

Seismic Evaluation of Vancouver's Aging Reservoirs

Tyler Clary

City of Vancouver

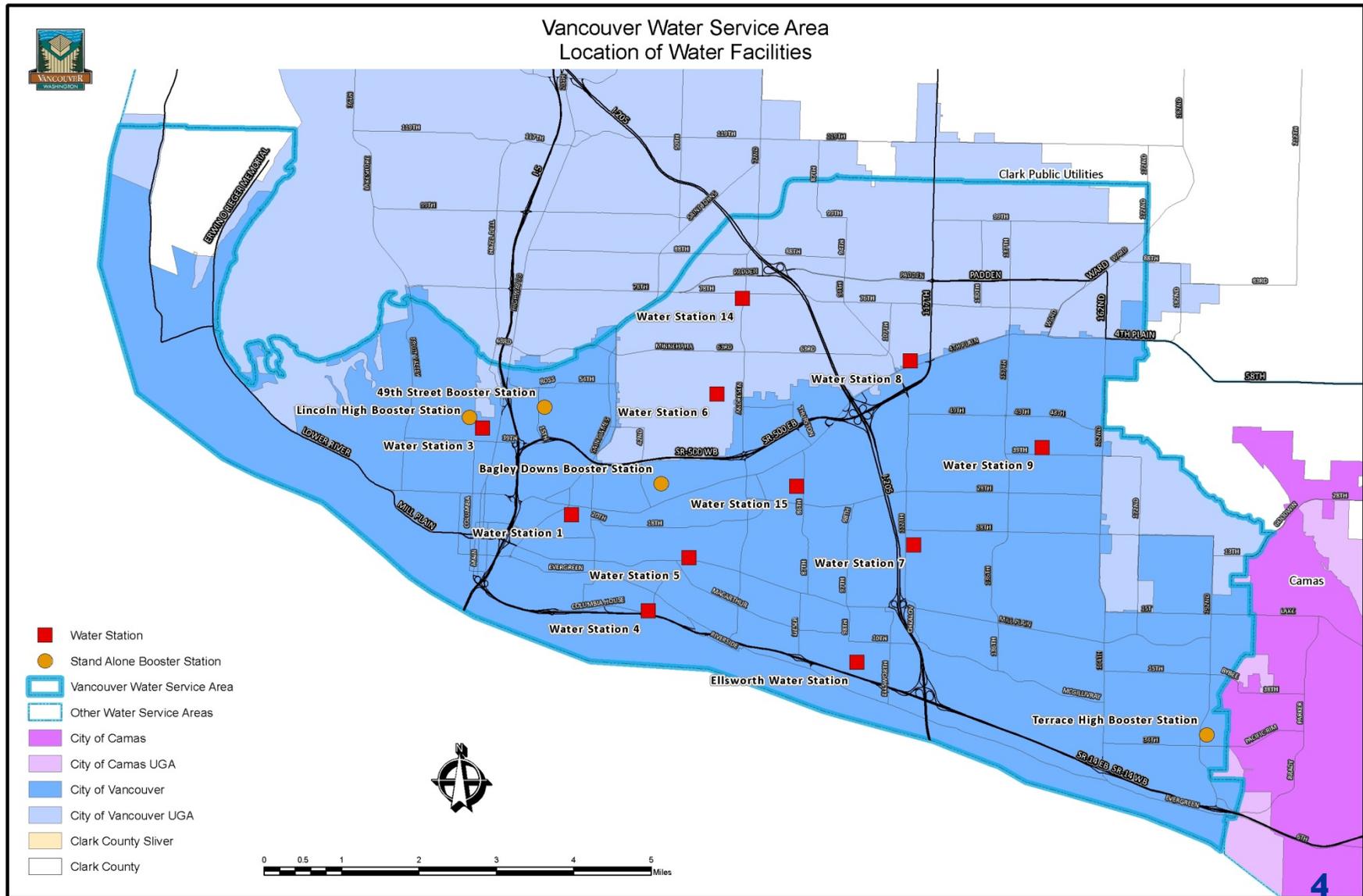
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*formerly Degenkolb Engineers



City of Vancouver Water Facilities/Service Area

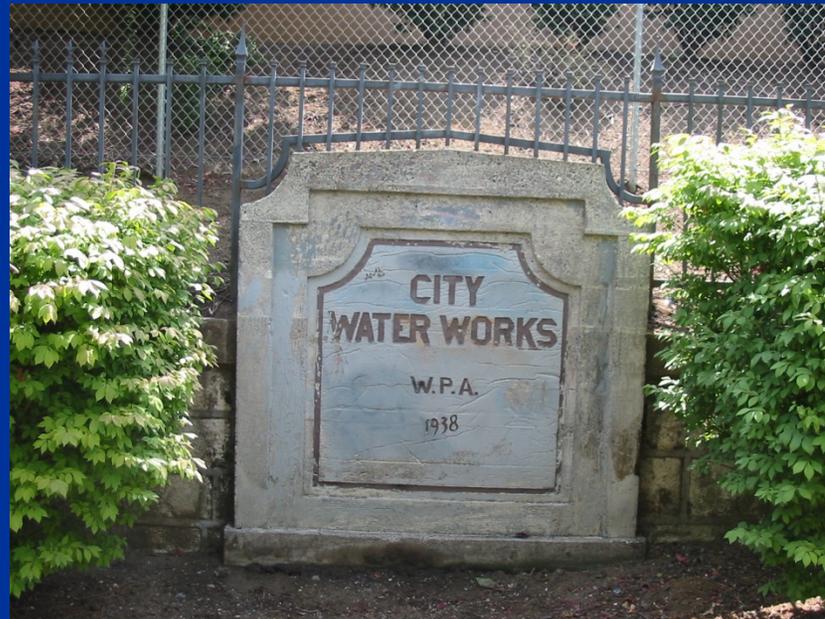


Water Station I Facilities

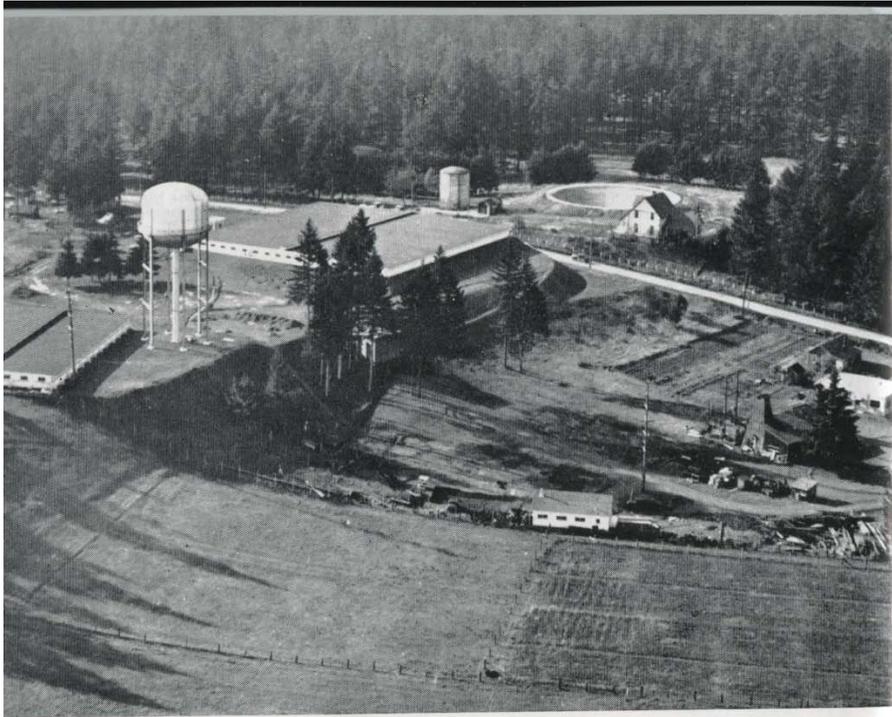
- Twelve wells
- Four booster pump stations
- Two ground level reservoirs
 - 1 MG
 - 4 MG
- One elevated tank - 250,000 gallon
- Treatment systems

Water Station I History

- Used as water source since 1880
- 1 MG reservoir constructed 1909
- City purchased water system in 1937
- 4 MG reservoir and elevated tank built 1938







Station No. 1, reservoirs and tank on hill; well and meter lab on right.

