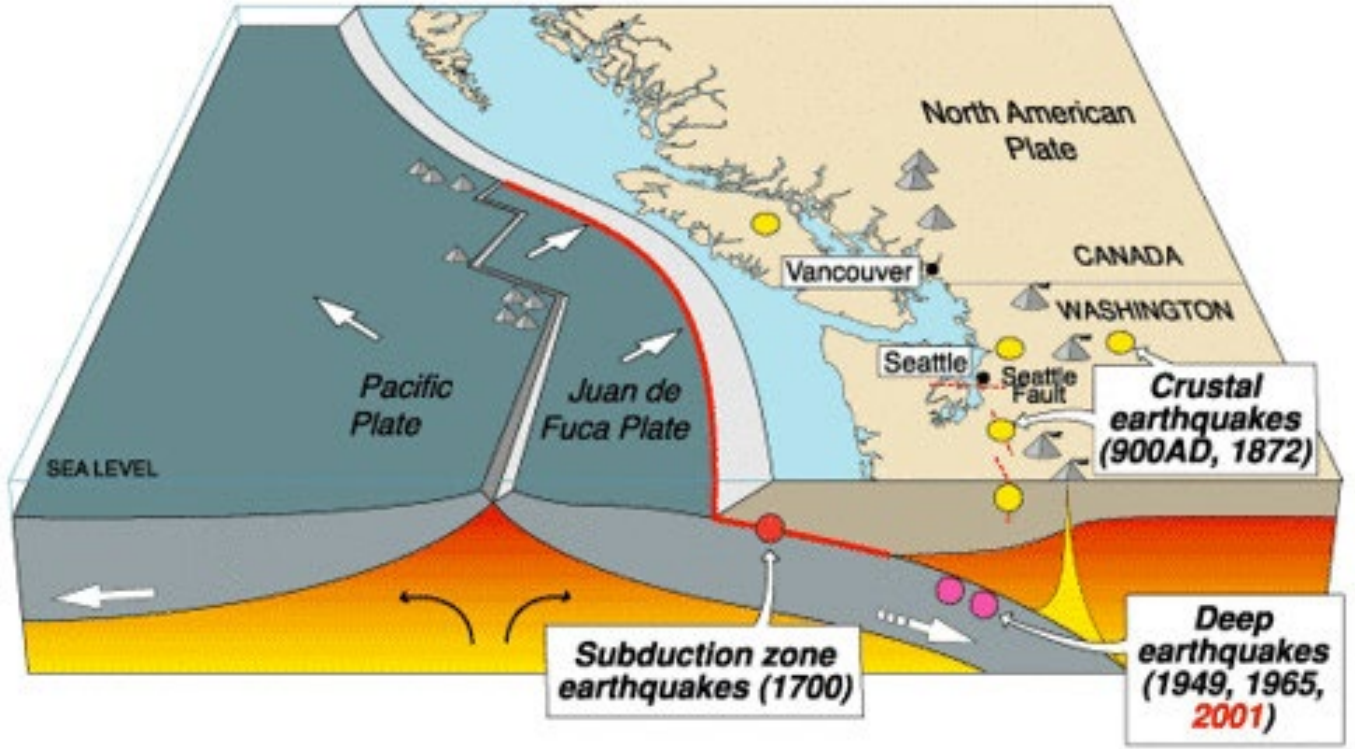
Installing Earthquake Resilient Watermains in Constrained Corridors

