

Resilient Pipeline Design for Yard Piping of the JWC WTP - 85MGD Expansion



Erika Murphy, PE – Joint Water Commission

Brad Phelps, PE - Jacobs

April 25th, 2018



JACOBS[®]

www.jacobs.com | worldwide

Agenda

	Topic
1	Health and Safety Moment
2	JWC WTP “Expansion to 85 MGD” Project Overview
3	Northwest Seismicity and Liquefaction
4	JWC WTP Seismic Hazard
5	JWC WTP Yard Piping Alternatives and Selection
6	Q&A

Acknowledgements

Joint Water Commission

- Project Manager: Erika Murphy, PE
- Plant Manager: Chris Wilson
- Plant Operations Lead: Zac Bertz
- JWC Operations Committee

Slayden Construction

- Bob Montgomery
- Kerry Larsen

Jacobs

- Project Manager: Brad Phelps, PE
- Design Manager: Kim Ervin, PE
- Civil Lead: Byrl Thompson, PE



Health and Safety Moment – Seismic Safety

Protect Yourself During Earthquakes

FEMA P-1078



1 In a high-rise or other tall building, three options: Drop, cover and hold on. If you are unable to drop, crouch against a strong interior wall. Stay away from windows and outside walls. If you are in a room with a large, heavy object, such as a desk, crouch under it. If you are in a room with a large, heavy object, such as a desk, crouch under it.



2 In a chair, crouch under the seat. Drop, cover and hold on. If you are unable to drop, crouch against a strong interior wall. Stay away from windows and outside walls. If you are in a room with a large, heavy object, such as a desk, crouch under it.



3 In a bed, crouch under the bed. Drop, cover and hold on. If you are unable to drop, crouch against a strong interior wall. Stay away from windows and outside walls. If you are in a room with a large, heavy object, such as a desk, crouch under it.



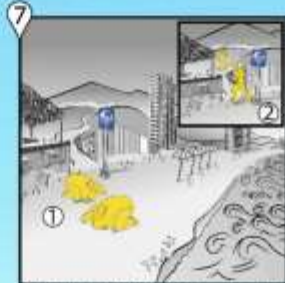
4 In a wheelchair, crouch under a desk or table. Drop, cover and hold on. If you are unable to drop, crouch against a strong interior wall. Stay away from windows and outside walls. If you are in a room with a large, heavy object, such as a desk, crouch under it.



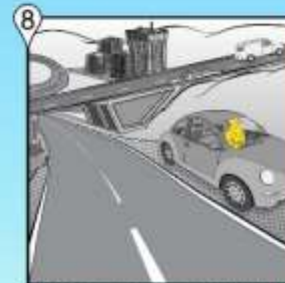
5 In a classroom, crouch under a desk or table. Drop, cover and hold on. If you are unable to drop, crouch against a strong interior wall. Stay away from windows and outside walls. If you are in a room with a large, heavy object, such as a desk, crouch under it.



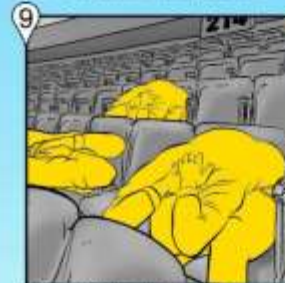
6 Outdoors, crouch on the ground. Drop, cover and hold on. If you are unable to drop, crouch against a strong interior wall. Stay away from windows and outside walls. If you are in a room with a large, heavy object, such as a desk, crouch under it.



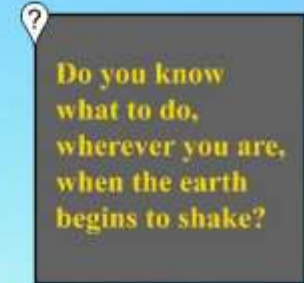
7 In a stadium or arena, crouch under a seat. Drop, cover and hold on. If you are unable to drop, crouch against a strong interior wall. Stay away from windows and outside walls. If you are in a room with a large, heavy object, such as a desk, crouch under it.



8 In a car, crouch on the floor. Drop, cover and hold on. If you are unable to drop, crouch against a strong interior wall. Stay away from windows and outside walls. If you are in a room with a large, heavy object, such as a desk, crouch under it.



9 In a stadium or arena, crouch under a seat. Drop, cover and hold on. If you are unable to drop, crouch against a strong interior wall. Stay away from windows and outside walls. If you are in a room with a large, heavy object, such as a desk, crouch under it.

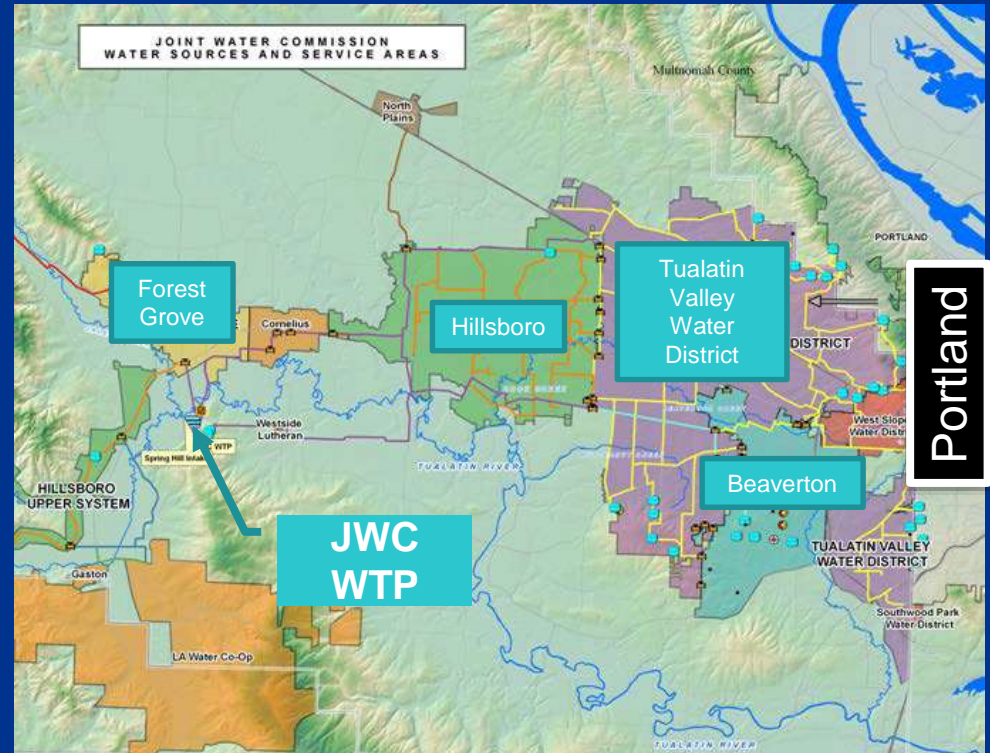


10 Do you know what to do, wherever you are, when the earth begins to shake?



JWC WTP “Expansion to 85 MGD” Project Overview

- ❖ Partnership Agencies
 - ✓ City of Hillsboro
 - ✓ City of Forest Grove
 - ✓ City of Beaverton
 - ✓ Tualatin Valley Water District
- ❖ The JWC WTP treats water from the Tualatin River.
- ❖ Raw Water Supply is supplemented with stored water from Hagg Lake and/or Barney Reservoir, located in the Oregon Coastal Range.