THE WATER SUPPLY

LIFE BLOOD OF THE CITY

Without water there would be no city. Old timers still remember when the precious fluid was peddled through the rutted streets by wagon. But the horse-and-wagon days are gone forever. In the past three years the city has bought and built a \$2,000,000 water system, equal to any of like size, for an expenditure of about \$1,000,000. This feat of finance was accomplished by careful planning, skilled engineering and by the use of WPA labor.

The history of water in Vancouver has been a troubled one. The first system, privately owned, was organized in March 19, 1868 with a capital stock of \$50,000. Water was brought from the present springs to the city by means of a flume. During the next 60 years the system changed hands ten times, growing up like Topsy as it did so.

[40]

Water service was never adequate. In the 20 years prior to 1933 ten complaints were lodged against the private owners and ten times the state department of public works investigated and ordered remedial action. Finally in 1933 the department itself initiated an action challenging the Oregon-Washington Water Service Company's rates, charges, rules and regulations and proceeded to launch an investigation into the company's rates and the adequacy of its service. Upon the findings of its engineers the department based an order placing the value of the company for rate-making purposes at \$350,000 and commanding the company to adopt new, reduced rate schedules effective June 1, 1934.

Water service continued to be inadequate and on September 1, 1936 the city council notified the People's Water and Gas Company (the then owners) of the city's intention to purchase the system under terms of an option embodied in the franchise. The franchise provided for a board of appraisers, including two engineers hired by the city, two by the company and a fifth agreeable to all.

After an independent appraisal this board agreed upon a price of \$610,000 for the system, which was accepted by the council. The city voted to issue \$610,000 in water revenue bonds for purchase of the system and an additional \$240,000 for improvements, replacements and extensions necessary to make the system usable.

On June 1, 1937 the purchase was consummated. Before the deal could be closed the roof on the old 1,000,000 gallon reservoir caved in. A couple of months later the old 100,000 gallon elevated wooden tank tower began to collapse.

Old wooden water tower collapses,
making way for new steel tank.

