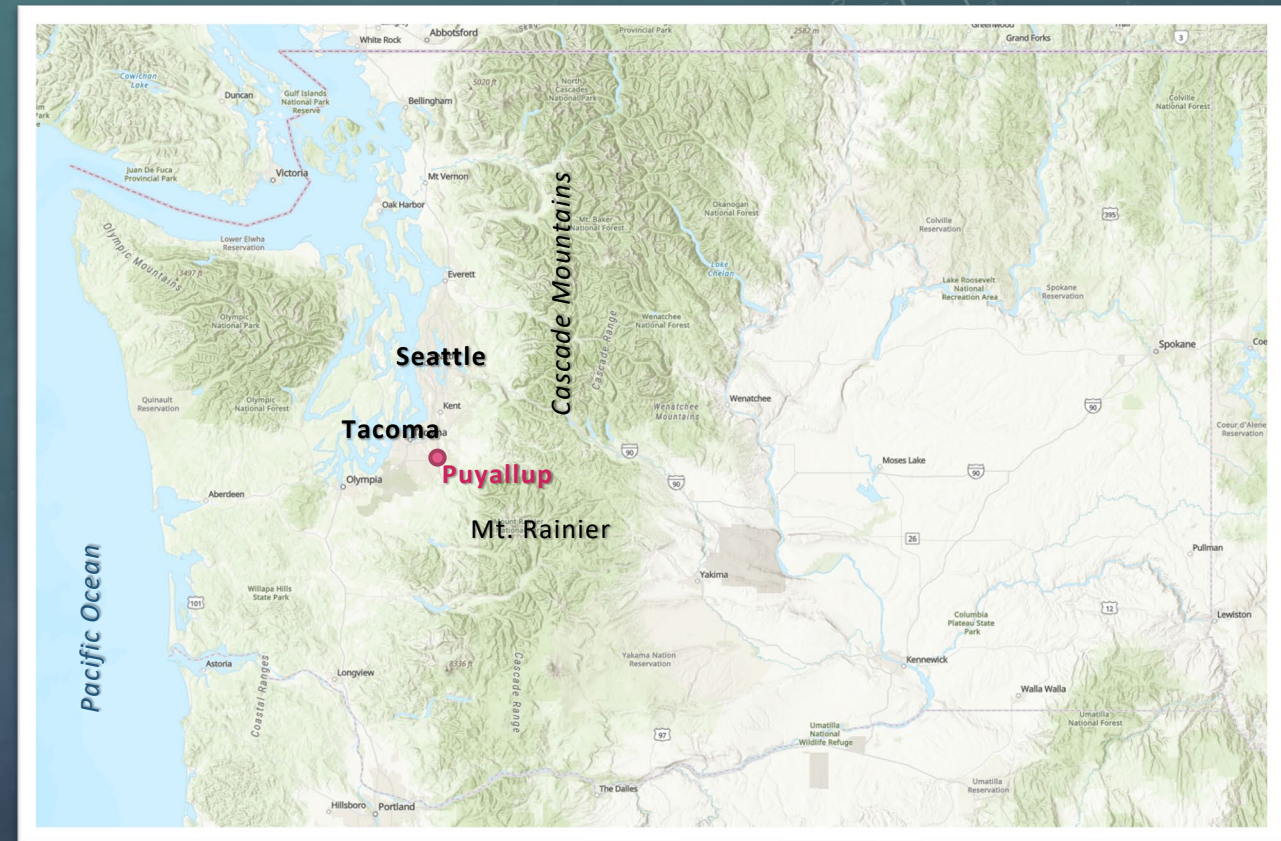
Regional geography for the City of Puyallup
Map courtesy of The City of Puyallup

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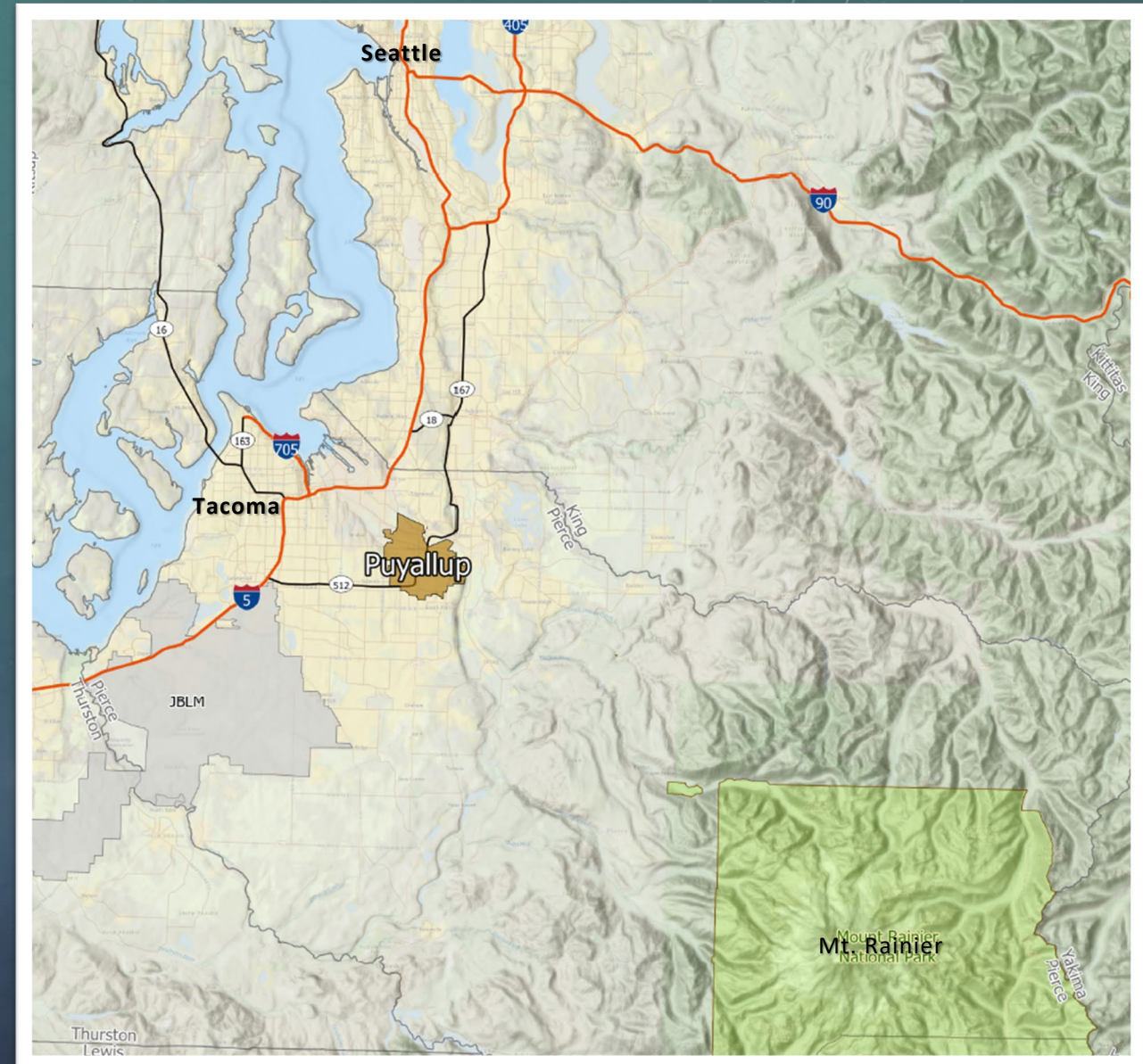
Regional geography for the City of Puyallup
Map courtesy of The City of Puyallup