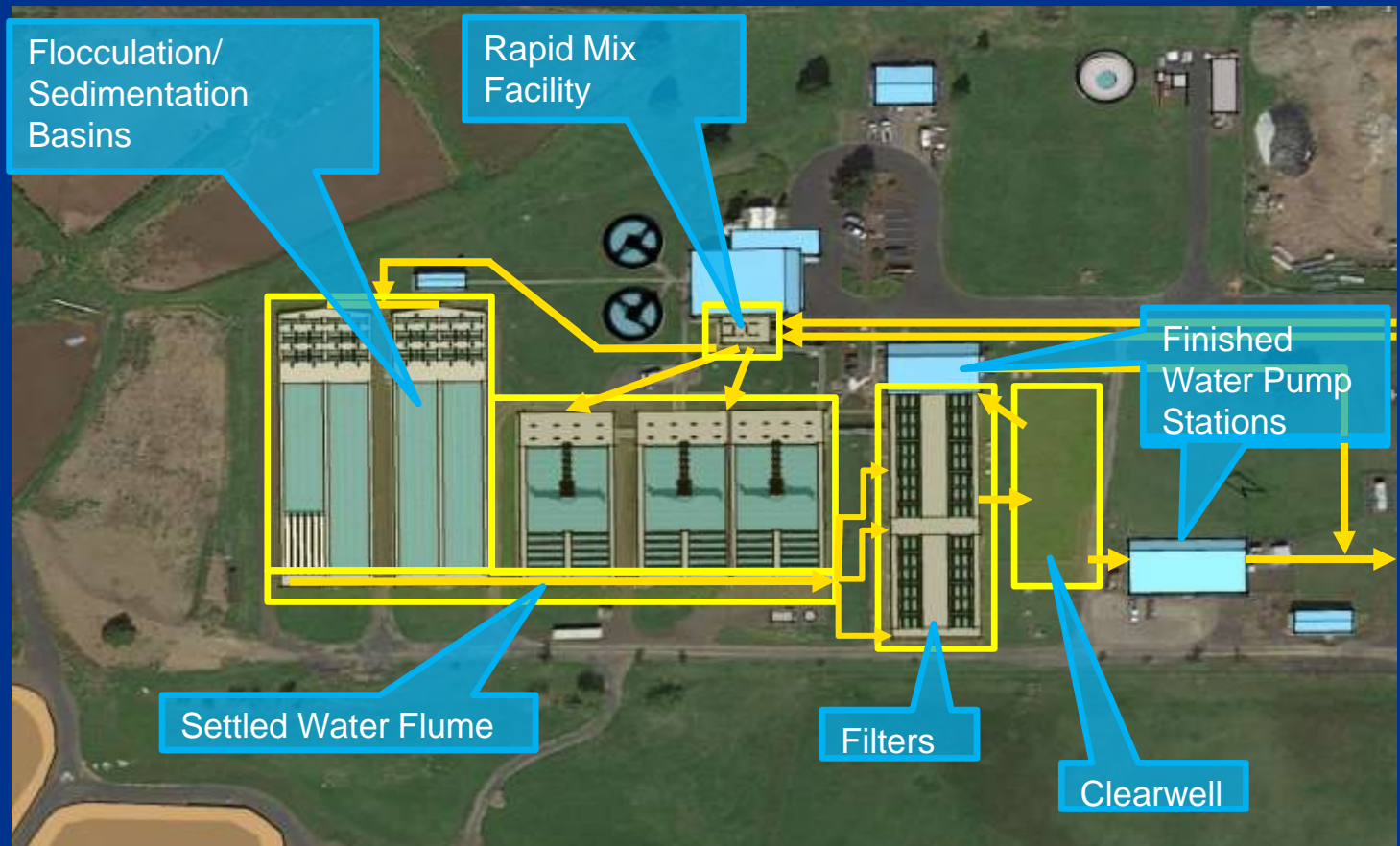


JWC WTP prior to Expansion to 85 MGD Project

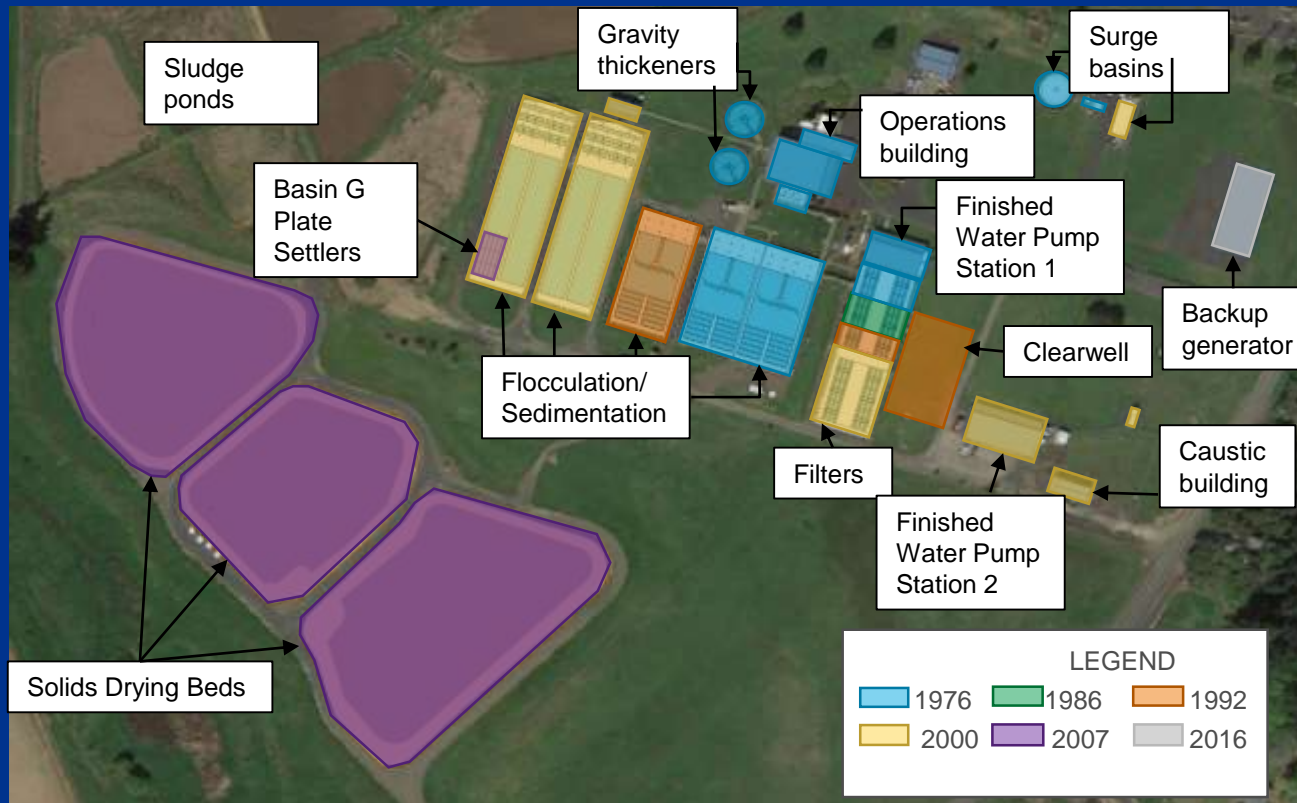
Rated Capacity:
- 75 MGD

Functional Capacity:
- 68 MGD

Process:
- Conventional Filtration Plant



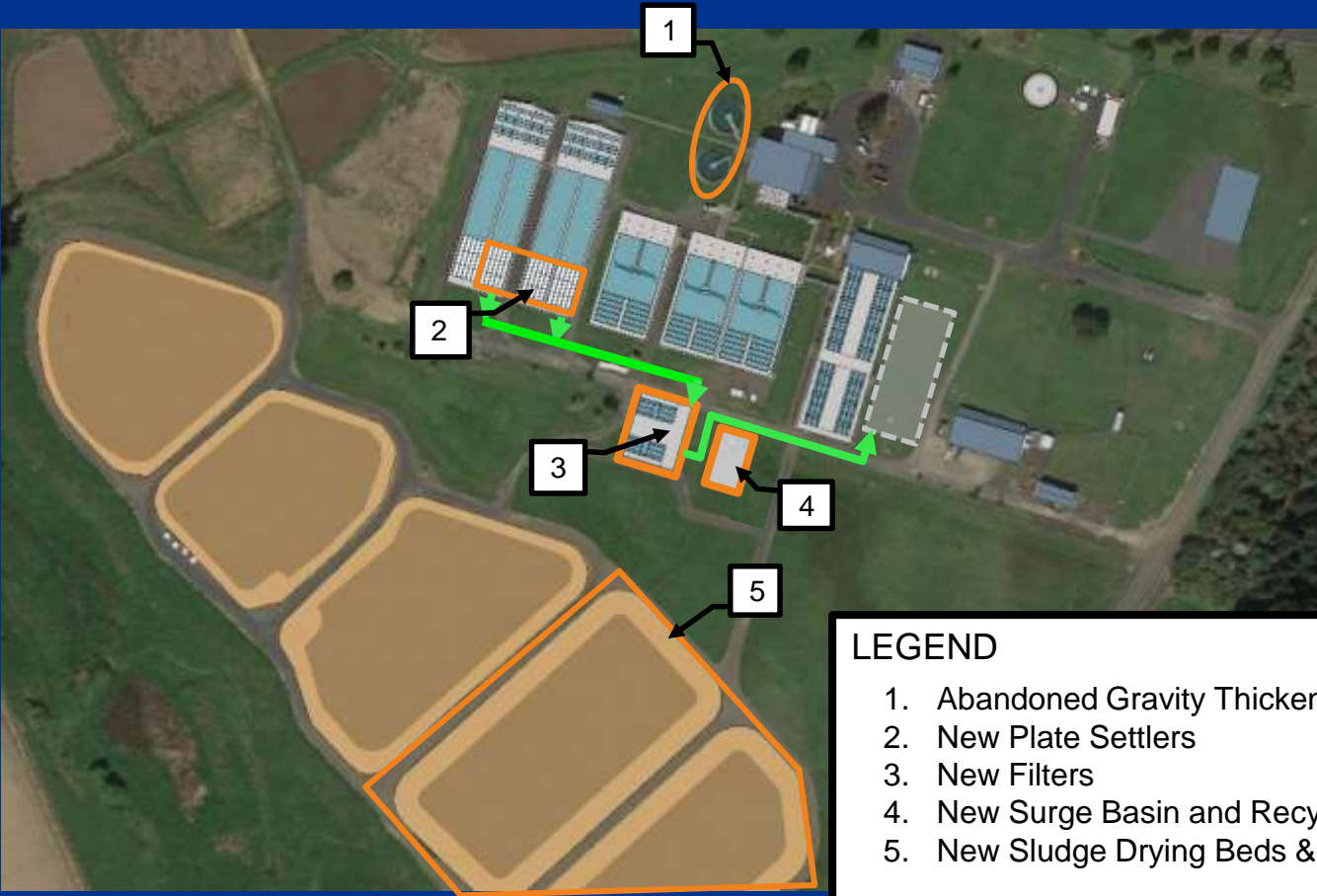
JWC WTP Expansion History



JWC WTP Expected Seismic Performance




Expansion to 85 MGD (2019)



LEGEND

- 1. Abandoned Gravity Thickeners
- 2. New Plate Settlers
- 3. New Filters
- 4. New Surge Basin and Recycle PS
- 5. New Sludge Drying Beds & Decant PS

 NEW PIPELINES

JWC WTP Post-Earthquake Level of Service Goals

Seismic Event	Immediate Capacity (MGD)	Short-Term Capacity (MGD)	Short-Term Restoration Time (Days)	Water Quality
72-year event	42 ^a	42 ^a	0	Potable
475-year event	0	24	1	Potable
2,475-year event ^b	0	12	3	Potable
		28 ^c	7 to 14	
		42 ^a	60 to 90	

^a Average day demand is 42 MGD.

^b Seismic event generally associated with a full rupture of the Cascadia Subduction Zone

^c Average winter demand is 28 MGD.