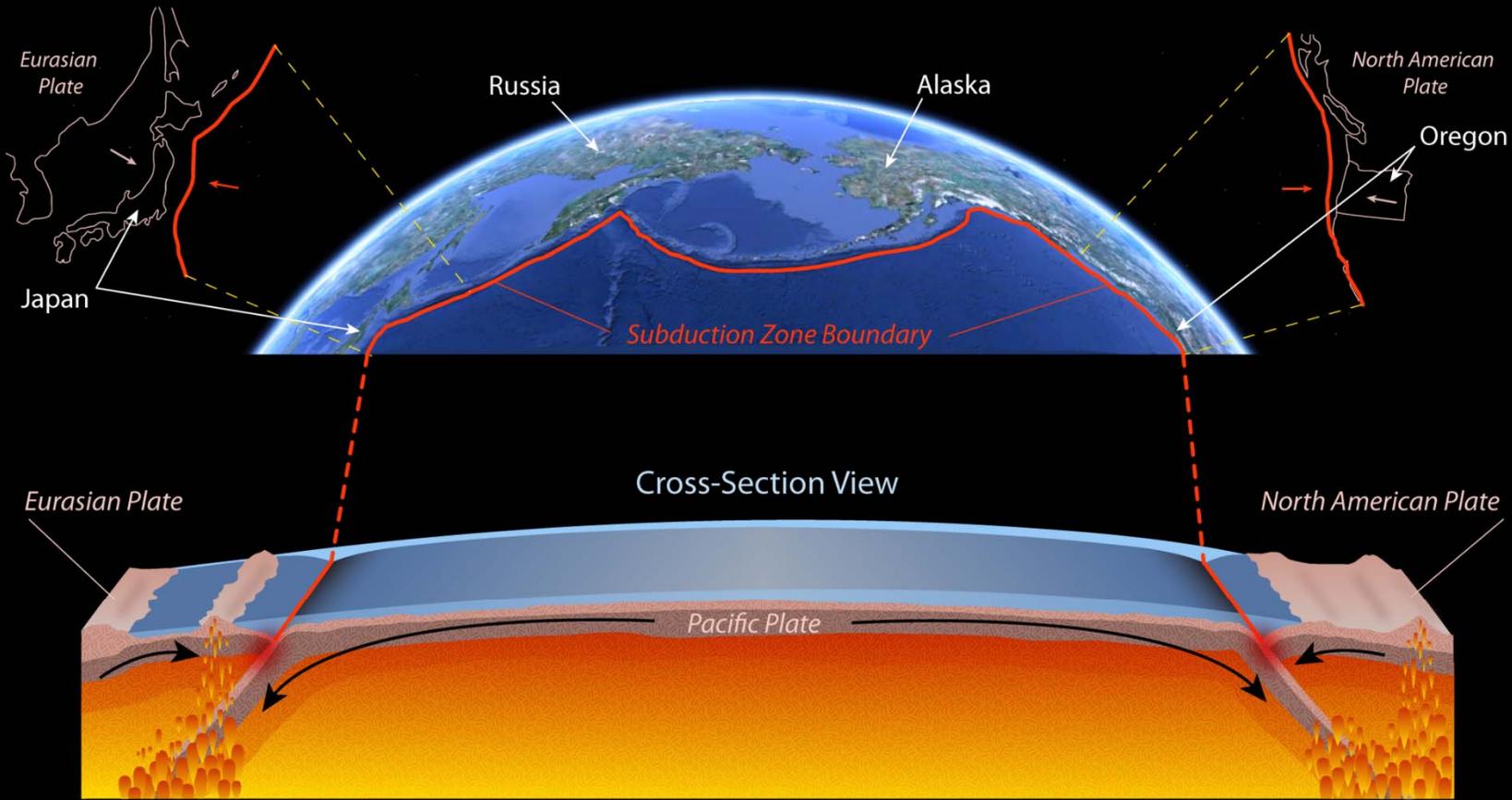


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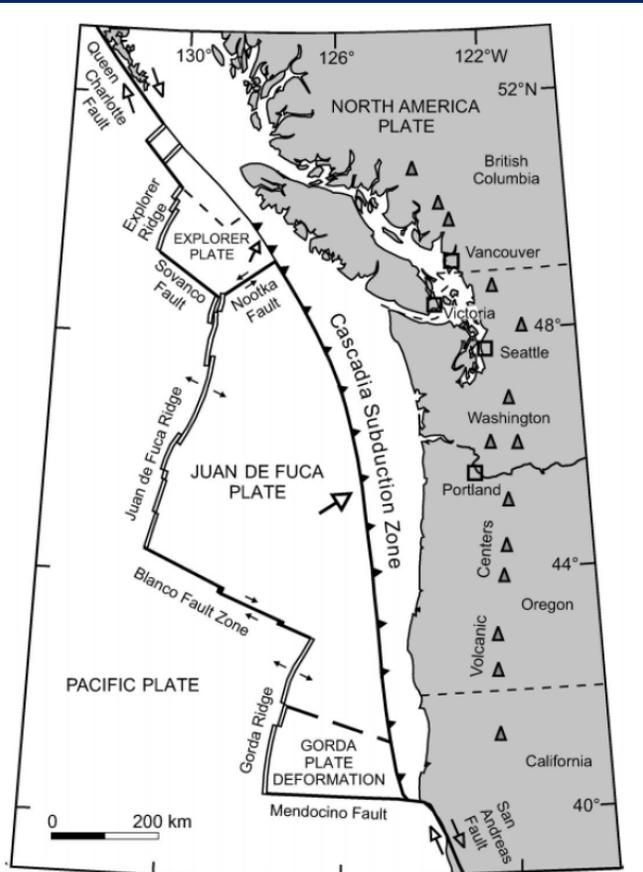
Why Complete a Seismic Evaluation?

- Aging facilities
- Site master plan 2005
 - Planned to replace all storage at the site
 - Two new 3 MG reservoirs
 - One new 0.5 MG standpipe
- Changing of the guard

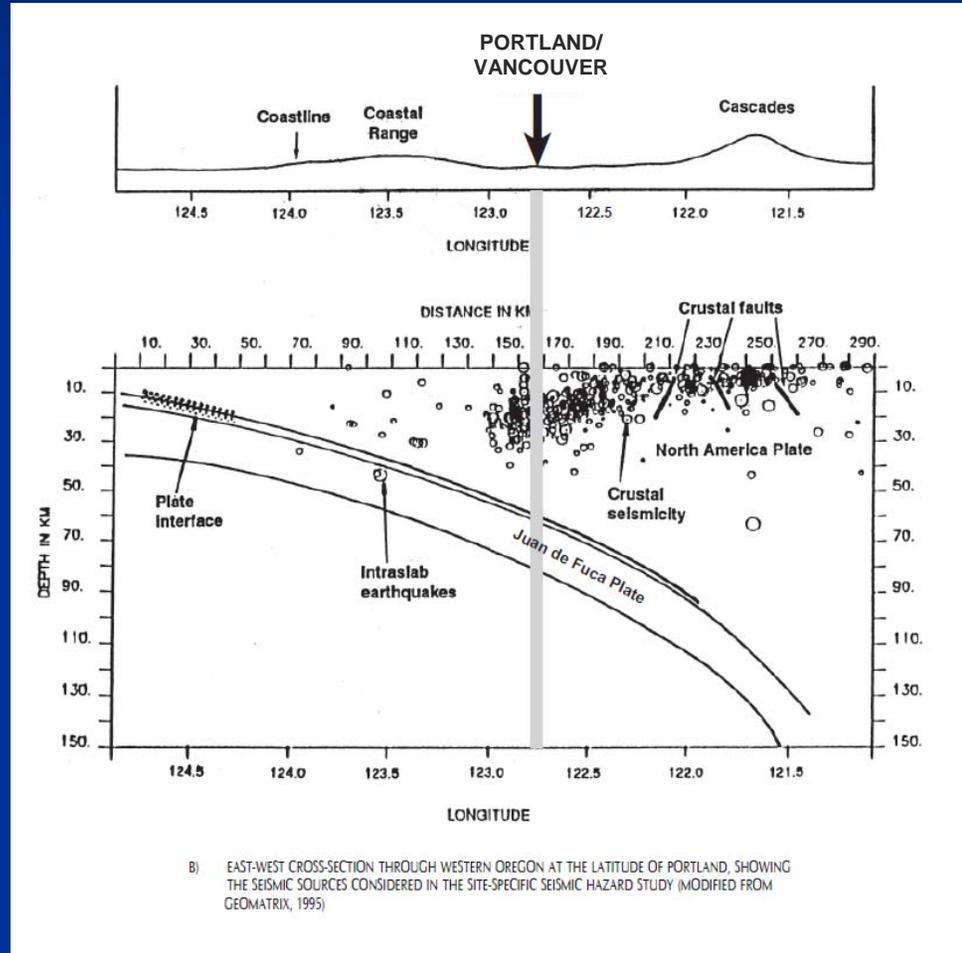
Seismic Hazard



Cascadia Subduction Zone



A) TECTONIC MAP OF PACIFIC NORTHWEST, SHOWING ORIENTATION AND EXTENT OF CASCADIA SUBDUCTION ZONE (MODIFIED FROM DRAGERT AND OTHERS, 1994)