PUYALLUP GEOGRAPHY AND GEOLOGY

- Mount Rainier
    - 30 miles southeast of Puyallup
    - Semi-active stratovolcano – the explosive kind
    - Most recent volcanic activity
        - 2,000 ya– Summerland eruptive period
        - 1,500 ya – Twin Creek eruptive episode
        - 1,000 ya – Fryingpan Creek eruptive period
        - 500 ya – Electron mudflow/lahar
   - 25 glaciers cover 35 mi^2 of Mt Rainier's flanks and supply water to 5 major rivers

A distant view of Mount Rainier volcano over Puyallup Valley, near Orting, Washington.
https://www.usgs.gov/media/images/mount-rainier-national-park
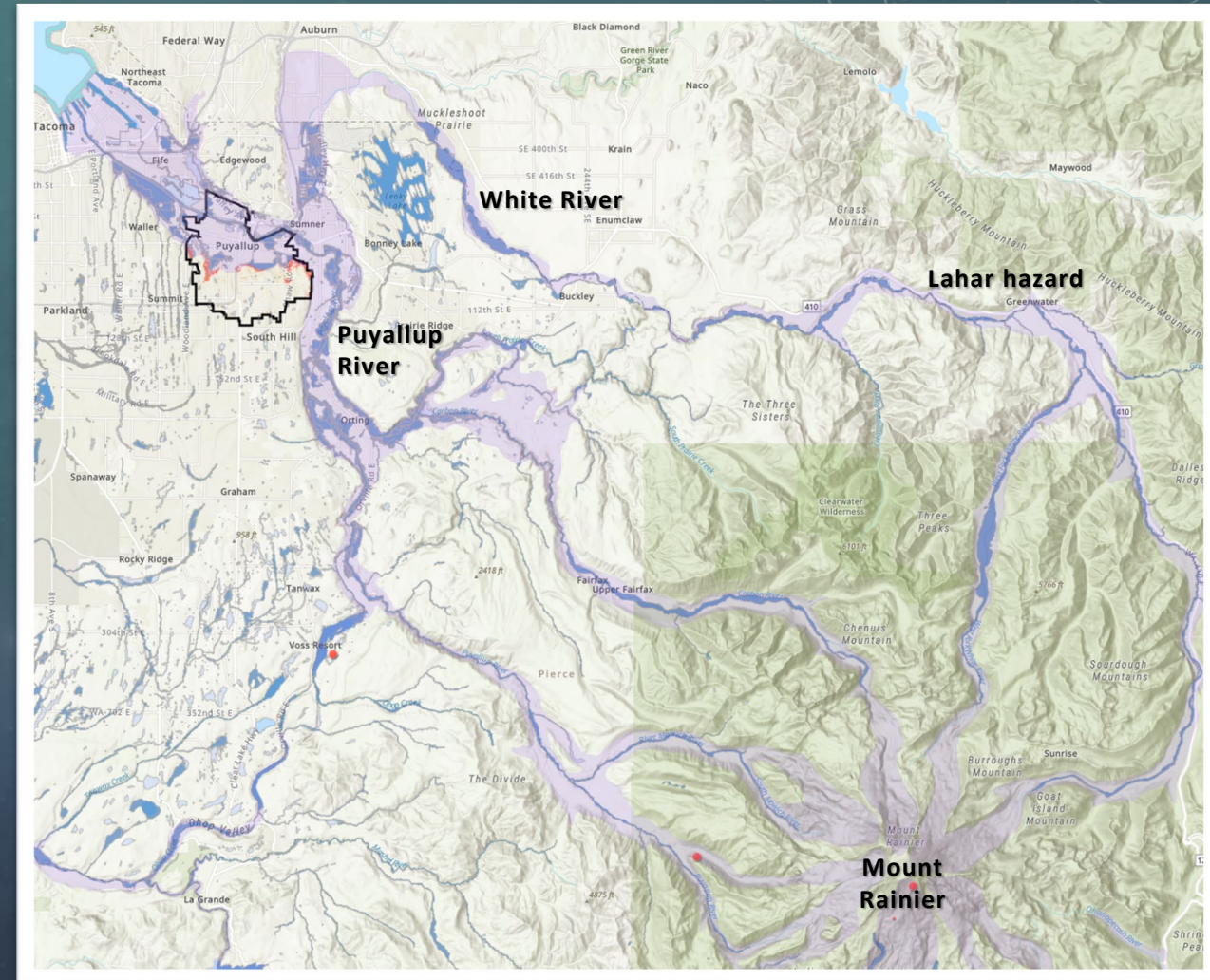
PUYALLUP GEOGRAPHY AND GEOLOGY

- Mount Rainier hazards

  - Lava is highly unlikely to reach Puyallup

  - Not close enough for volcanic bombs

  - Wind is likely to blow ash east, across the Cascades and away from the city

  - Primary concern – Lahars

    - Massive debris flows of volcanic mud from melting snow and glaciers – flowing cement