Pacific Northwest Seismic Hazards

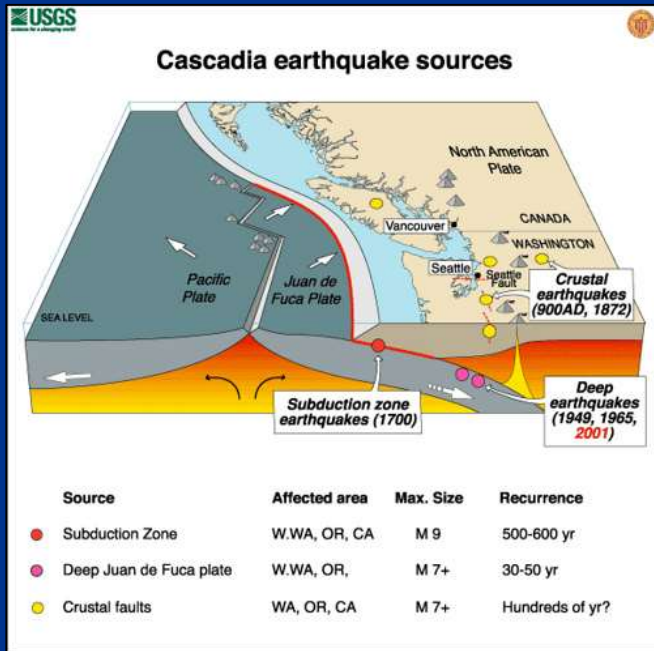
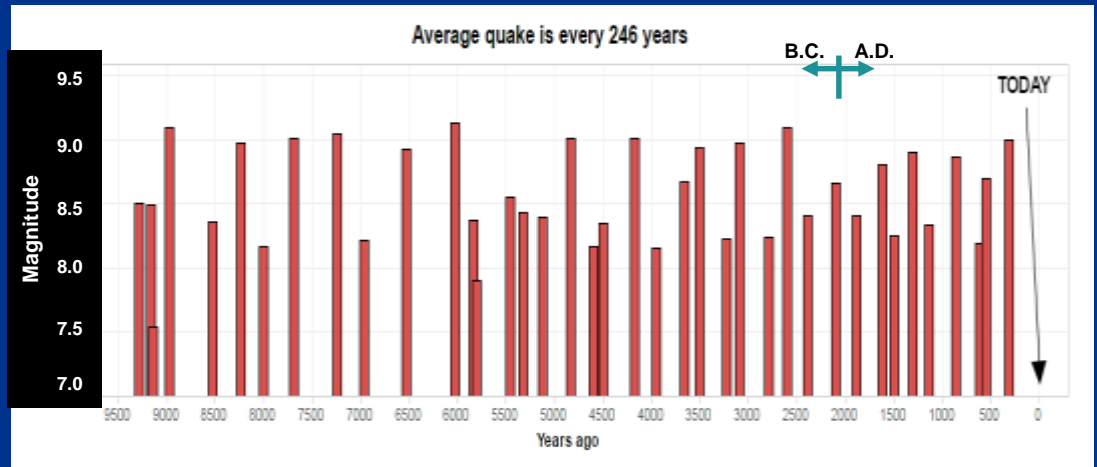


Image reprinted from Pacific NW Seismic Network



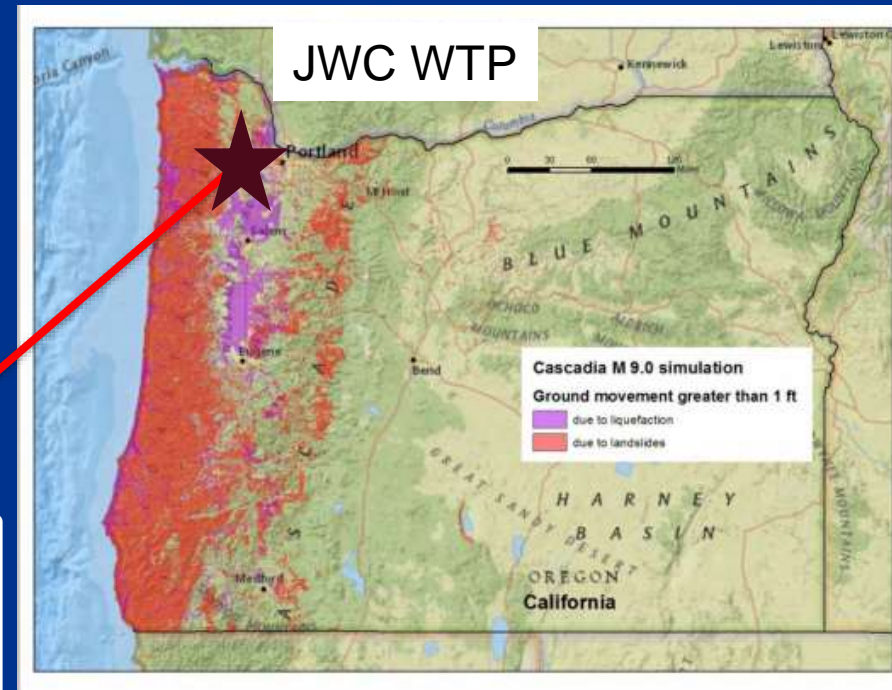
- Earthquake of Magnitude 9+ (fault breaks along entire subduction zone)
- Earthquake of Magnitude 8 to 8.5 (fault breaks along southern half of subduction zone)
- Average Magnitude 8+ earthquake every 246 years
- Average Magnitude 8.5+ earthquake every 530 years