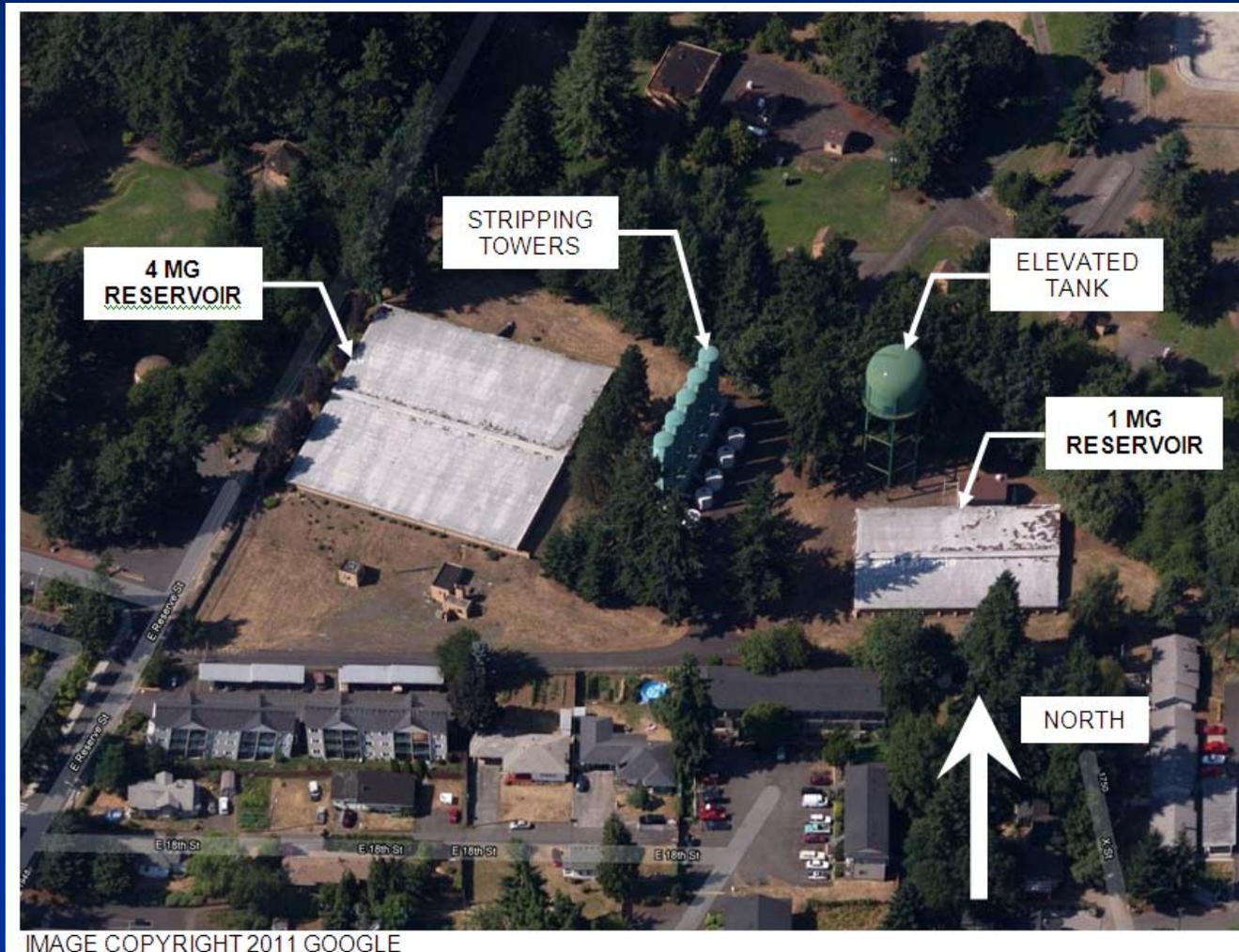


B) EAST-WEST CROSS-SECTION THROUGH WESTERN OREGON AT THE LATITUDE OF PORTLAND, SHOWING THE SEISMIC SOURCES CONSIDERED IN THE SITE-SPECIFIC SEISMIC HAZARD STUDY (MODIFIED FROM GEOMATRIX, 1995)

Performance Objective

- Water system is critical for post-earthquake fire suppression and longer-term economic recovery
- Design Earthquake (10% in 50 yrs.)
 - Minor structural damage
 - Repair during continued operation
- Max. Considered Earthquake (2% in 50 yrs.)
 - More extensive structural damage
 - Repair possible but may not be economical

Water Station No. 1



I MG Reservoir Construction



West Side



Triangular Concrete Buttress

I MG Reservoir Construction



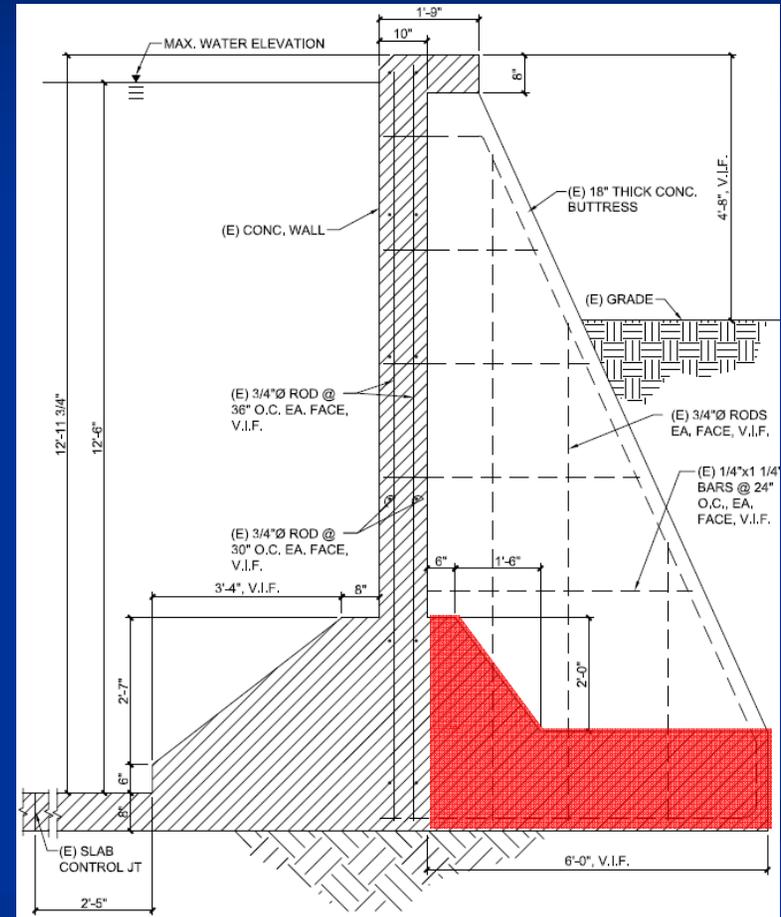
Locating Reinforcing with
Ground Penetrating Radar
(Widely Spaced Reinforcing)



I MG Reservoir Construction



I MG Reservoir Construction



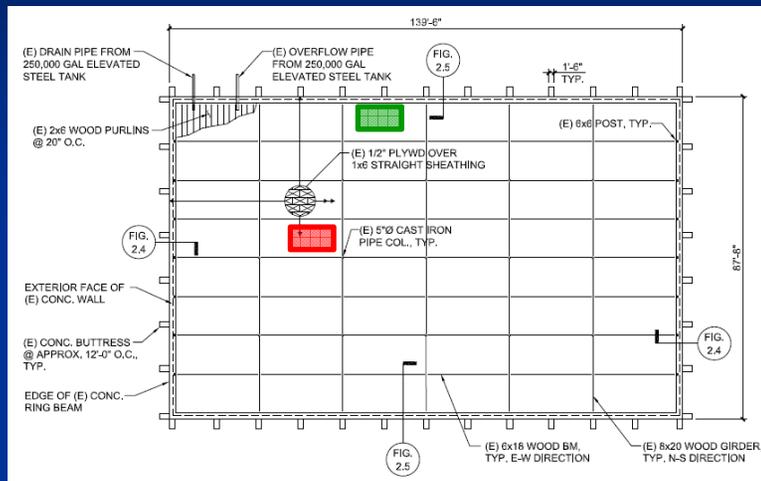
Concrete Strip Footing not shown on Available Original Drawings

I MG Reservoir Construction



Tank Floor Slab Cracking
(Unreinforced Concrete)