    - Leave deposits of mud and debris tens of meters thick

Lahar pathways from events heading on Mount Rainier – map showing three major events from last 10,000 years.
https://www.usgs.gov/media/images/lahar-pathways-events-heading-mount-rainier-map-showing-t
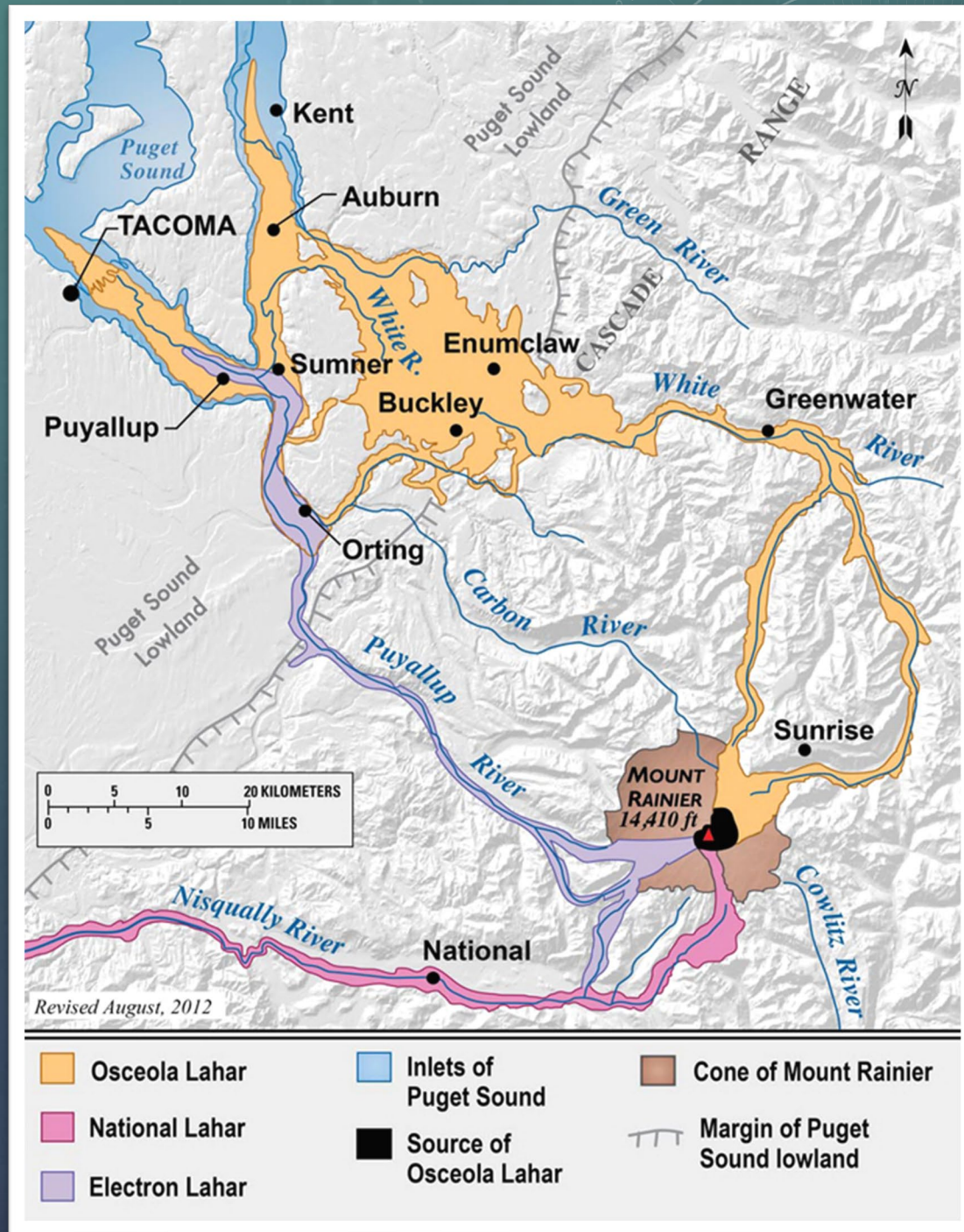
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The aftermath of a lahar from the 1982 eruption of Galunggung, Indonesia
Robin Holcomb, U.S. Geological Survey

PUYALLUP GEOGRAPHY AND GEOLOGY

- At the confluence of the White and Puyallup Rivers, both originating from Mt. Rainier glaciers

- North half of city in river valley, built on historic volcanic lahar deposits and prone to flooding

- South half of city on bluffs of glacial deposits prone to landslides
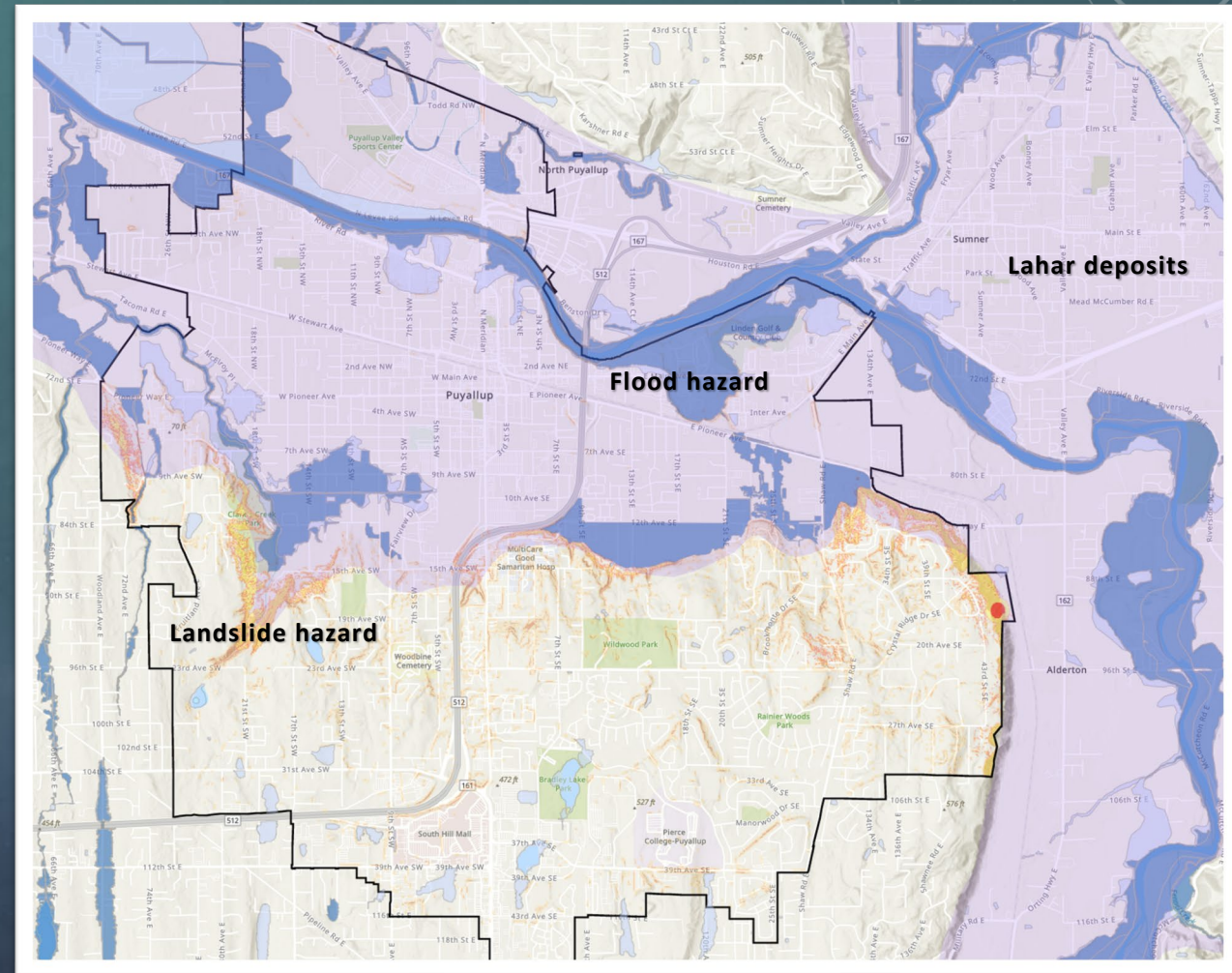
- Bisected by State Route 512

Map courtesy of the City of Puyallup Hazard App
https://puyallup.maps.arcgis.com/apps/webappviewer/index.html?id=b7669b258f704838aa29c9607477bc08

PUYALLUP GEOGRAPHY AND GEOLOGY

- At the confluence of the White and Puyallup Rivers, both originating from Mt. Rainier glaciers

- North half of city in river valley, built on historic volcanic lahar deposits (purple) and prone to flooding (blue)