Oregon Resiliency Plan

Permanent Ground Deformation Predictions

Red = >1-ft PGD due to landslides

Purple = >1-ft PGD due to liquefaction



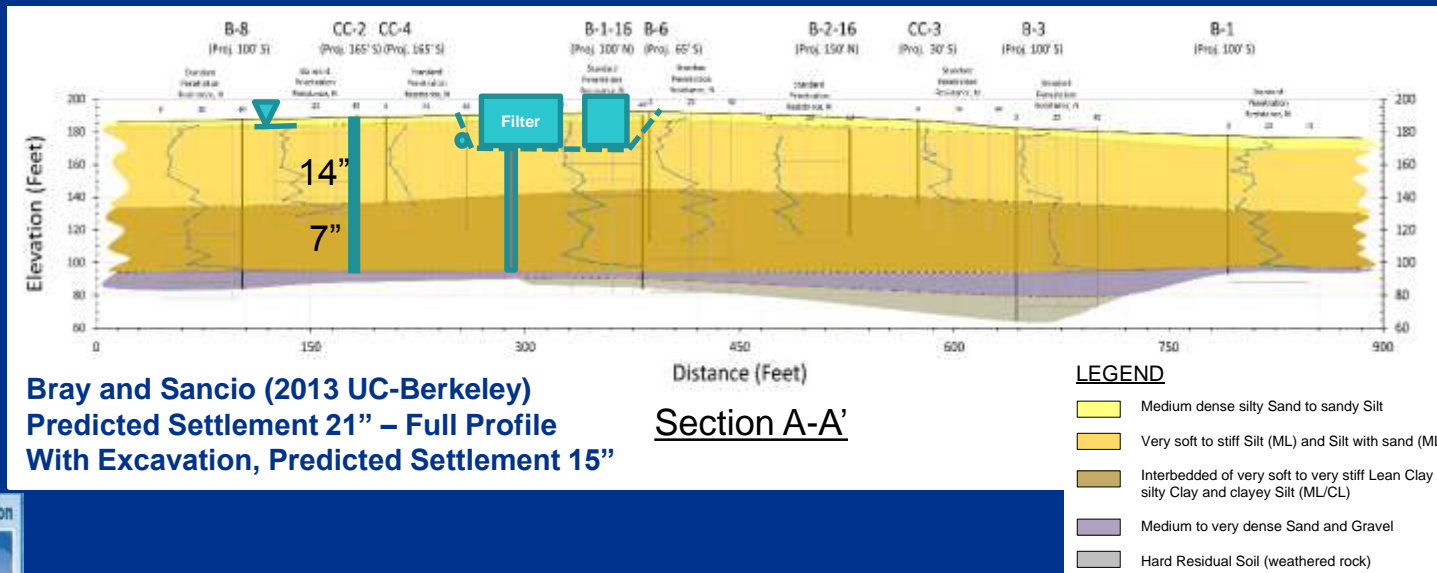
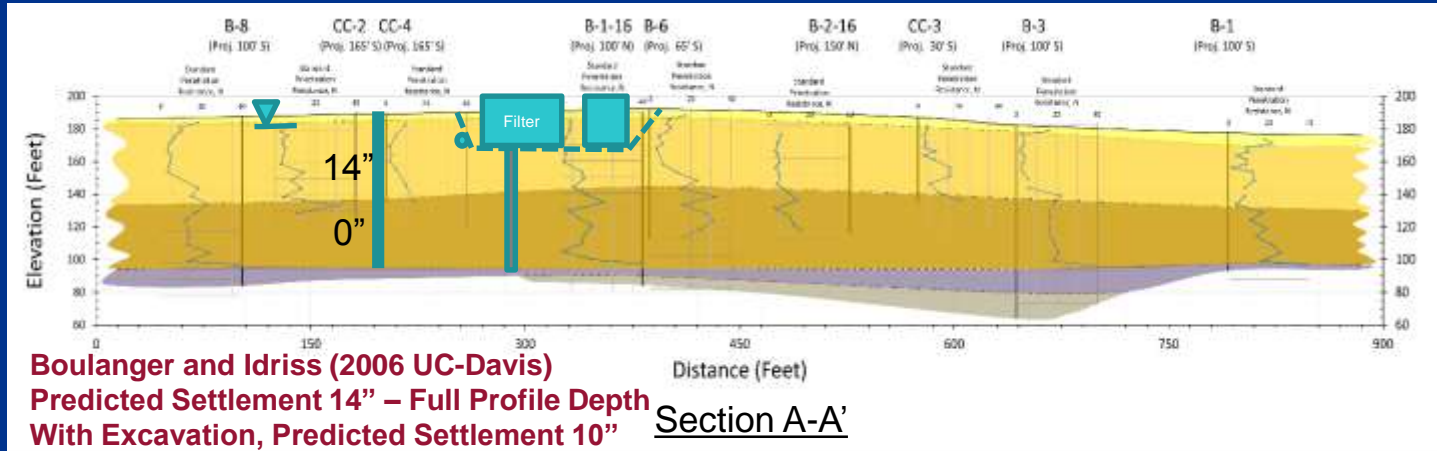
Liquefaction at Water Treatment Plants