American Water Works Association
Pacific Northwest Section

Outline

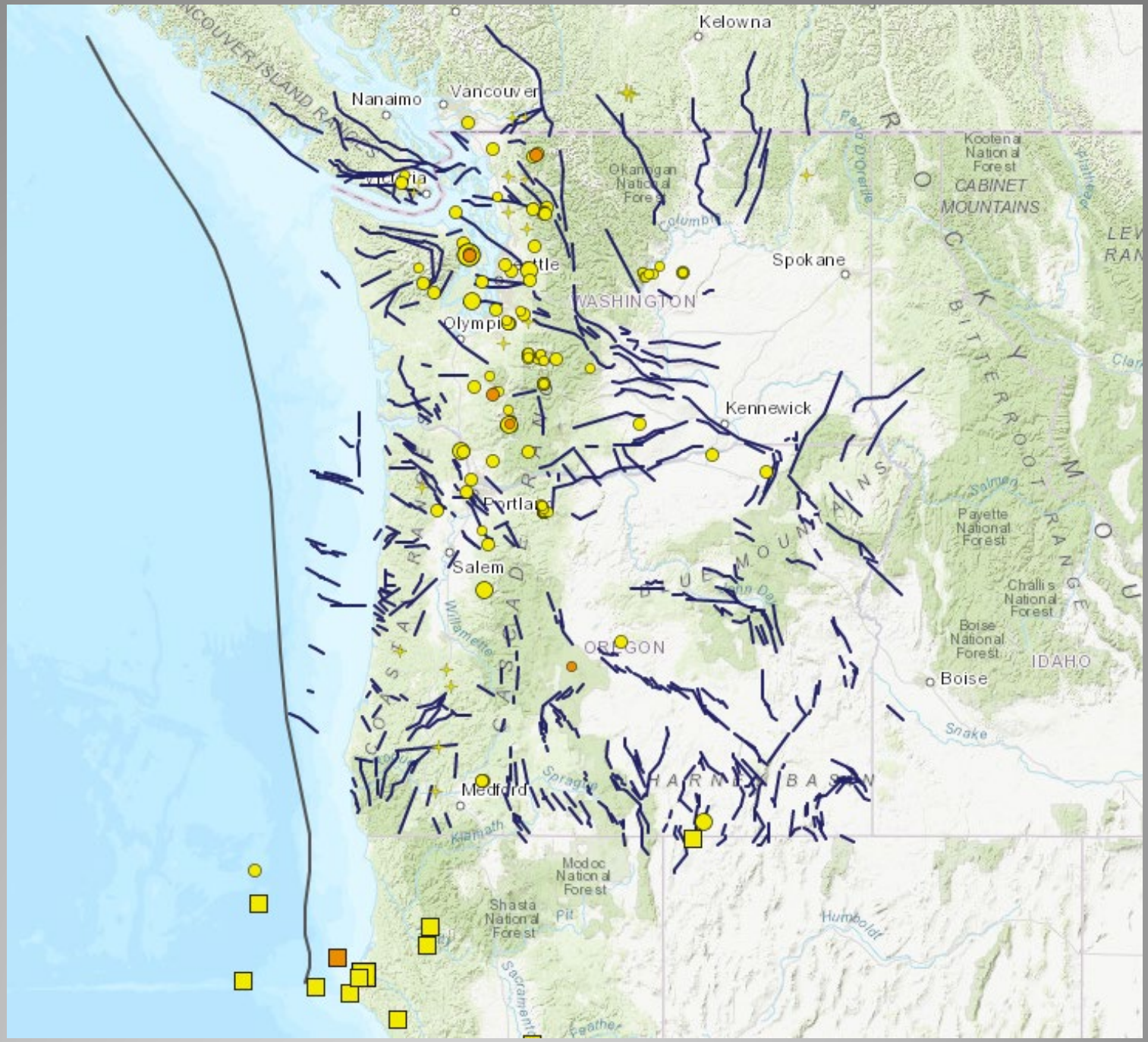
- ERDIP Introduction
- Project Description
- Challenges
- Solutions
  - Thrust Restraints
  - Large Utility Crossings
  - Appurtenance Structures
  - Corrosion Protection Design for Gas Main Crossing

Cascadia earthquake sources



Source	Affected area	Max. Size	Recurrence
Subduction Zone	W.WA, OR, CA	M 9	500-600 yr
Deep Juan de Fuca plate	W.WA, OR,	M 7+	30-50 yr
Crustal faults	WA, OR, CA	M 7+	Hundreds of yr?

PNW Faults


Kelowna
Nanaimo
Vancouver
Okanagan National Forest
Kootenai National Forest
CABINET MOUNTAINS
Spokane
WASHINGTON
Olympia
Kennewick
Portland
Salem
Payette National Forest
Challis National Forest
Boise National Forest
IDAHO
Boise
OREGON
Medford
Modoc National Forest
Shasta National Forest
Columbia
Snake
Klamath
Humboldt

Earthquake Resilient Ductile Iron Pipe (ERDIP)

Type of restrained joint

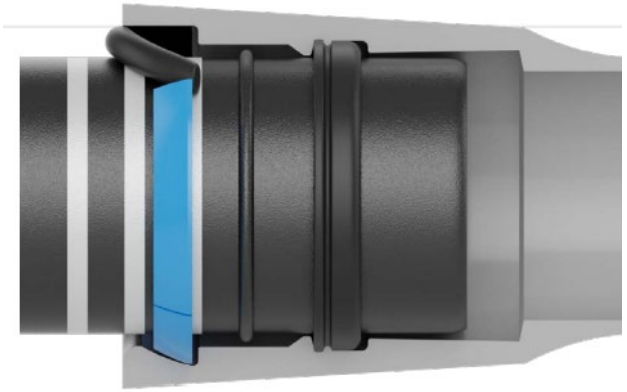
Design

Seismic Hazard

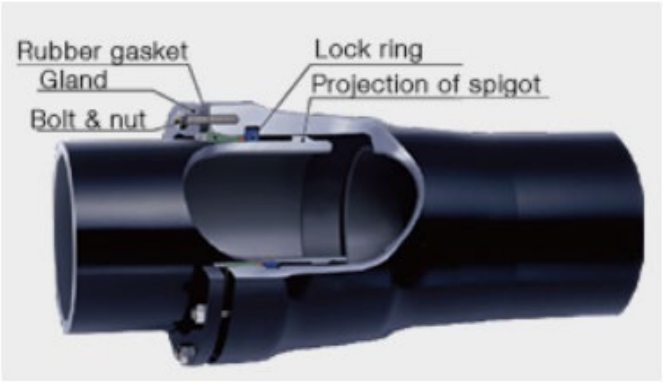
- Temporary Ground Deformation
- Nearby Non-Resilient Structures
- Permanent Ground Deformation