- South half of city on bluffs of glacial deposits prone to landslides (orange)
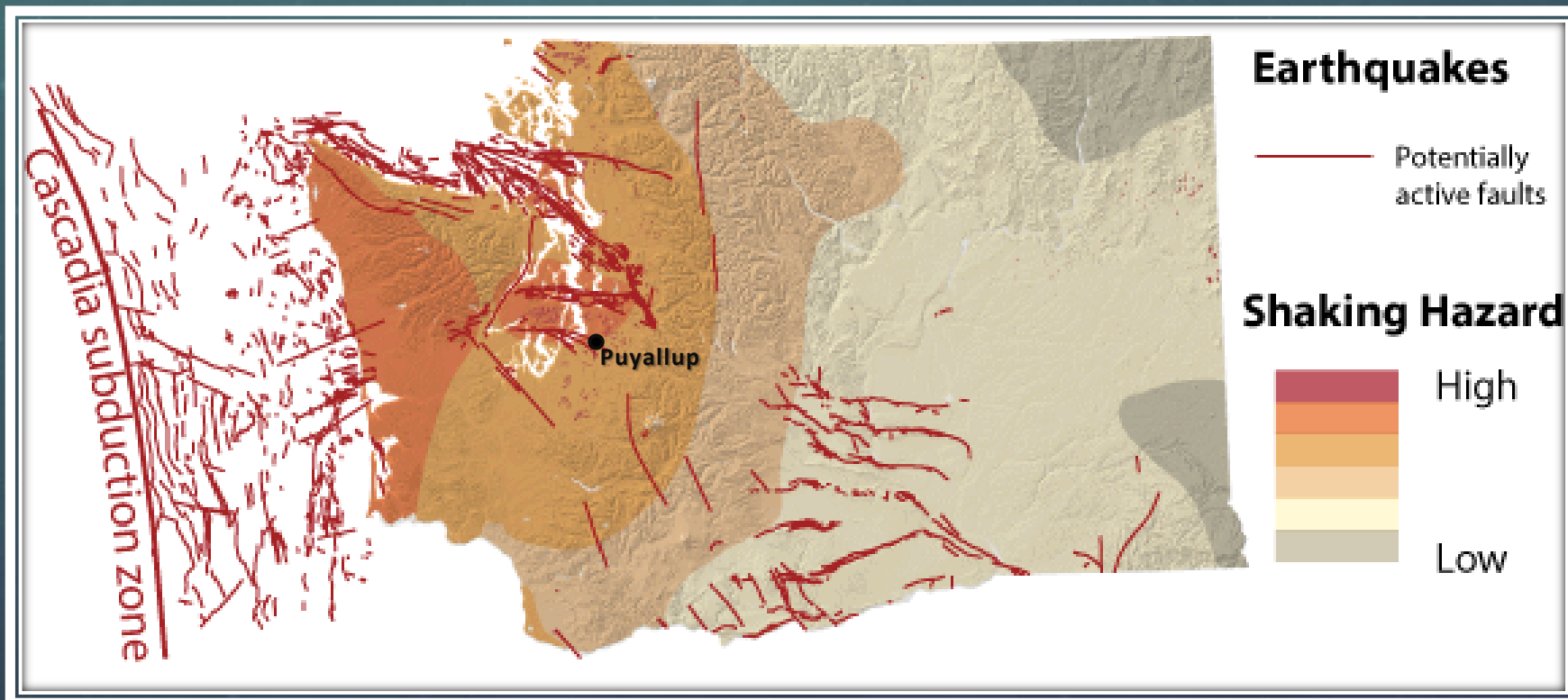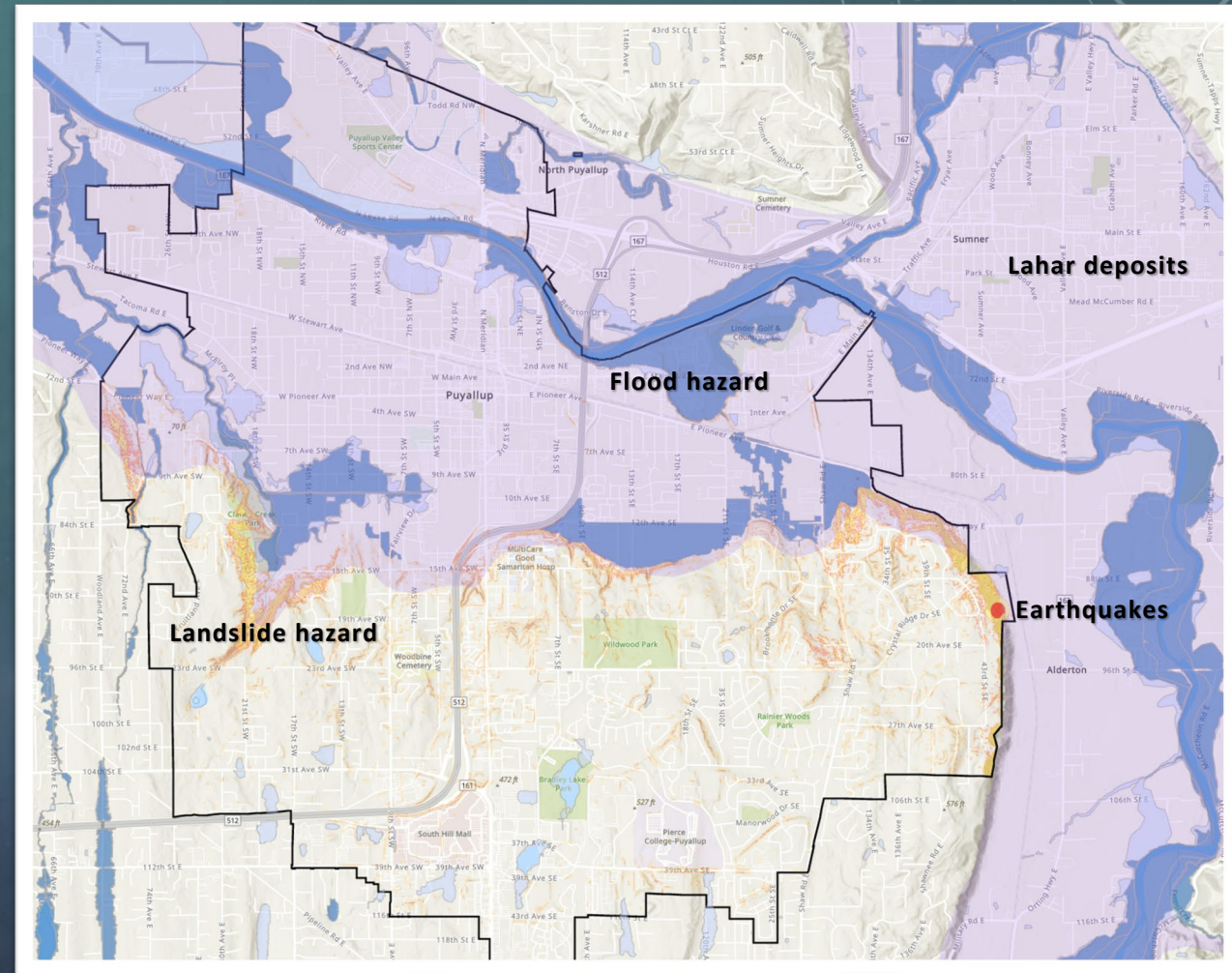
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PUYALLUP GEOGRAPHY AND GEOLOGY