Photos Courtesy of Oregon State University

<https://www.youtube.com/watch?v=GviJkVEMfwQ>

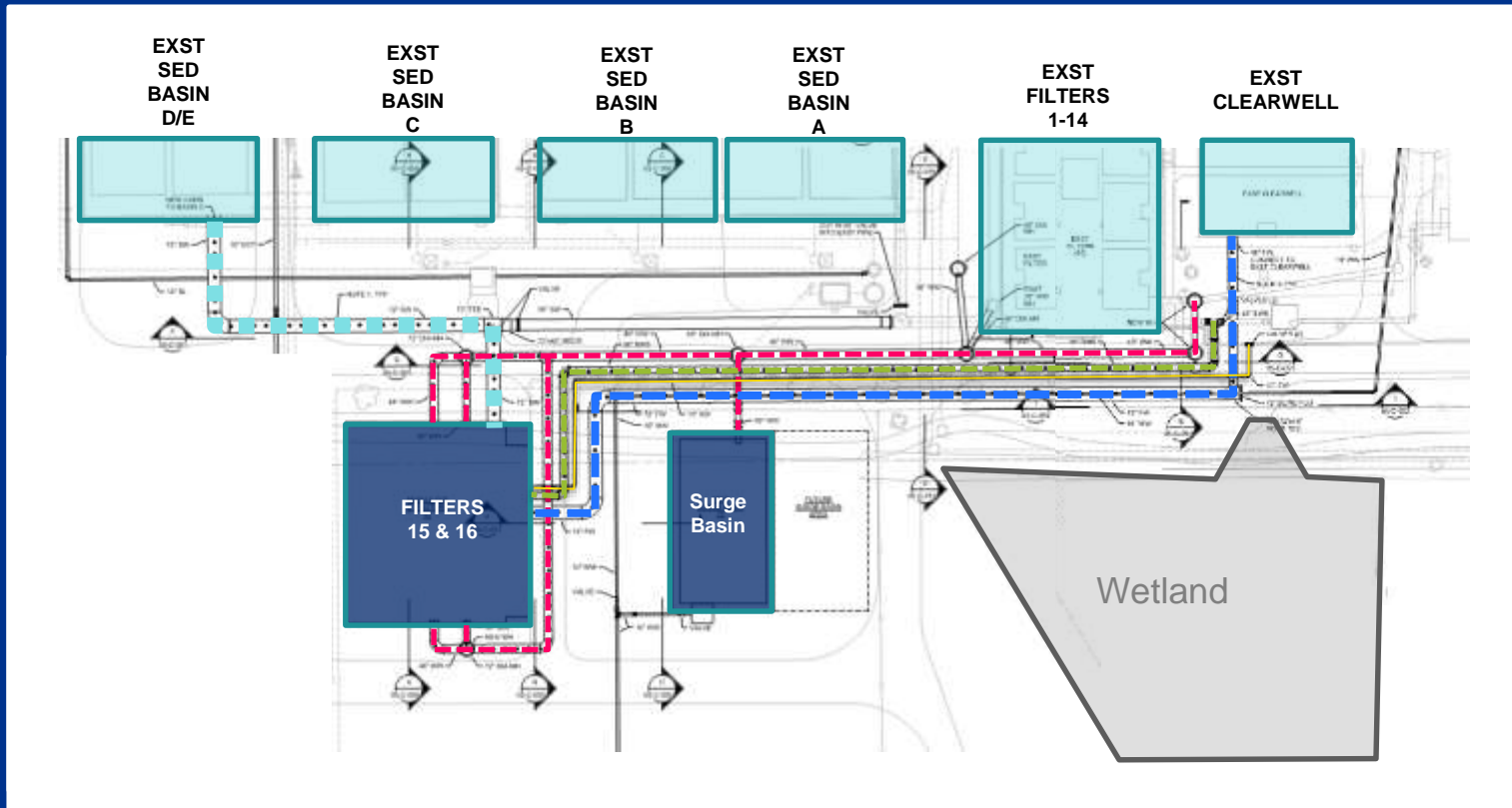
JWC WTP Subsurface Conditions



Yard Piping Seismic Resiliency Alternatives and Selection



Expansion Project Yard Piping



Added Pipe Systems



Settled Water



Air Wash Supply



Waste Washwater



Filter Effluent



Backwash Supply

Initial Pipeline Ground Improvement Considerations For Filter Yard Pipelines

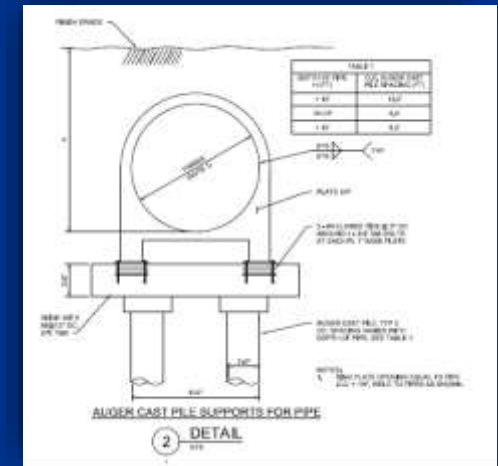
	Structure Flotation Prevention	Spoils Generation	Neighbor Impacts	Subsurface Compatibility
Nothing	-	-	-	-
Cement Soil Mixing	-	High	Low	Yes
Stone Columns	-	Medium	Low	No Not Below EL 130
Auger Cast Piles	Resists Flotation	Medium	Low	Yes
Driven Steel Piles	Resists Flotation	Low	High	Yes

Initial Design Auger Cast Piles:

Filter Structure: 53 Piles

Surge Basin: 45 Piles

Pipelines: 280 Piles



Initial Design - New Filter Yard Piping Cost Breakdown Auger Cast Pile Supported

Element	Estimated Cost
Pipe and Valves	\$2.4 M
Installation	\$1.8 M
Foundation Improvements	\$5.0 M
Total Yard Piping Cost for New Filters	\$9.2 M

Alternative Evaluation (Mechanical) Considerations

Flexible Piping Alternatives

- ✓ Kubota Pipe
- ✓ American Pipe
- ✓ US Pipe*
- ✓ Victaulic Couplings

Flexible Structure Connection Alternatives

- ✓ EBAA Iron Flex-Tend
- ✓ Victaulic Advanced Groove System (AGS)

Kubota Earthquake Resistant Ductile Iron Pipe (ERDIP)



Joint

Lineup of ERDIP

Pipes

GENEX_®
Nominal Diameter
3" ~ 16"
(76mm ~ 406mm)
Flush-on joint
Wall Thickness D1/D2

GENEX_®
Nominal Diameter
3" ~ 16"
(76mm ~ 406mm)
Mechanical joint

N S
Nominal Diameter
20" ~ 40"
(508mm ~ 1016mm)
Mechanical joint
Wall Thickness D2

N S
Nominal Diameter
20" ~ 40"
(508mm ~ 1016mm)
Mechanical joint

S
Nominal Diameter
44" ~ 104"
(1118mm ~ 2642mm)
Wall Thickness XXX

U F
Nominal Diameter
32" ~ 104"
(813mm ~ 2642mm)
Wall Thickness XXX

① In the range of over DN400 (DN700mm), S-type joint is fixed up. If you have interests in S-type joint large diameter pipes, feel free to contact us anytime.

Concept

The Earthquake Resistant Ductile Iron Pipe (ERDIP) absorbs the large ground displacement such as ground subsidence and crack by joints extension/contraction, deflection, and anti-pull out structure. When one joint fully extends at the event of large earthquakes, the joint can pull the next pipes one after another like a buried chain. Therefore, this pipeline is called chain structure pipeline.

Chain structure Pipeline

Lock ring Spigot Protrusion
1% of pipe length
1% of pipe length

Performance of the Joint

The joint performance of ERDIP is the highest rank in ISO 16134.

Property	Performance	ISO 16134
Amount of expansion/contraction	±1% of L	Class S-1
Pull-out resistance	30 kN 17,000L (kg) (SD~NN)	Class A
Joint deflection angle	6.2°	

① Nominal pipe length
② Nominal diameter of pipe (outside)
③ Nominal diameter of pipe (inside)
④ Joint deflection angle rate depending on pipe diameter