International Standard ISO 16134

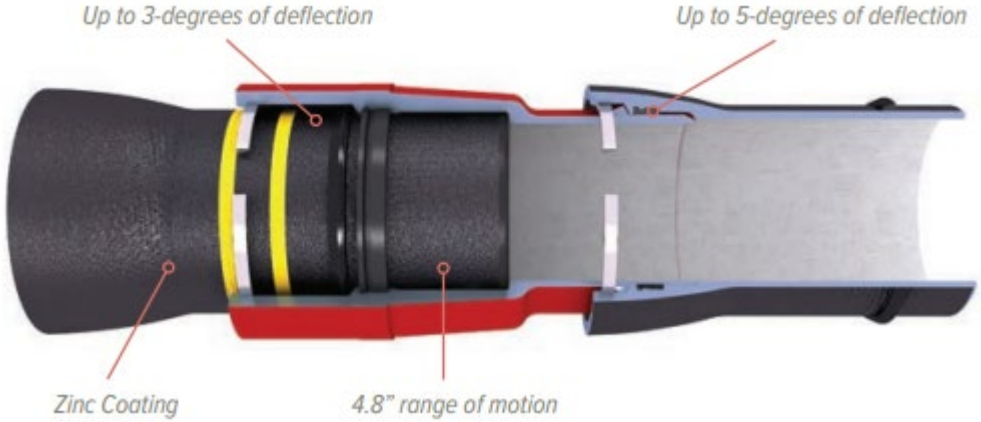
- Expansion/Contraction
- Pull Apart Resistance
- Joint Deflection Angle



US Pipe



Kubota



American

ISO 16134

	CLASS	COMPONENT PERFORMANCE
Expansion/Contraction Performance (Elongation)	S1	± 1% L or more
	S2	± 0.5% L to ± 1% of L
	S3	Less than ± 0.5% of L
Pull Apart Resistance	A	17,000 d lbs +
	B	8,500 d lbs–17,000 d lbs
	C	4,250 d lbs–8,500 d lbs
	D	Less than 4,250 d lbs
Joint Deflection Angle	M1	15° or more
	M2	7.5° < 15°
	M3	Less than 7.5°