- Pacific Coast is seismically active

- Earthquakes – less frequent than California but potentially larger magnitude

REVIEW: HAZARDS OF CONCERN IN PUYALLUP

- Volcanic Lahar from Mount Rainier

- Severe weather and flooding

- Landslides

- Earthquakes

    - Major – Cascadia Subduction Zone

    - Minor – local faults

- Fire and wildfire

- Hazardous material containment breach

- Human health

Major natural hazards, courtesy of the City of Puyallup Hazard App
https://puyallup.maps.arcgis.com/apps/webappviewer/index.html?id=b7669b258f704838aa29c9607477bc08

EMERGENCY MANAGEMENT IN PUYALLUP

- At risk for devastating hazards with little to no warning
- Building on existing emergency management framework
- Factors coming together to breathe new life into planning efforts
  - New staff
    - Puyallup EOC manager
    - Puyallup GIS coordinator
  - New enterprise GIS capabilities
  - Puyallup leading new East Pierce county Interlocal Coalition (EPIC) Emergency Operations Center, 7 cities and towns with similar hazards (https://www.epiceoc.com/)

Prevention

Protection

Mitigation

Response

Recovery

Modified from https://www.fema.gov/emergency-managers/national-preparedness/goal

CRITICAL FACILITIES PROJECT

- When a disaster hits – what do we need to know about first?

    - "Critical facilities include schools, nursing homes, hospitals, police, fire and emergency response installations, and installations which produce, use, or store hazardous materials or hazardous waste." (Puyallup Municipal Code)

    - Shelter and staging locations

- How do we get facility status from the field to Emergency Operations Center?

Image from cold storage fire incident in Puyallup, WA, August 2021
https://twitter.com/PuyallupPD/status/1429075276663717892/photo/1
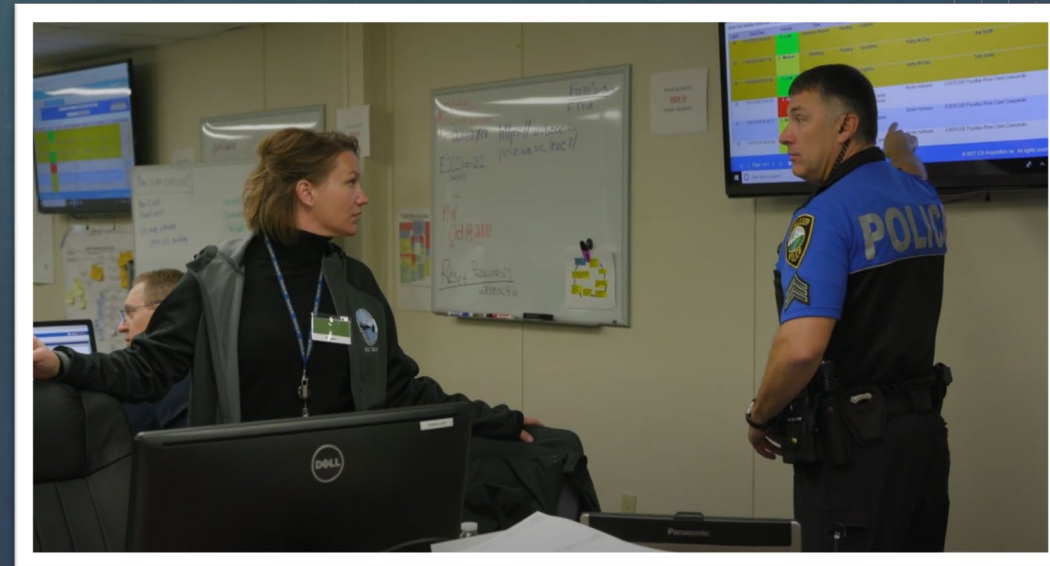
Image from "City of Puyallup Shelter Exercise," December 5, 2018
https://www.youtube.com/watch?v=mu_JQ7Z24Yg

CRITICAL FACILITIES PROJECT

- Existing project – Started in 2018, shelved for other priorities
    - Critical facilities within City identified
    - Draft shapefile of CF parcels
    - PDF map created
    - Critical facilities categorized into priority response tiers
- Current project goals
    - Integrate critical facilities monitoring into new emergency response GIS framework
    - Create a way to get facility status from field to emergency operations center in the event of a disaster
    - Field test with full scale lahar evacuation exercise