Pull-out resistance
60 (300kg)
(300kN)
= 30 cars' weight



American Earthquake Pipe



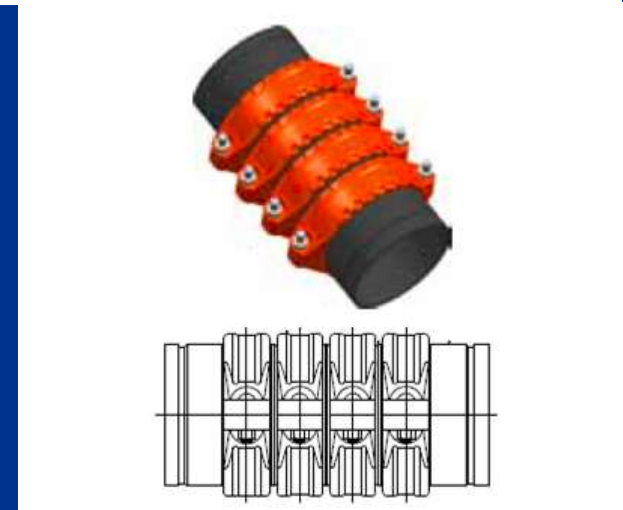
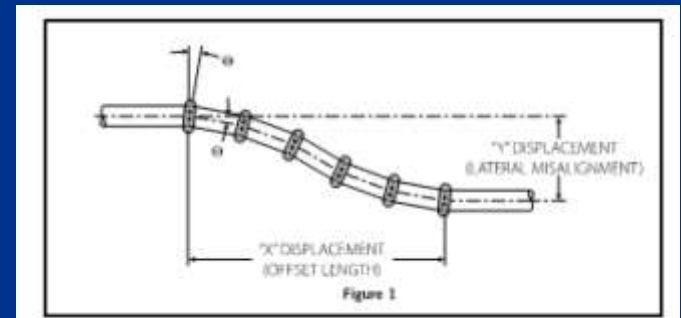
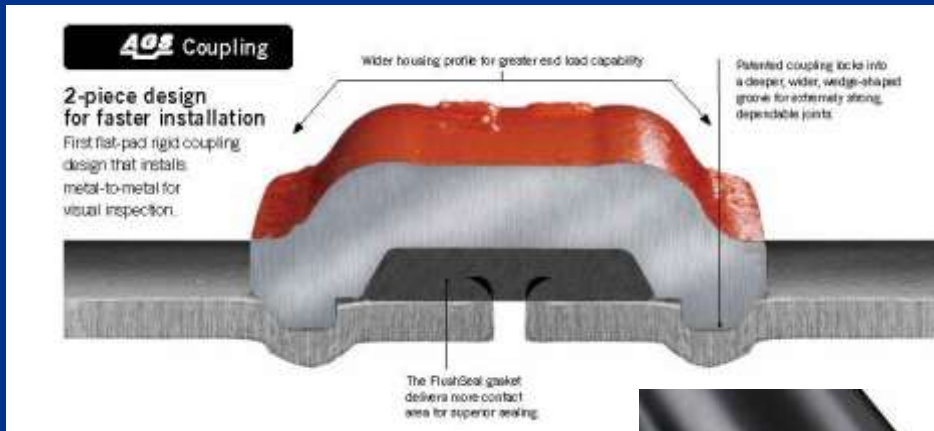
**American Flex-Lok Ball
Joint Pipe**

American Earthquake Joint System

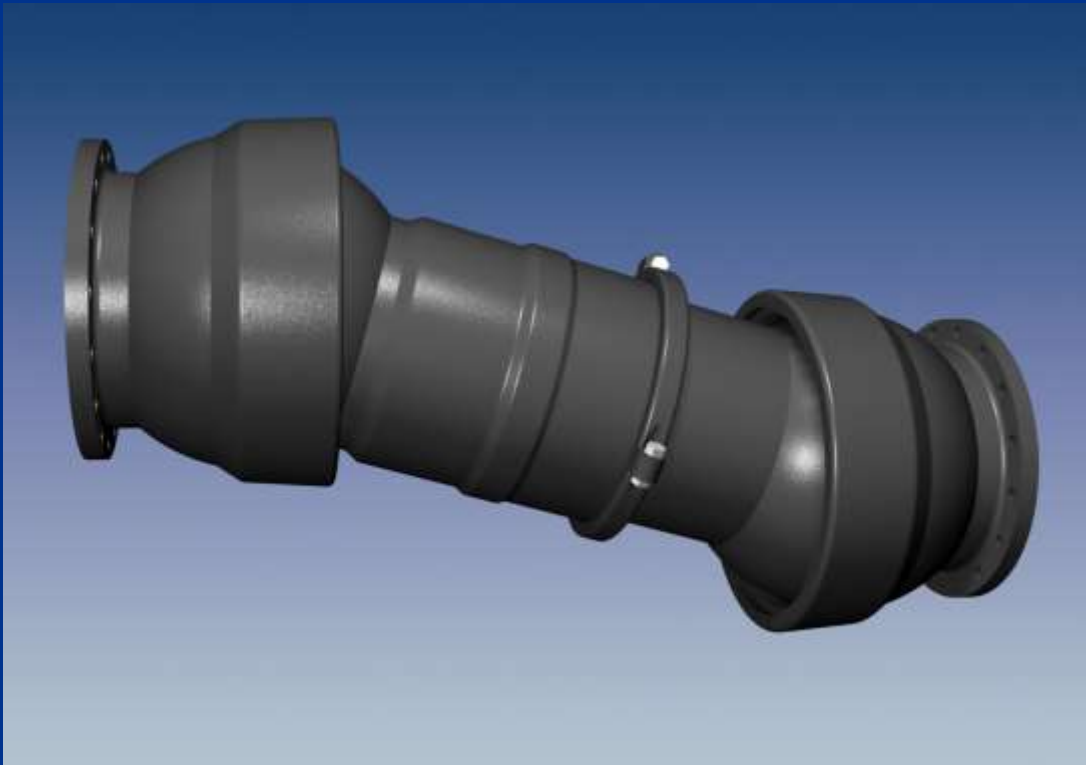
[American Earthquake Joint Video](#)



Victaulic Advanced Groove System (AGS)