"L" is the component length in inches

"d" is the nominal pipe diameter in inches

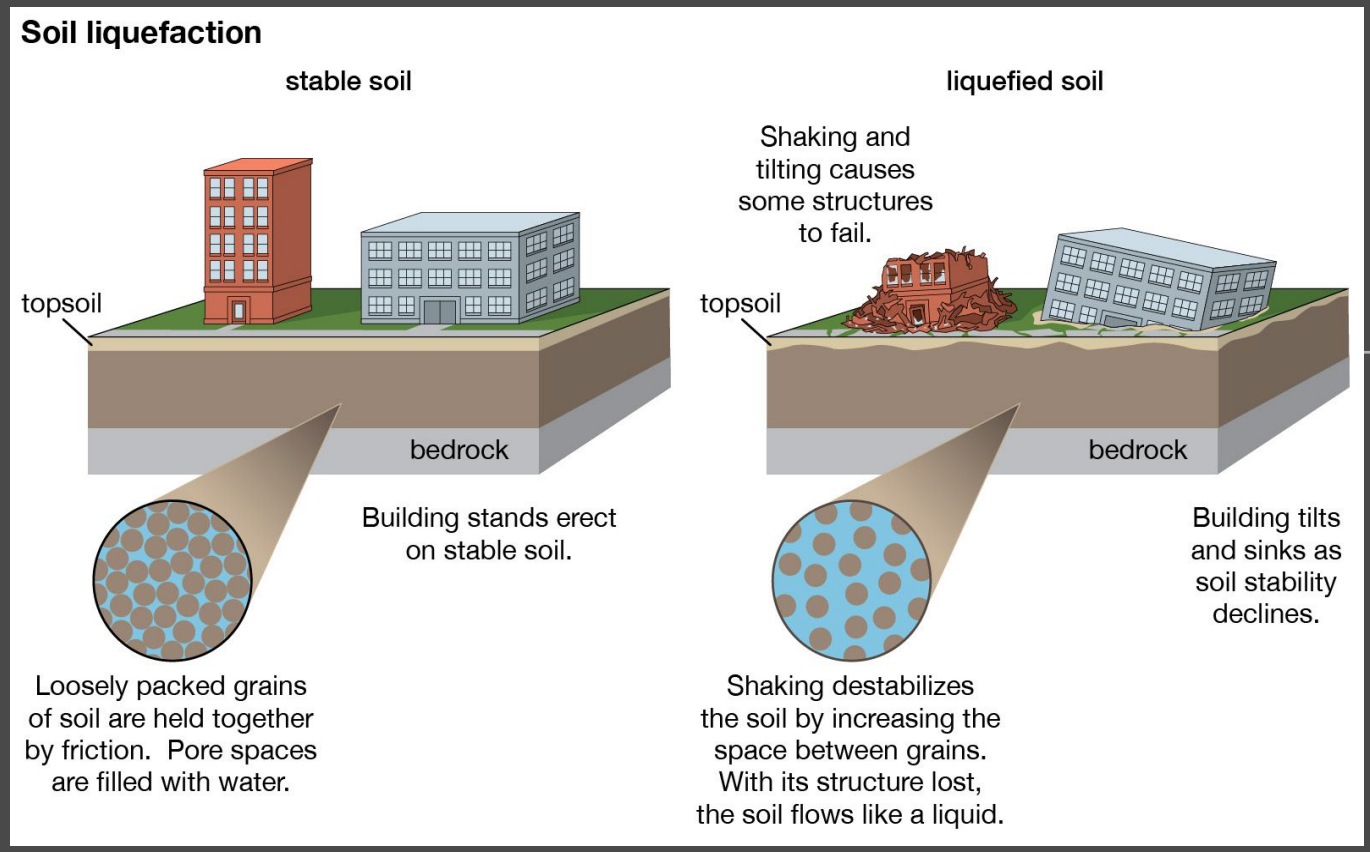
Project Details – Earthquake Impacts

Earthquake Zones

- Seattle Fault Zone: <7.3 magnitude earthquakes
- Cascadia Subduction Zone: 9.3 magnitude earthquakes