Phase 1

Identify and Assess Risk

Estimate Needs

Build and sustain response capabilities

Deliver capabilities

Validate capabilities

Review and Update

Phase 2

Adapted from FEMA National Preparedness System
https://www.fema.gov/emergency-managers/national-preparedness/system
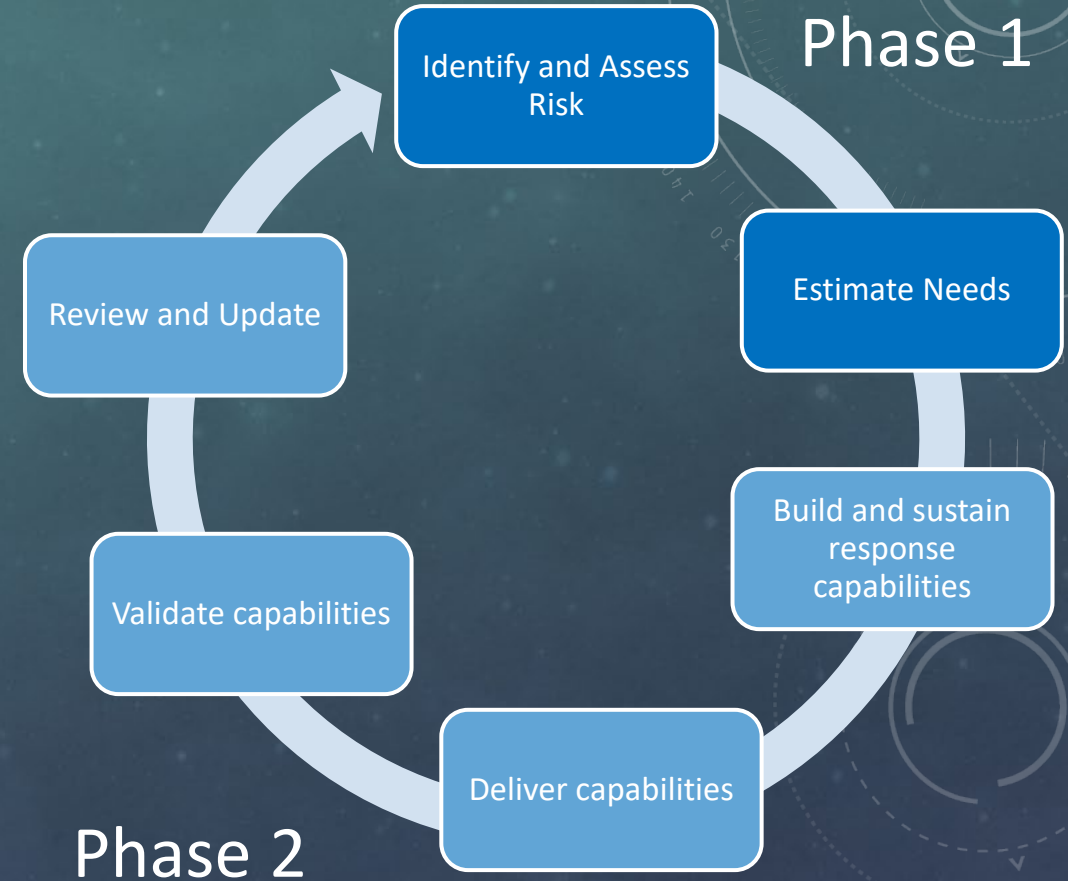
CRITICAL FACILITIES PROJECT TEAM
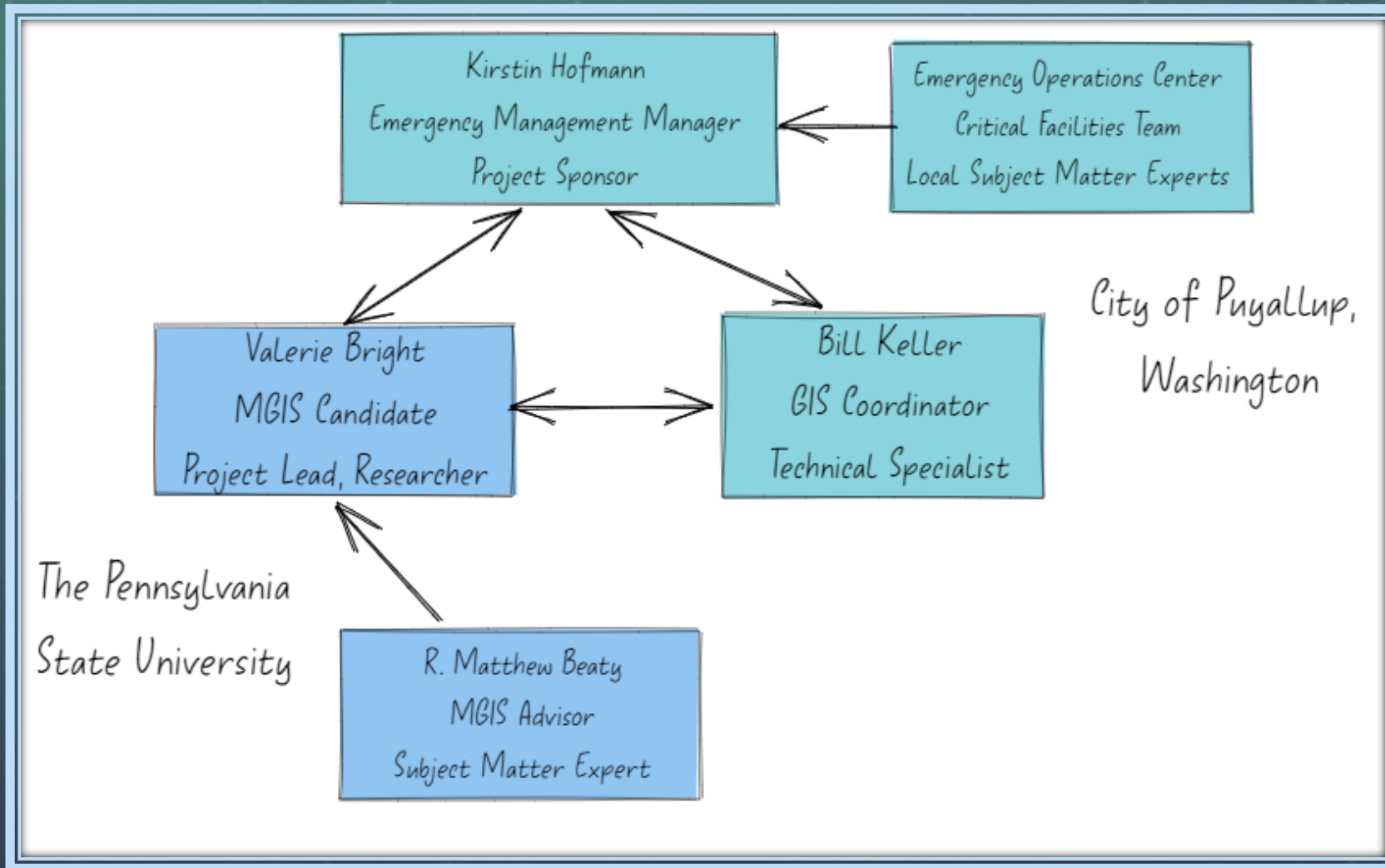
BENEFITS OF GIS FOR EMERGENCY RESPONSE

- Easily see all available information in one place and in standardized format

- Query on the fly for flexible response

- Reduces number of phone calls and contacts, improves response time

  - Don't need to call Public Works to find out if there's a drinking water well in the chemical fire hazard zone

  - Existing GIS incorporates Authoritative data from City, county, and state

- Quickly disseminate information for internal and public consumption

- Future additions could include live data feeds and cloud-hosted GIS

Snapshot of Puyallup public emergency management dashboard, with road closures

www.cityofpuyallup.org/eocdashboard

RISKS OF GIS FOR EMERGENCY RESPONSE

- GIS requires power for servers and devices (computers, tablets, phones) and internet connection -

  - ArcGIS Online - hosted on Amazon Web Services servers with multiple redundancies, off-location

  - Build in ability for offline data collection with in-office sync

  - FirstNet - Emergency Services cell network, restricted use, provides mobile data and hot spots, built to be reliable when other cell networks aren't

    - "FirstNet network will be a single, nationwide, interoperable LTE network dedicated to public safety communications." https://www.firstnet.com/power-of-firstnet/why-firstnet/reliable-network.html
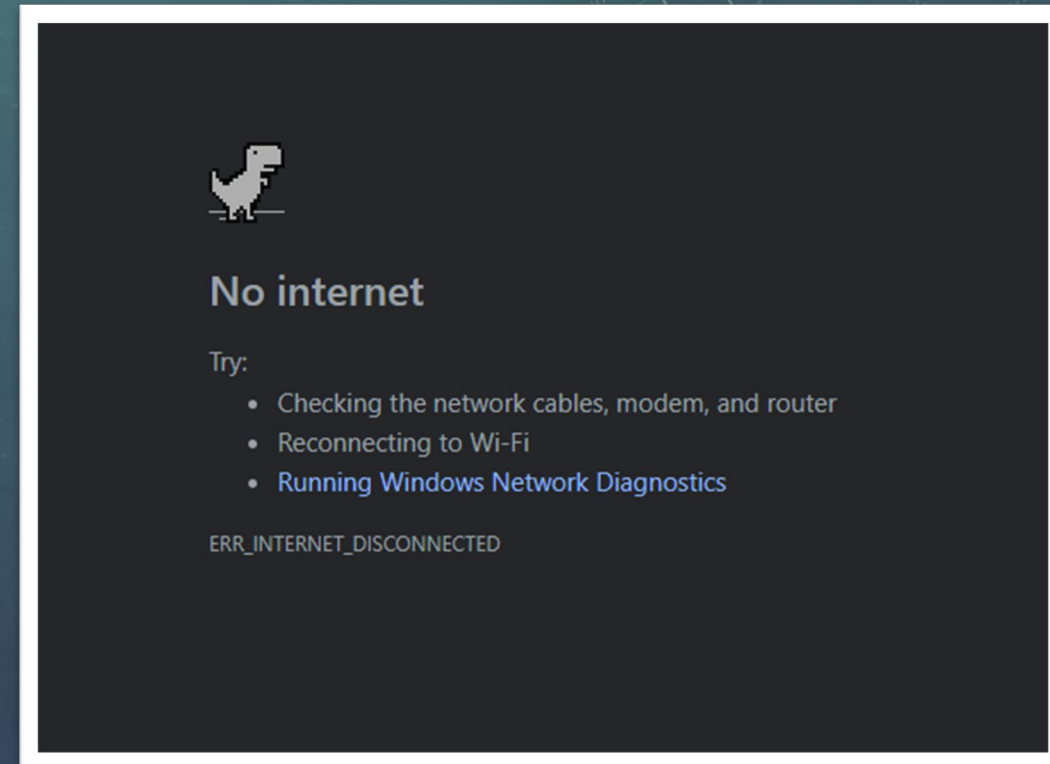
"No internet" error message from Chrome web browser