I MG Reservoir Construction



Investigation Locations



Plywood Overlay

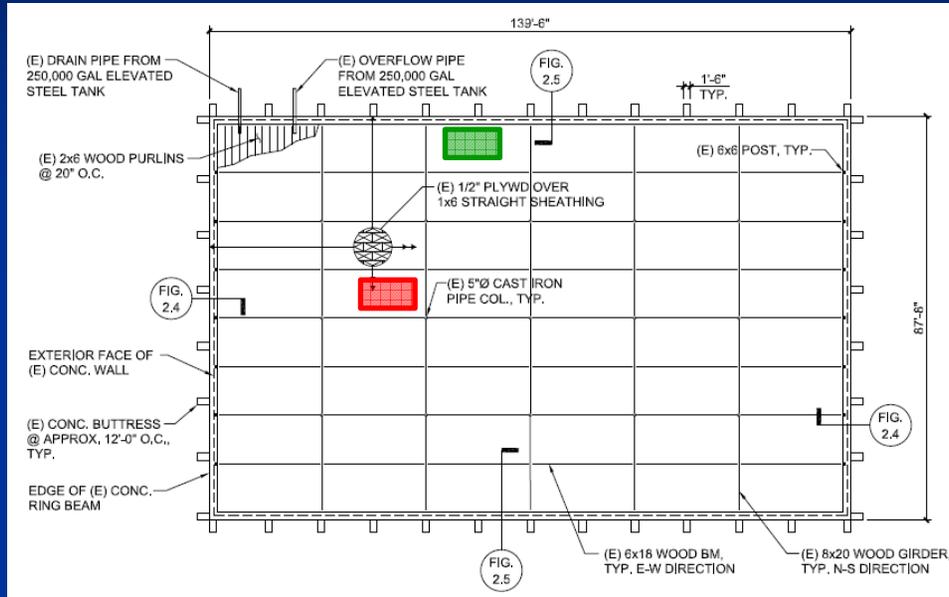


1x6 Straight Sheathing



Plywood Buckled from Moisture

I MG Reservoir Construction



Roof Plan

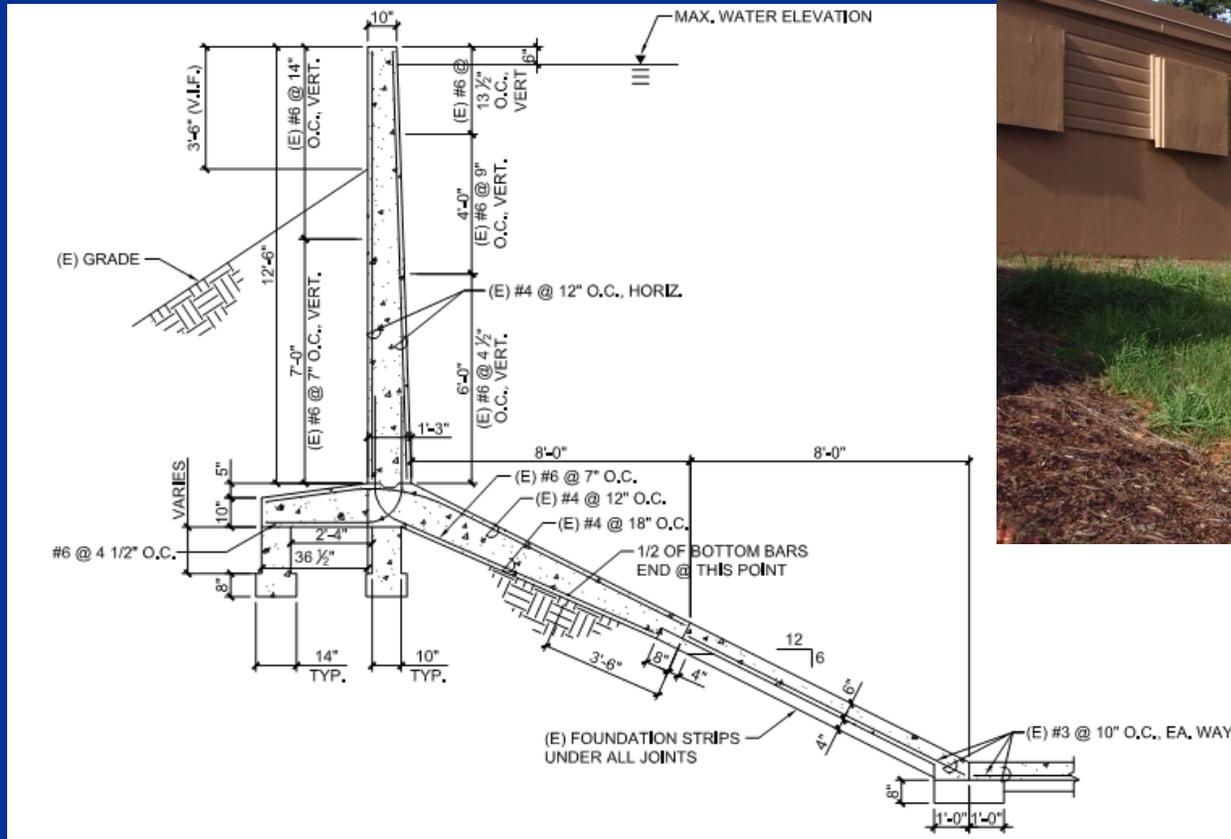


Plywood Overlay Nails



Straight Sheathing Nails

4 MG Reservoir Construction

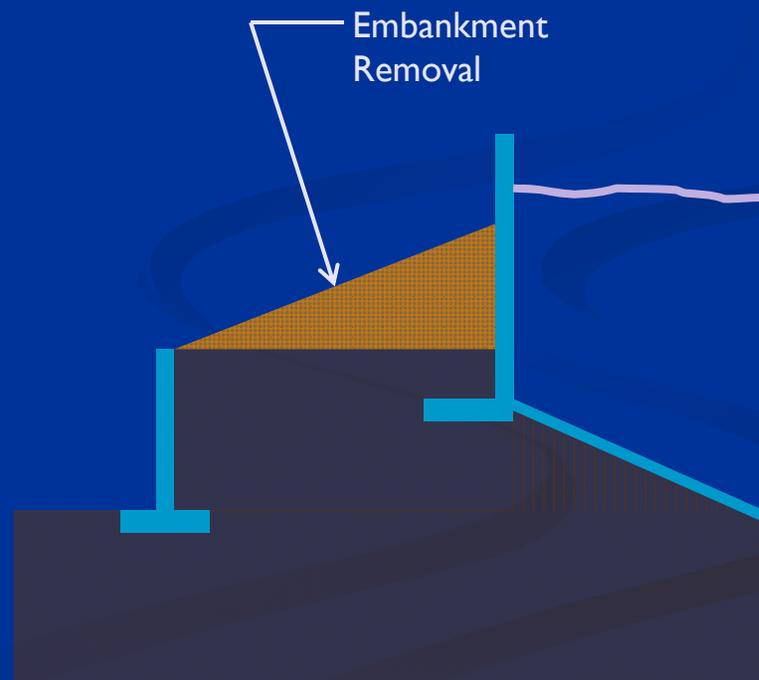


East Side

4 MG Reservoir Construction



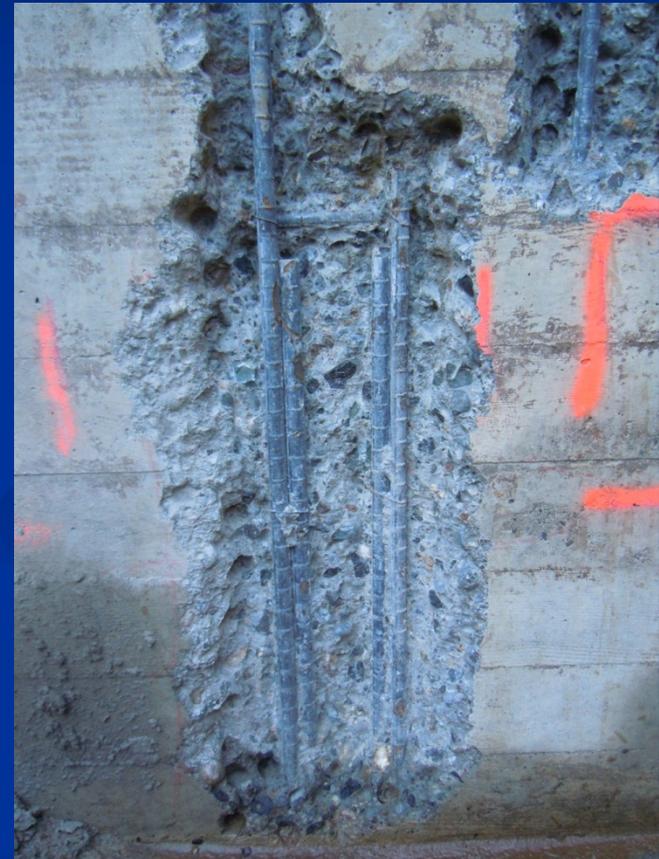
Retaining Wall on West Side



4 MG Reservoir Construction

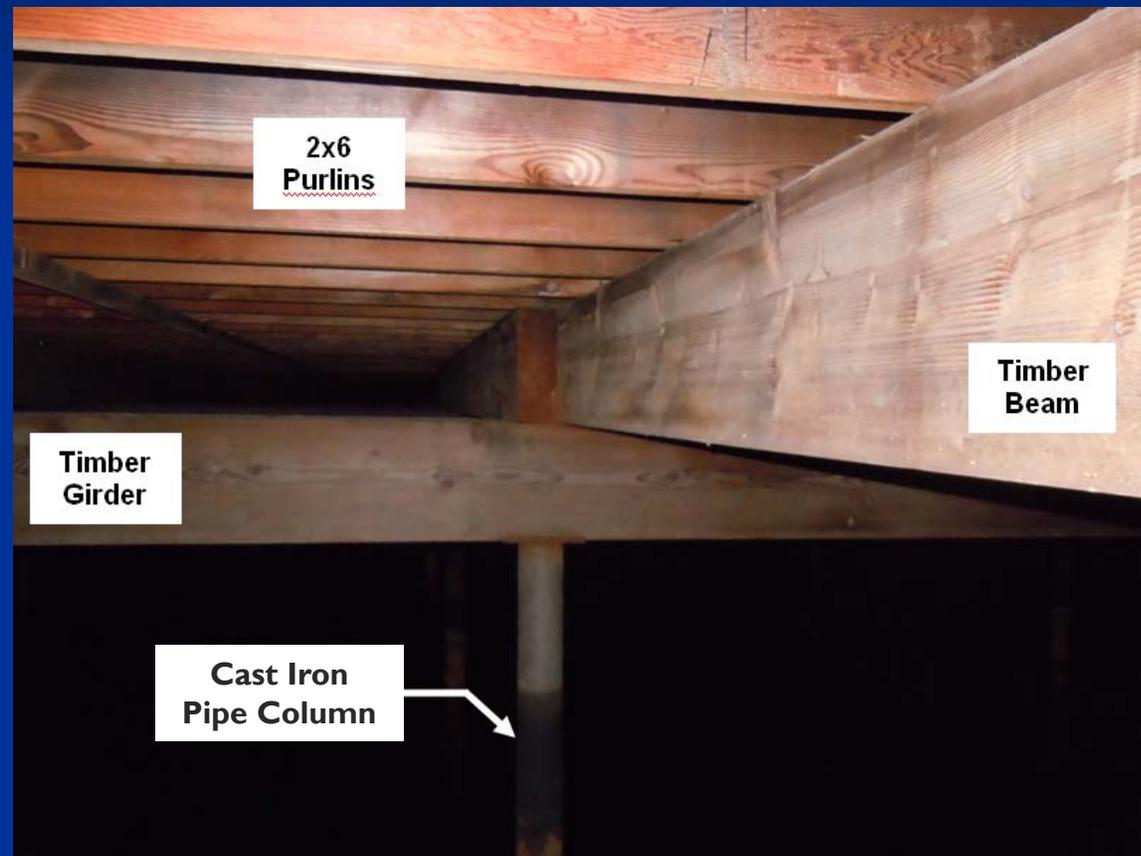


Located Reinforcing



Reinforcing Lap Splice

4 MG Reservoir Construction



Timber Roof Framing

4 MG Reservoir Construction



Tuberculation and Corrosion
Pitting of Columns