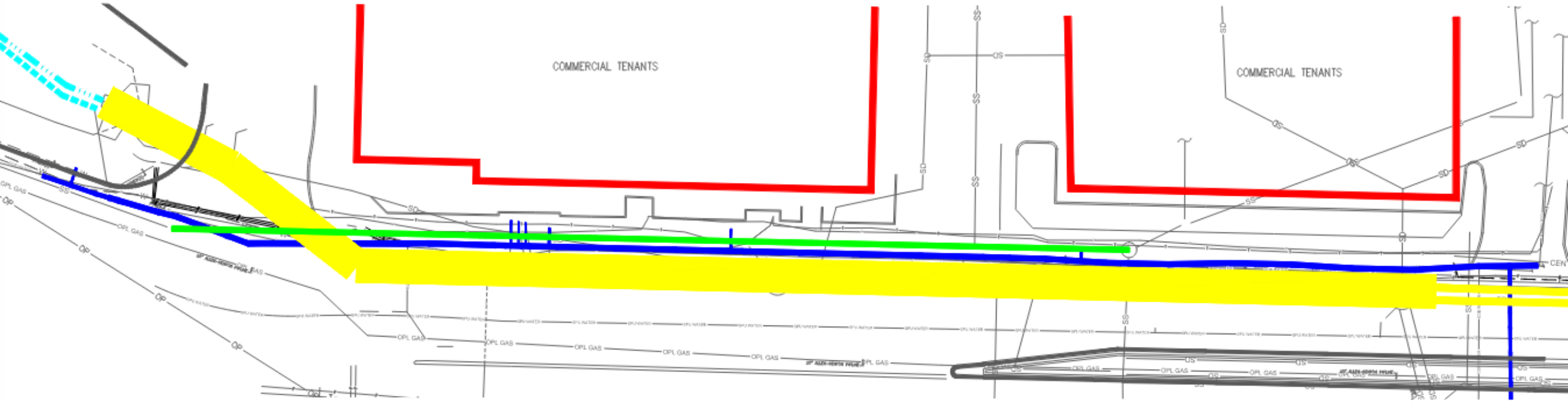
Ground Response

- - Liquefaction



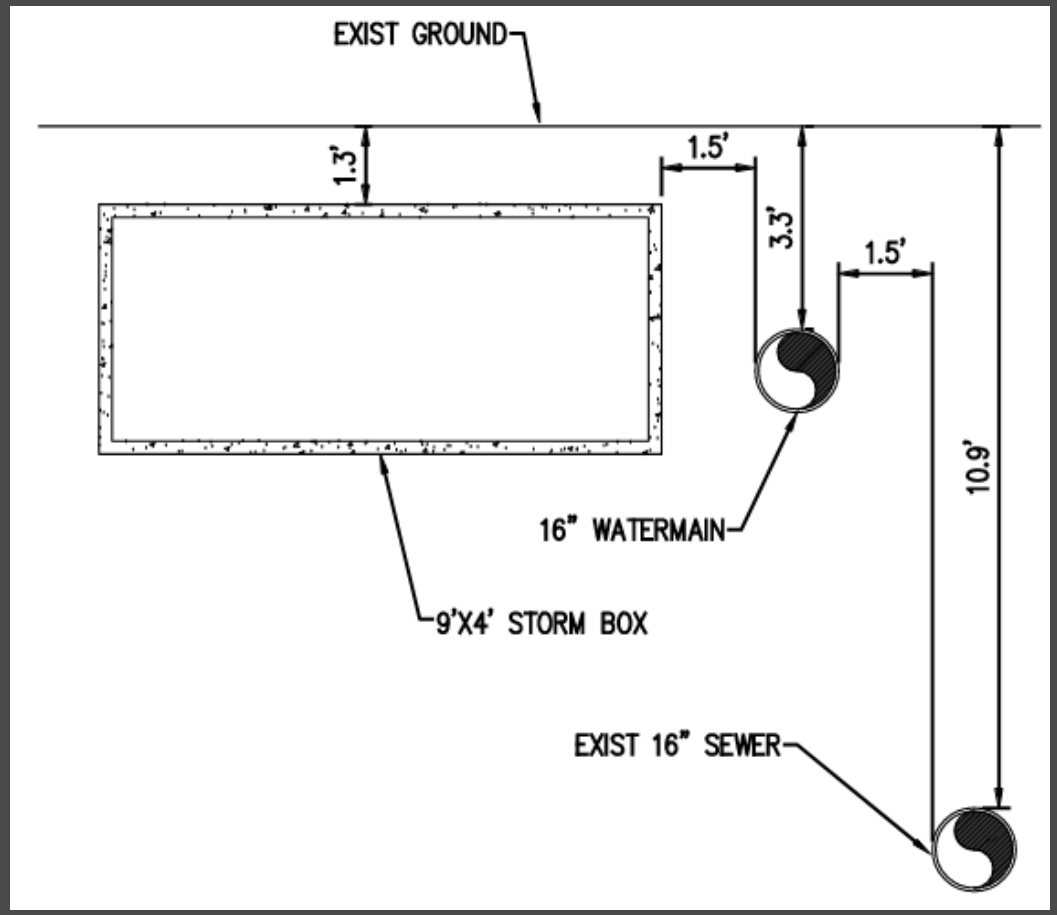
Project Details – General

- Major street/intersection of a strip mall
- Watermain serves the strip mall and is a main conveyance pipe from the water reservoir
- Existing 12” ductile iron watermain
- Proposed 16” earthquake resilient ductile iron watermain
- Proposed 9’x4’ concrete storm box
- Watermain lies between storm box and sewer pipe


STORMWATER
SEWER
WATER
BUILDING
CREEK
N
COMMERCIAL TENANTS
COMMERCIAL TENANTS

Project Challenges Overview

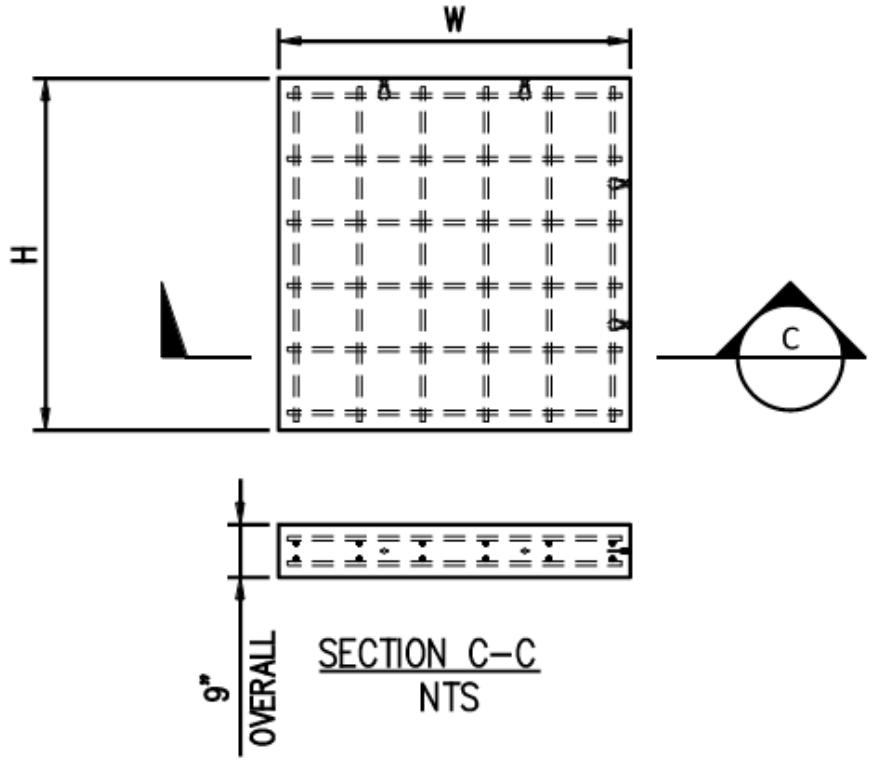
- 1.5’ horizontal clearance between water and sewer
- 1.5’ horizontal clearance between water and storm box
- Watermain crosses underneath 9’x4’ storm box
- Impacts of liquefaction on mostly empty structures
- Providing cathodic protection for a gas main while threading the needle between existing utilities