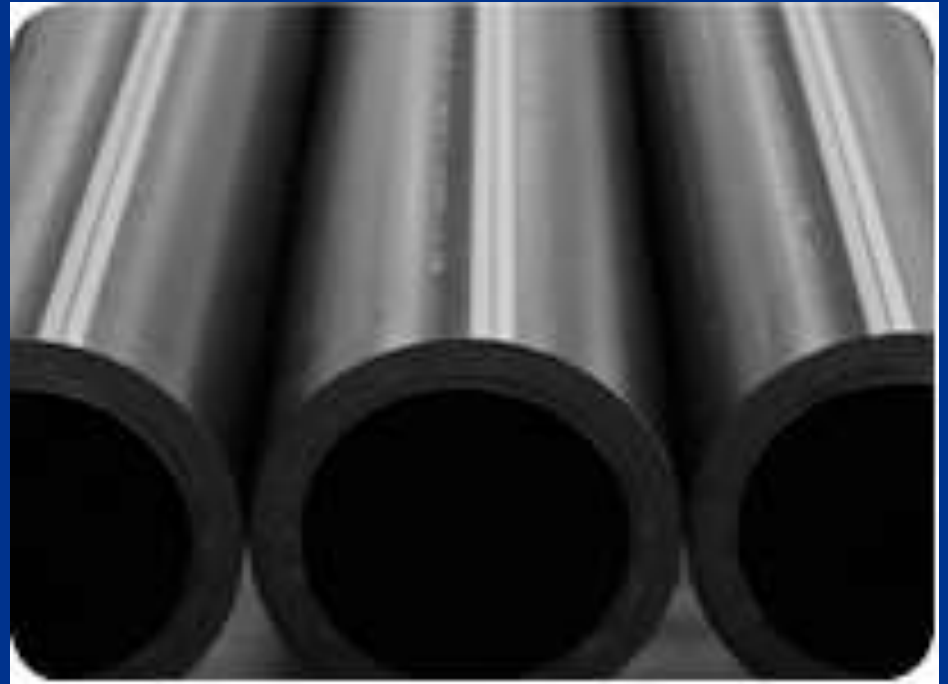


EBAA Flex-Tend



HDPE

IPS Sizes to 63-inch - 100 psi
DIP Sizes to 48-Inch - 125 psi



High level of flexibility over long distances

Seismic Structure Connection Alternatives Summary

(Based on 48" Pipe)

Kubota ERDIP
(American ERDIP
deflection equal or greater)



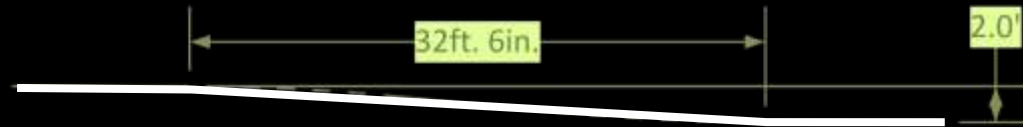
6 Degree Deflection @ 20' O.C. (x2)

Traditional Restrained Pipe



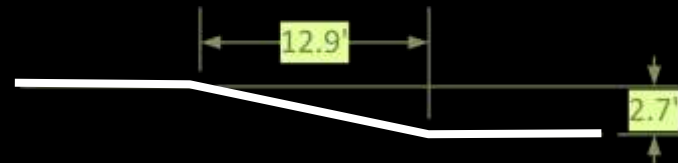
2 Degree Deflection @ 10' O.C. (x4)

Victaulic AGS System



0.45 Degree Deflection @ 1' O.C. (x24)

EBA Flex-Tend



12 Degree Deflection @ 13' O.C. (x2)



Settled Water Pipe Alternatives

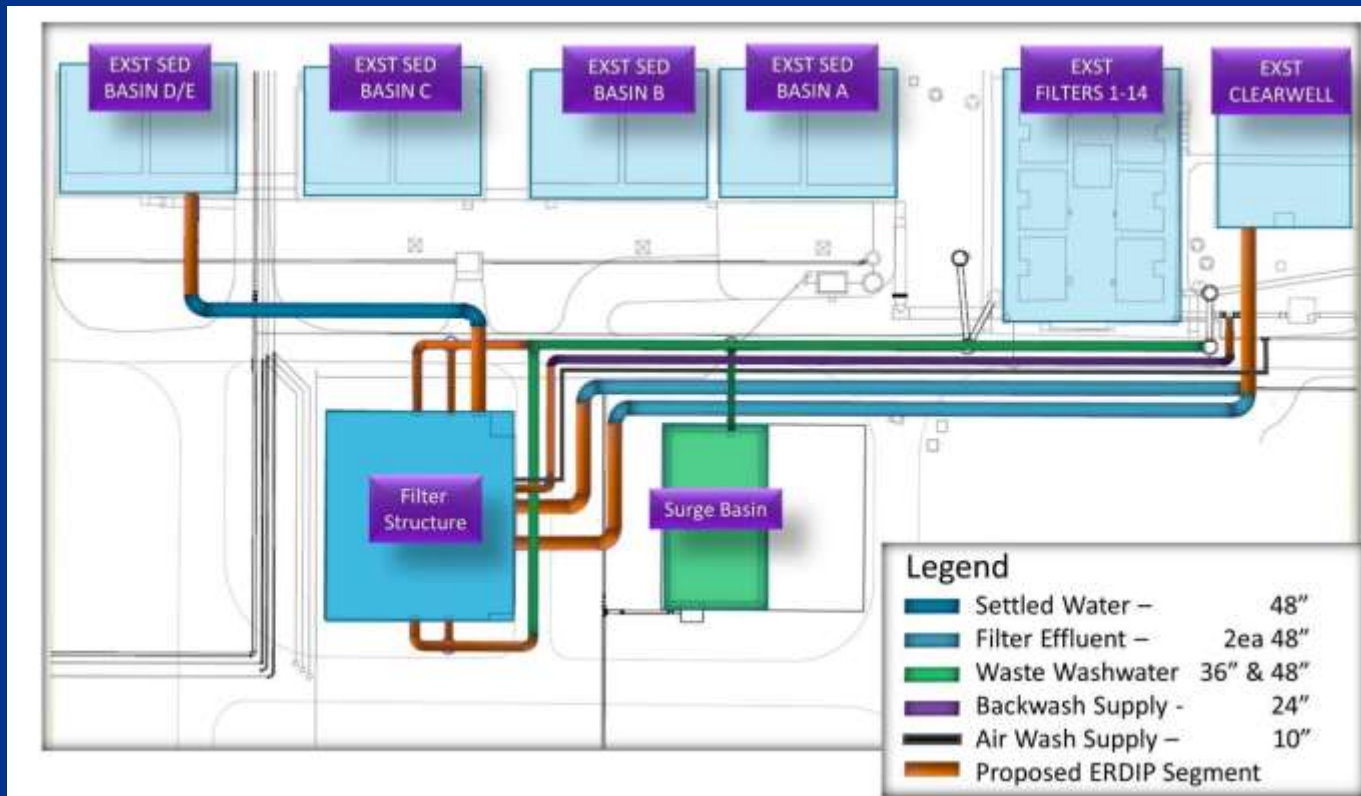
Option	Likelihood of Achieving Level of Service Goals		Cost
	475-yr Event	2,475-yr Event	
48" ERDIP combined with Restrained Ductile Iron Pipe	High	High	\$380K

Revised Cost Estimate

(Combined with reduced Pipe Sizes)

Alternative	Filter Yard Piping Cost
Initial Design Concept with Steel Pipe on Auger Cast Piles	\$9.2 M
Revised Design Concept with Seismic Ductile Iron Pipe	\$2.5 M
Yard Piping Cost <u>Savings</u>	\$6.7 M

Selected Seismic Pipe Alternative – ERDIP



PRESENTATION END & Questions