No Girder to Column
Connection



4 MG Reservoir Construction



Roof Diaphragm Deflection



Timber
Beam

6x6
Post

2x4 Pony
Wall

East and West Wall Framing

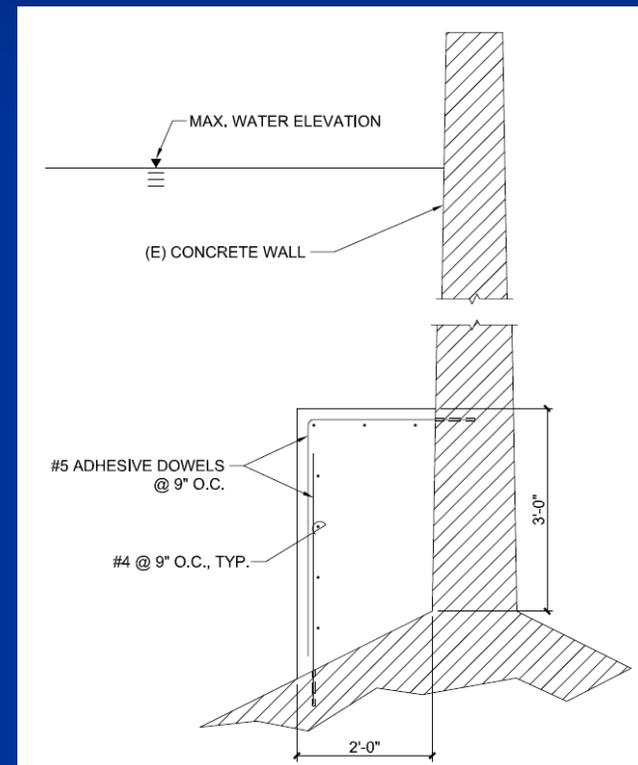
I and 4 MG Retrofit Schemes

- All schemes retrofit concrete tank
- Roof Retrofit Options
 - Scheme A – Retrofit (E) Timber Roof
 - ❖ Good Seismic Performance
 - ❖ 30-50 yr. Design Life
 - Scheme B – New Aluminum Roof System
 - ❖ Good Seismic Performance
 - ❖ 50-100 yr. Design Life
 - Scheme C – Minimal Roof Retrofit
 - ❖ Probable Collapse of Roof Structure
 - ❖ 30-50 yr. Design Life (dependent on occurrence of earthquake)

All Schemes – Concrete Retrofit

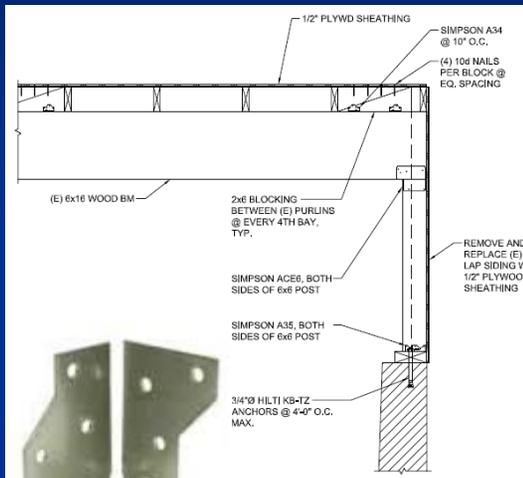


Polypropylene Liner
(1 MG)