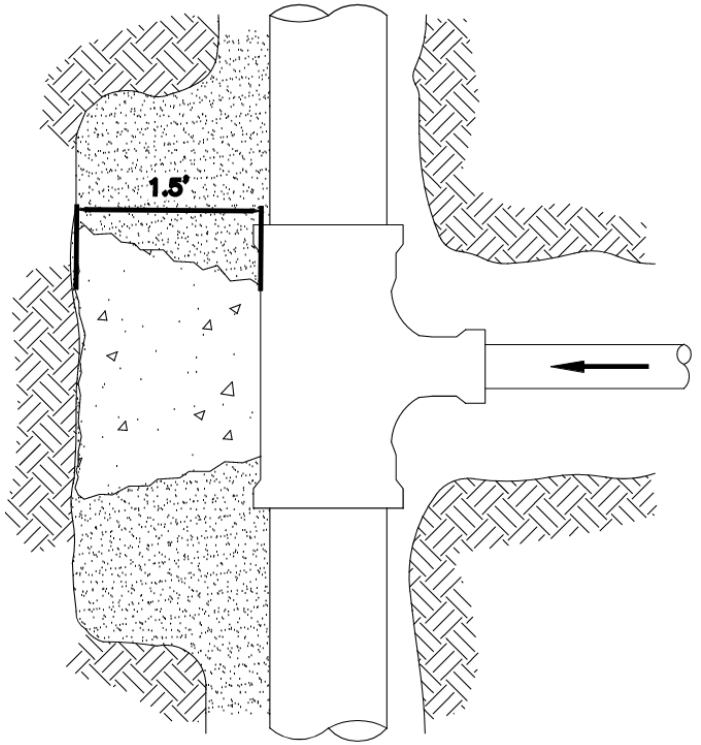


Thrust Restraints

How do you install thrust blocks with 1.5’ clearance between the watermain and storm box?

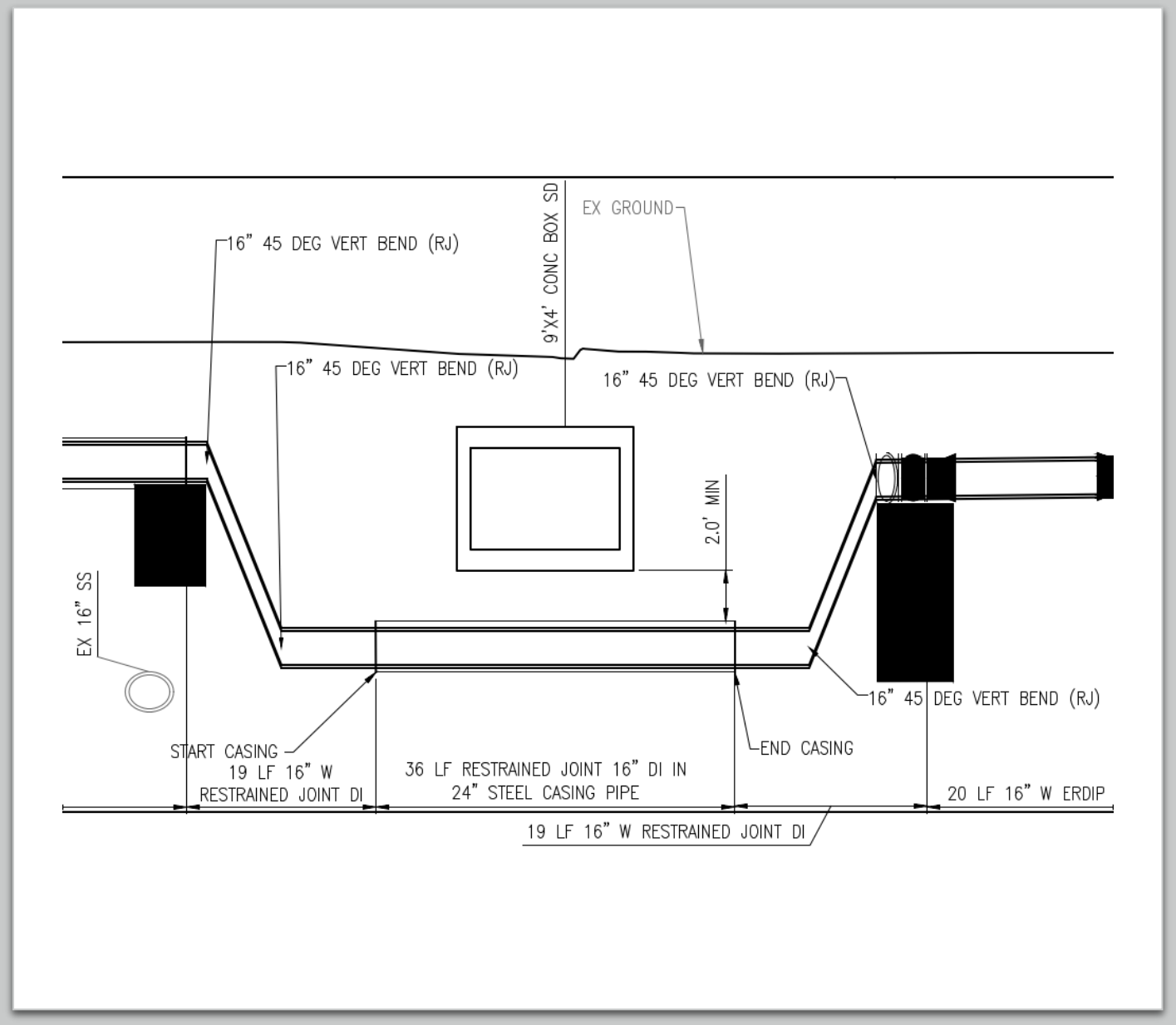
- Precast dailey blocks
  - Thin concrete block
  - Dual layer crisscross rebar pattern for reinforcement