DESIRED CRITICAL FACILITIES WORKFLOW

Planning and Preparedness

↓

Disaster occurs

↓

Determine areas of likely damage

↓

Identify Critical Facilities within area of concern

↓

Triage affected facilities for inspection

↓

Dispatch crews to collect data about critical facility status

↓

Return data to Emergency Operations for response planning

DISASTER OCCURS

- Emergency operations center activated by EOC Coordinator

- Immediate maps and messaging by EOC GIS team

  - EOC Rapid Response app

  - Public Dashboard

  - Twitter

- Status: Currently functional

Snapshot of Puyallup public emergency management dashboard, with road closures
www.cityofpuyallup.org/eocdashboard

DETERMINE AREAS OF LIKELY DAMAGE

- EOC GIS team identifies area of concern within the City
  - EOC internal dashboard
  - Hazard map
  - Initial reports
- Output: Area of concern polygon

- Status: Currently functional
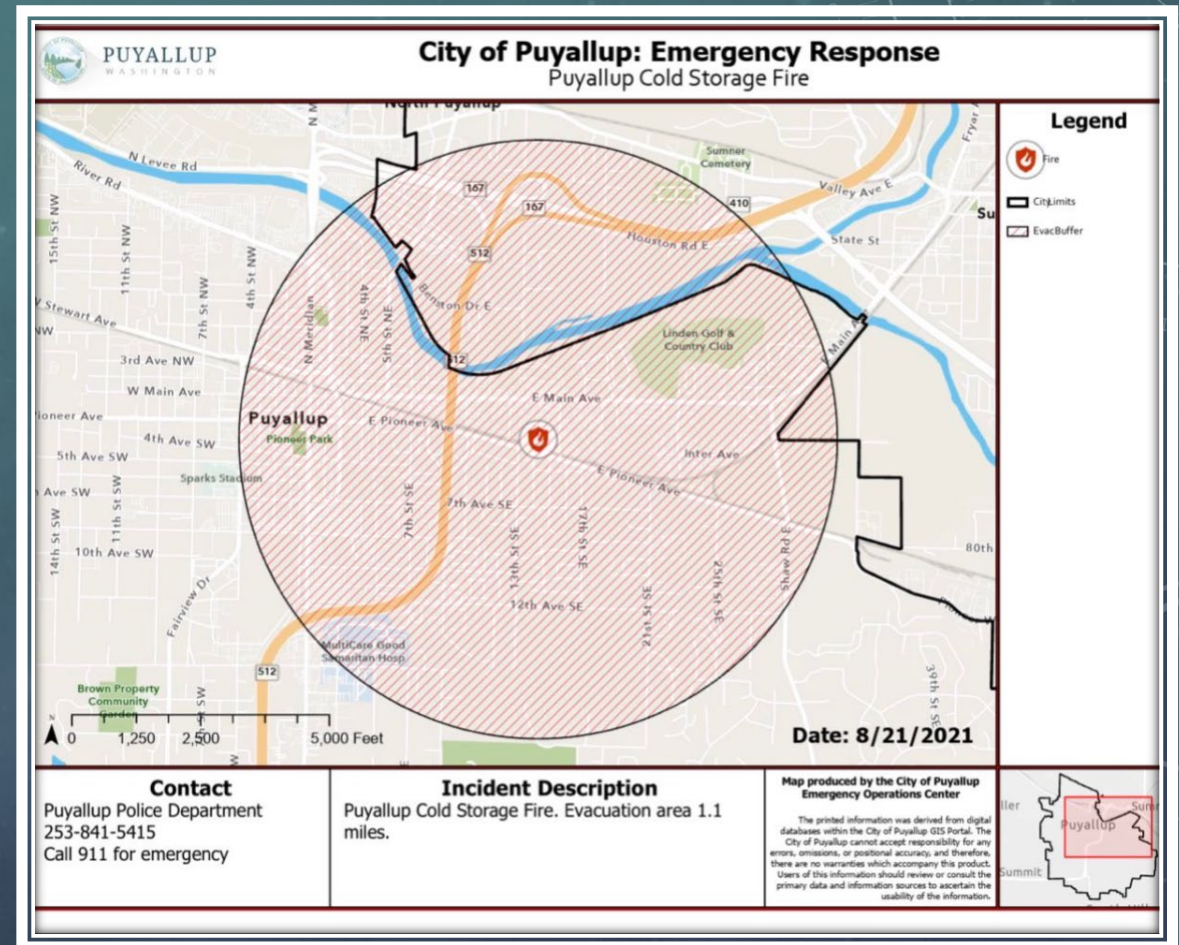
Print template output from City of Puyallup EOC internal dashboard

IDENTIFY CRITICAL INFRASTRUCTURE WITHIN LIKELY DAMAGED AREAS

- Select critical facilities of concern (EOC GIS)
    - Spatial query for infrastructure within hazard area

- Status: **Needs work**
    - Critical infrastructure shapefile needs cleaning
        - Some facilities (6 total) are in multiple response tiers – overlapping polygons significantly complicate the GIS
        - Currently duplicates other city data (parcels)
    - Upload Critical Infrastructure to ArcGIS Online, not reliant on City servers and intranet
    - Build in spatial query functionality into existing EOC internal app
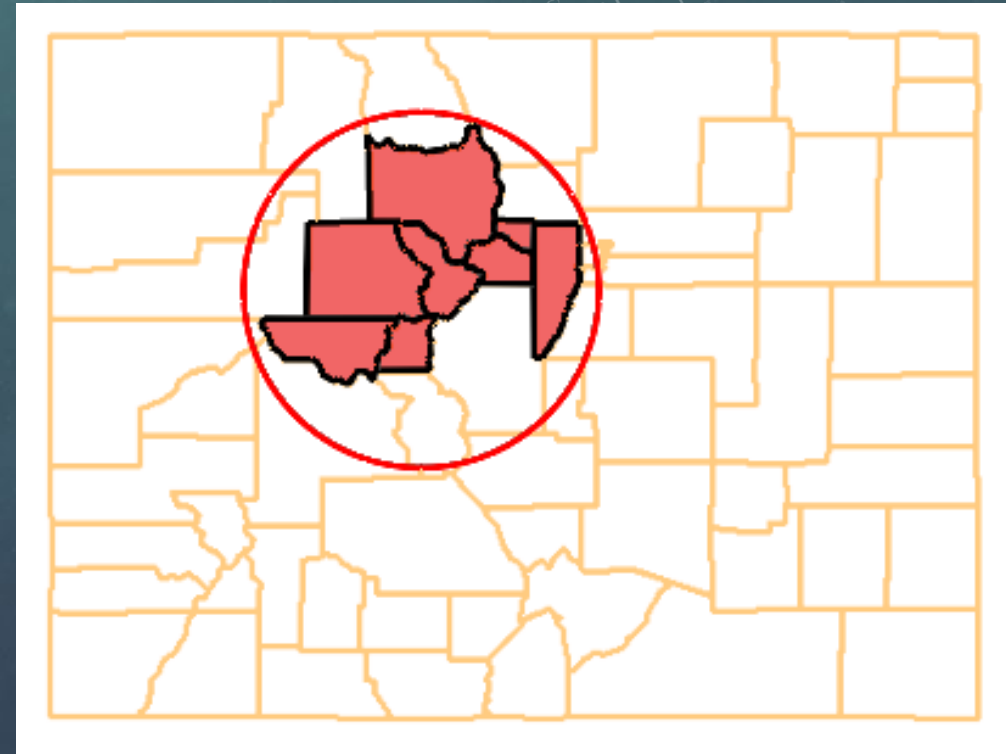
Image credit: esri, "Spatial Query"
https://webhelp.esri.com/arcgisexplorer/2500/en/spatial_query.htm