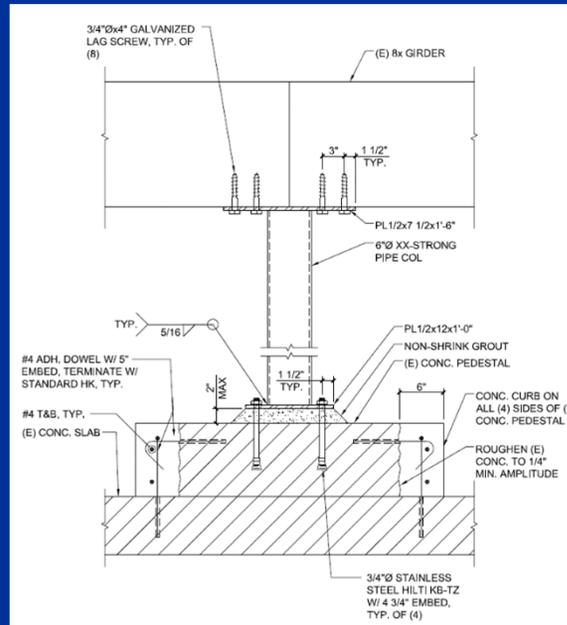


Concrete Haunch
(4 MG)

Scheme A – Retrofit (E) Timber Roof



Load Path



Replace Columns



Improved Ventilation

Scheme B – Aluminum Roof

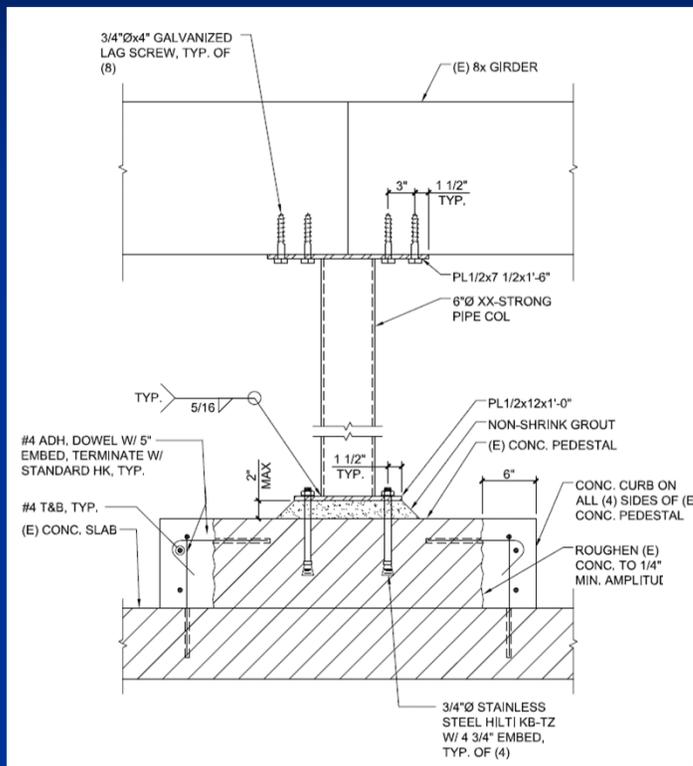


Images Courtesy of CST Covers

Scheme C – Minimal Roof Retrofit



Improved Ventilation



Replace Columns

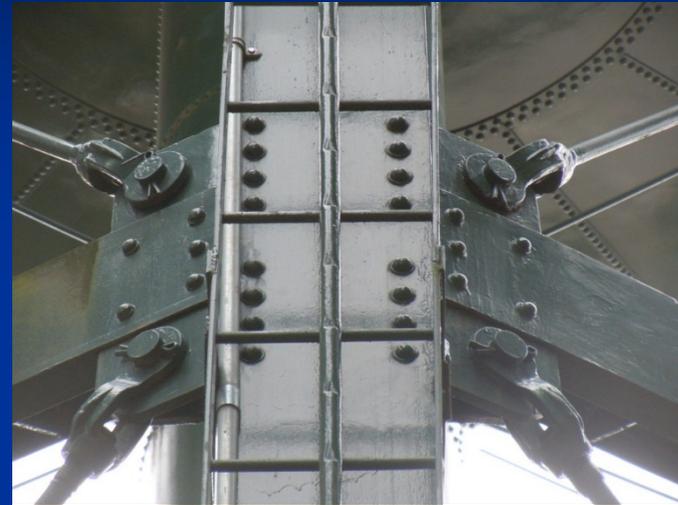


Debris Guard

Decision Matrix – 4 MG Reservoir

Decision Variable	Scheme A [Retrofit (E) Timber Roof]	Scheme B (New Aluminum Roof System)	Scheme C (Minimal Roof Retrofit)
Seismic Performance	2.5	2.5	1
Construction Cost	2	1	3
Annualized Construction Cost	1	2.5	2.5
Construction Schedule	1	2	3
Maintenance	1.5	3	1.5
Life Span	1.5	3	1.5
Total Score	9.5	14.0	12.5