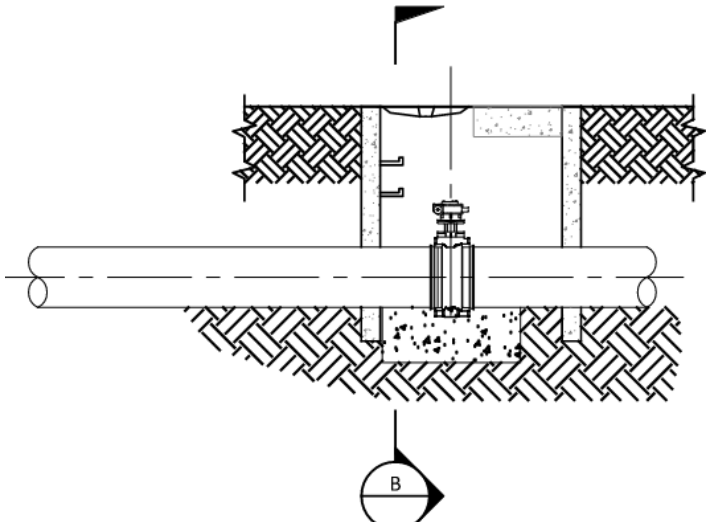


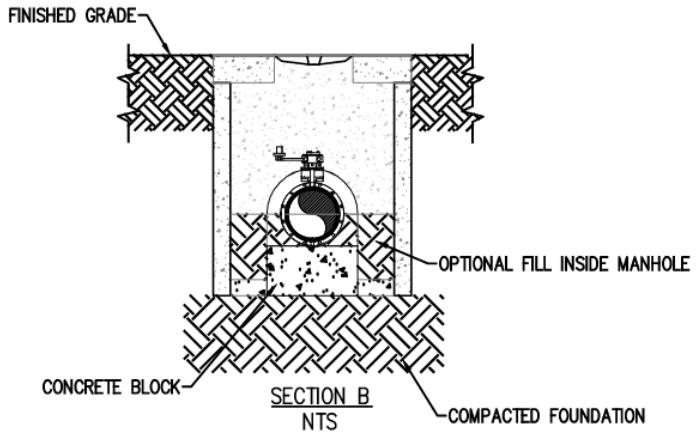


Large Utility Crossings

- What pipe material should be used for large utility crossings?
- Restrained or fused pipe that will act as one cohesive unit during the seismic event