TRIAGE AFFECTED FACILITIES FOR INSPECTION

- Create list of facilities for inspection, with order of priority (EOC Coordinator + EOC GIS)

    - Use list/map of affected facilities from previous step to determine if inspection is needed, and triage order of inspection

    - Update "Current Status" of critical facilities as information is available on EOC dashboard:

        - No inspection needed

        - Inspection needed

        - Inspection pending

        - Inspected – safe

        - Inspected – restricted

        - Inspected – unsafe

- Status: **Needs work**

    - Add "Current status" to critical facilities layer with domains to restrict input

DISPATCH CREW TO COLLECT DATA ABOUT CRITICAL FACILITY STATUS

- Dispatch crew (EOC) to affected parts of city

- EOC field staff conducts critical facility inspections (EOC field staff)

  - Incorporate official WASafe building inspections and unofficial field status

- Status: **Needs work**

  - Identify data to be collected

    - Use WAsafe (**WA**shington **S**afety **A**ssessment of **F**acilities **E**valuators) Rapid Evaluation safety Assessment Form as basis for Survey123 survey

  - Build database structure for data collection

  - Build mobile survey for data collection

  - Build mobile map for data collection

    - Note: mobile map and survey will also be usable on web or in office

- Update EOC internal dashboard to include critical facilities map

WAsafe Rapid Safety Assessment of Facilities form

https://www.wabo.org/assets/pdfs/EmergencyManagement/template%20rapid%20evaluation%20safety%20assessment%20form.pdf

RETURN DATA TO EOC FOR RESPONSE PLANNING

- Upload data automatically with cell or internet connection using ArcGIS Online

- Collect data offline and sync manually when in office

- Collect field observations from messages and phone calls and update database from EOC office

- Status: **Needs work**

  - Ensure data integrates with City EOC database

    - Note: Data may also need to be compatible with higher level EOC operations (state or federal gov, FEMA, etc)

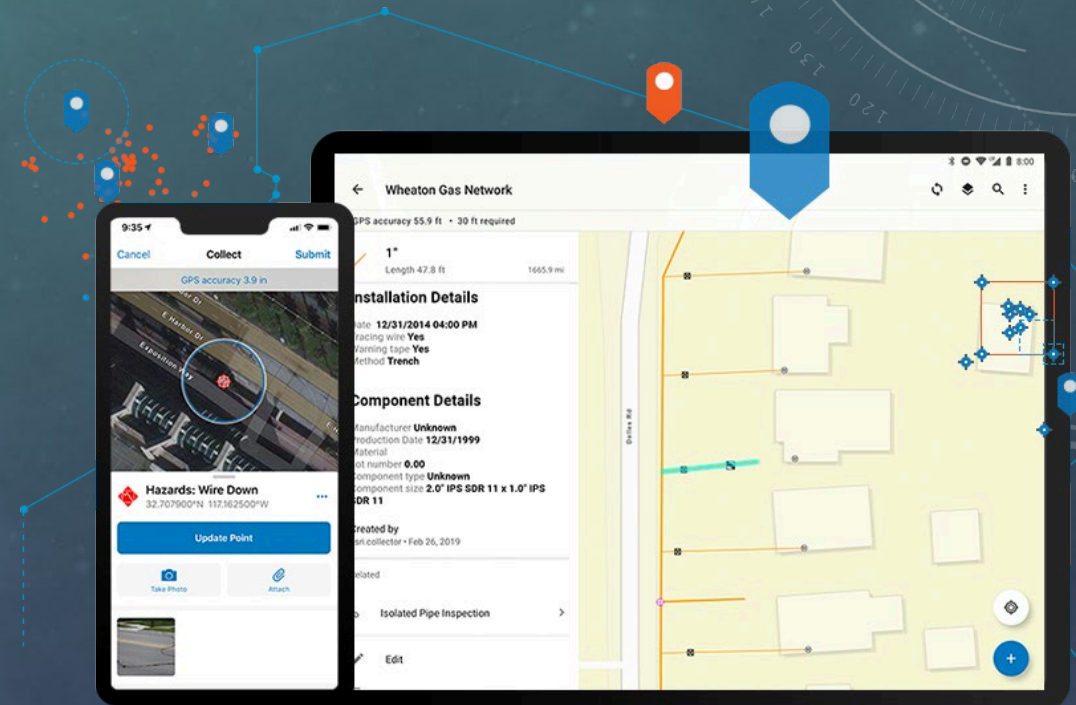 - Create flexible system that can take multiple inputs

Illustration of mobile data collection, Esri
https://www.esri.com/en-us/arcgis/products/arcgis-collector/overview

SUMMARY OF DELIVERABLES

- Feature Layer of critical facilities hosted on enterprise GIS

- Database structure to store critical facility data and status,
  - Ideally with ability to store update history

- Interactive map with critical facility parcels showing facility tier and current status (safe, restricted use, unsafe, unknown)

- Mobile survey to collect facility data
  - Official digital version of Rapid Evaluation Safety Assessment form
  - Unofficial simplified survey that can be used by City volunteers and EOC staff

- Documentation and training materials for EOC staff

- Template for other jurisdictions to follow

- Presentation at Washington GIS Association Conference in May 2022

MEASURING SUCCESS

- Ongoing meetings with EOC coordinator and GIS coordinator

- Meeting with wider Puyallup EOC staff in January to present plan, solicit feedback

- Project will be stress-tested at full-scale lahar evacuation exercise in April 2022, including 7 cities and multiple school districts

Students from Meeker Elementary walk their lahar evacuation route in downtown Puyallup. Lahar evacuation exercise, 2019.
https://mil.wa.gov/news/largest-volcano-evacuation-drill-in-us-took-place-here-in-washington-state

View from Downtown Puyallup with Mount Rainier on the horizon, looking southeast. https://www.cityofpuyallup.org/748/About-