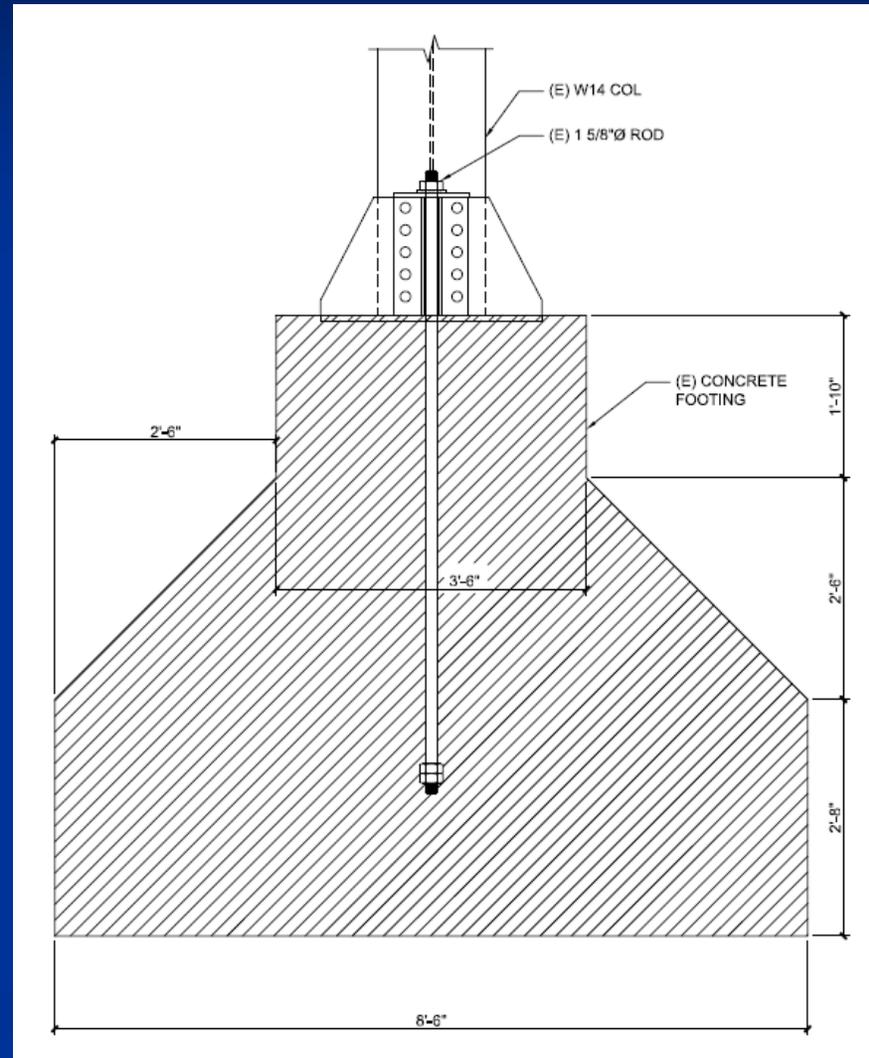
250 KG Tank Construction



250 KG Tank Construction



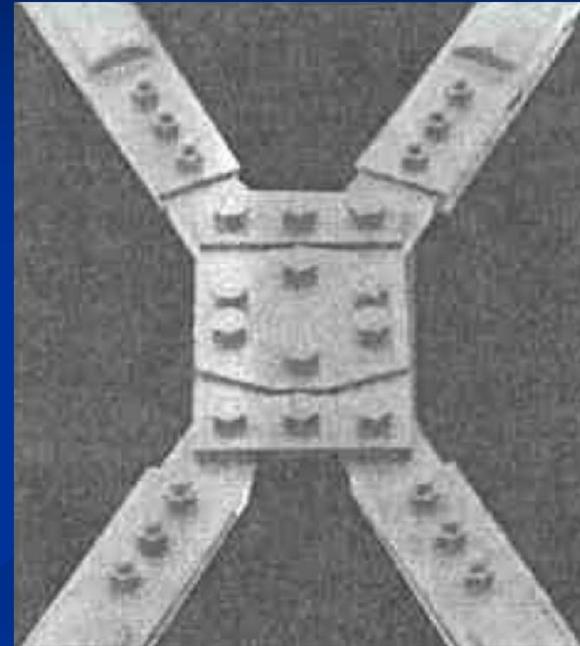
Footing Dimensions



250 KG Scope of Retrofit Scheme



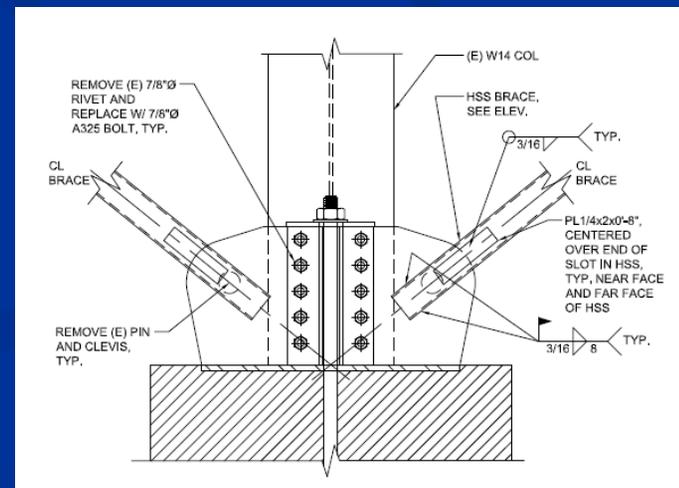
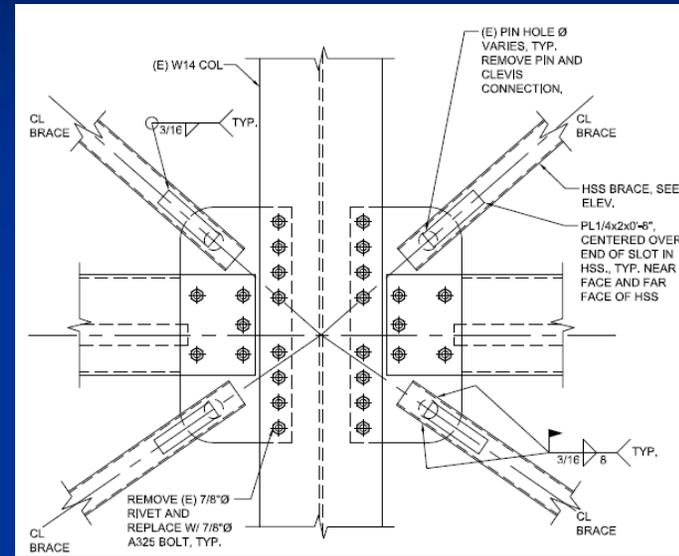
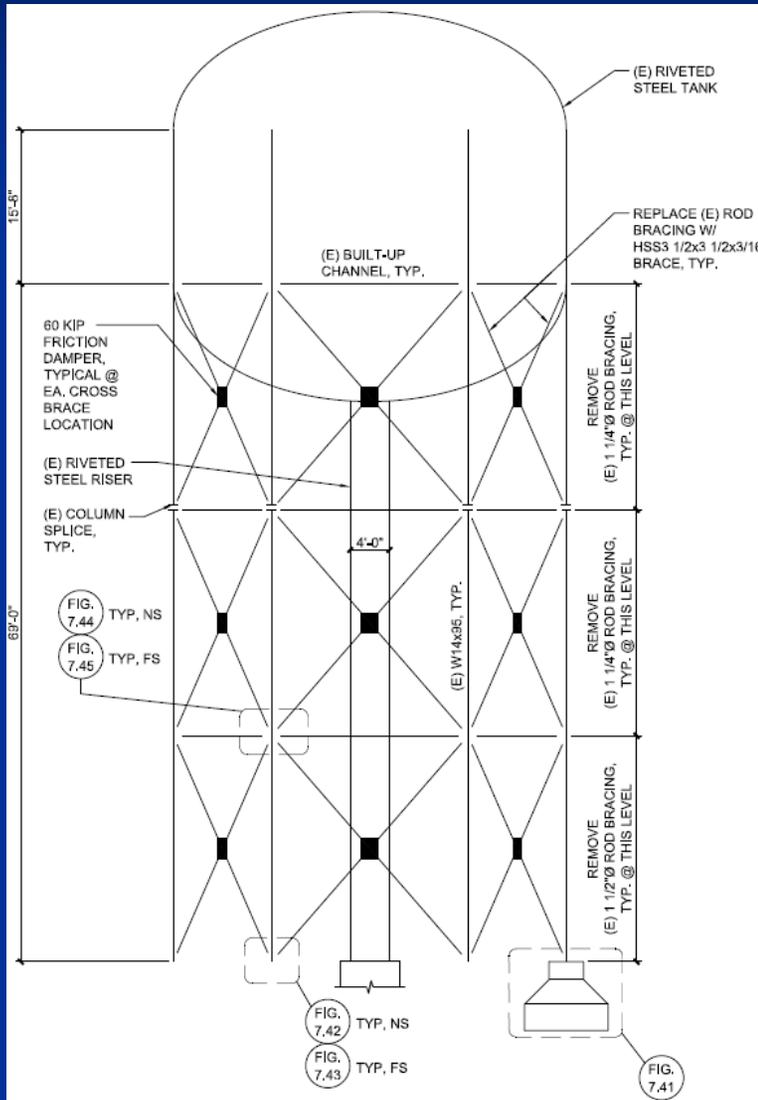
City of Renton
Rolling Hills 300 KG Tank



Pall Friction Damper



250 KG Expected Seismic Performance and Scope of Retrofit Schemes



Moving Forward

- Completely remove 1 MG reservoir
- Remove elevated tank and replace with a standpipe
- Complete seismic retrofits including roof replacement to 4 MG reservoir
- Install one new 3 MG reservoir

Questions/Discussion