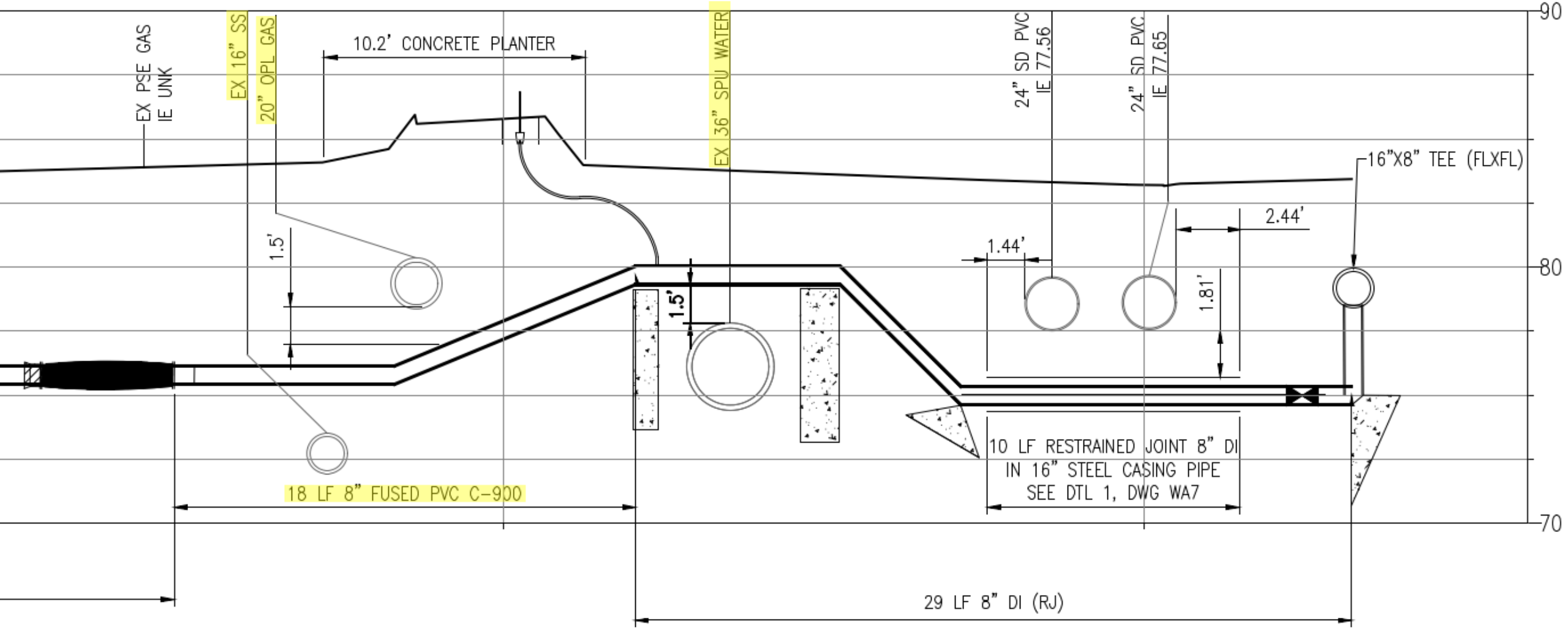


Appurtenance Structures

- What type of structures should be used to house large appurtenances?

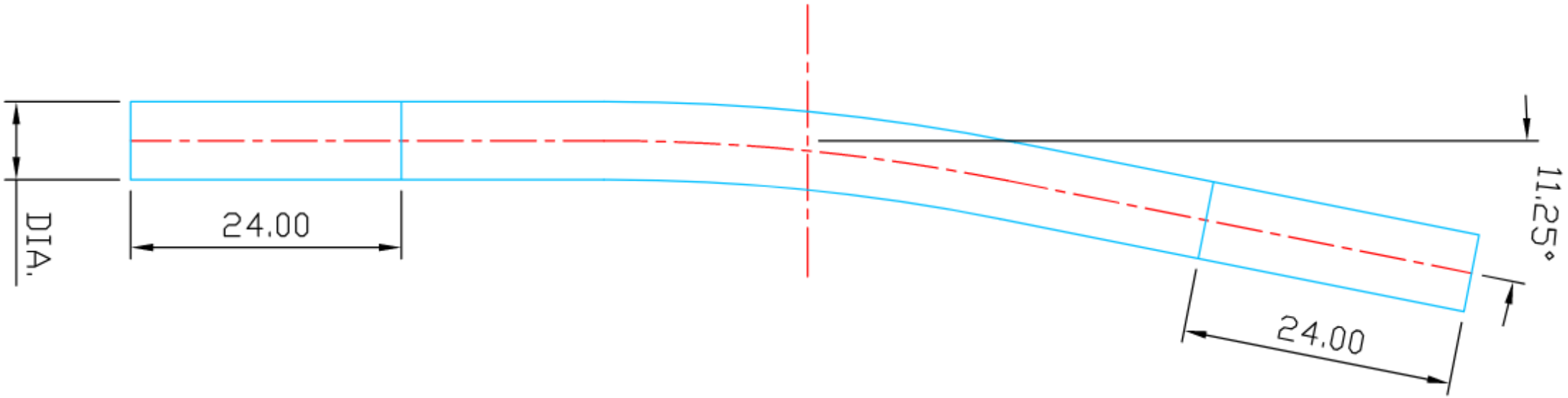
- Bottomless structures
  - Empty, light structures tend to float during liquefaction

Cathodic Protection Design for OPL Crossing



Fusible PVC

- Fabricated sweep for vertical bend



Conclusion

Toolbox additions:

- Precast dailey blocks are an option for thrust restraints in horizontally limited areas
- For large utility crossings use pipe that will act as a single unit during a seismic event
- Large appurtenances should be housed in bottomless structures
- Fusible PVC as a cathodic protection solution

Questions?

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