John Day Navigation Lock
Monolith Repair

Presented by Matthew D. Hanson, P.E.
Portland District

August 4, 2005

John Day Navigation Lock
Catastrophic Failure Prevention and Monolith Repair

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JOHN DAY DAM

JOHN DAY NAVIGATION LOCK

Historical

- 1968 - Project completed and pool filled.
- Post tension anchors installed in navigation lock gate and tainter valve monoliths (5,6,29,30,27,28,7,8,) as a result of problems at Ice Harbor before lock was filled.
- Seepage noted at D/S toe of North embankment (right abutment) 5 days into initial filling @ pool .
- July 1968 structural inspection cited areas of spalling concrete and water flowing down stair treads in the powerhouse gallery.

Historical Cont'd

- **March 1969: First Periodic Inspection cited spalling, cracking, inadequate reinforcement**
- **Subsequent reports indicate increasing amount of cracking, spalling, failed waterstops and leaking.**
- **Continuous monitoring and repairs on lock monoliths, concrete, etc.**
- **Waterstop repair contract, tainter valve shaft concrete removal contracts (2001)**

Historical Contd'

- **Primary Problems necessitating repair (2003)**
  - **Monolith 8 split in two pieces**
  - **Monolith 27 in danger of failure**
  - **Monolith 8 valve shaft spalling and Tainter valve out of service – no operational redundancy**
  - **Leakage into backfill and boneyard (sinkholes)**
  - **Monolith movement, cracking, spalling, etc.**
  - **Customer complaints**

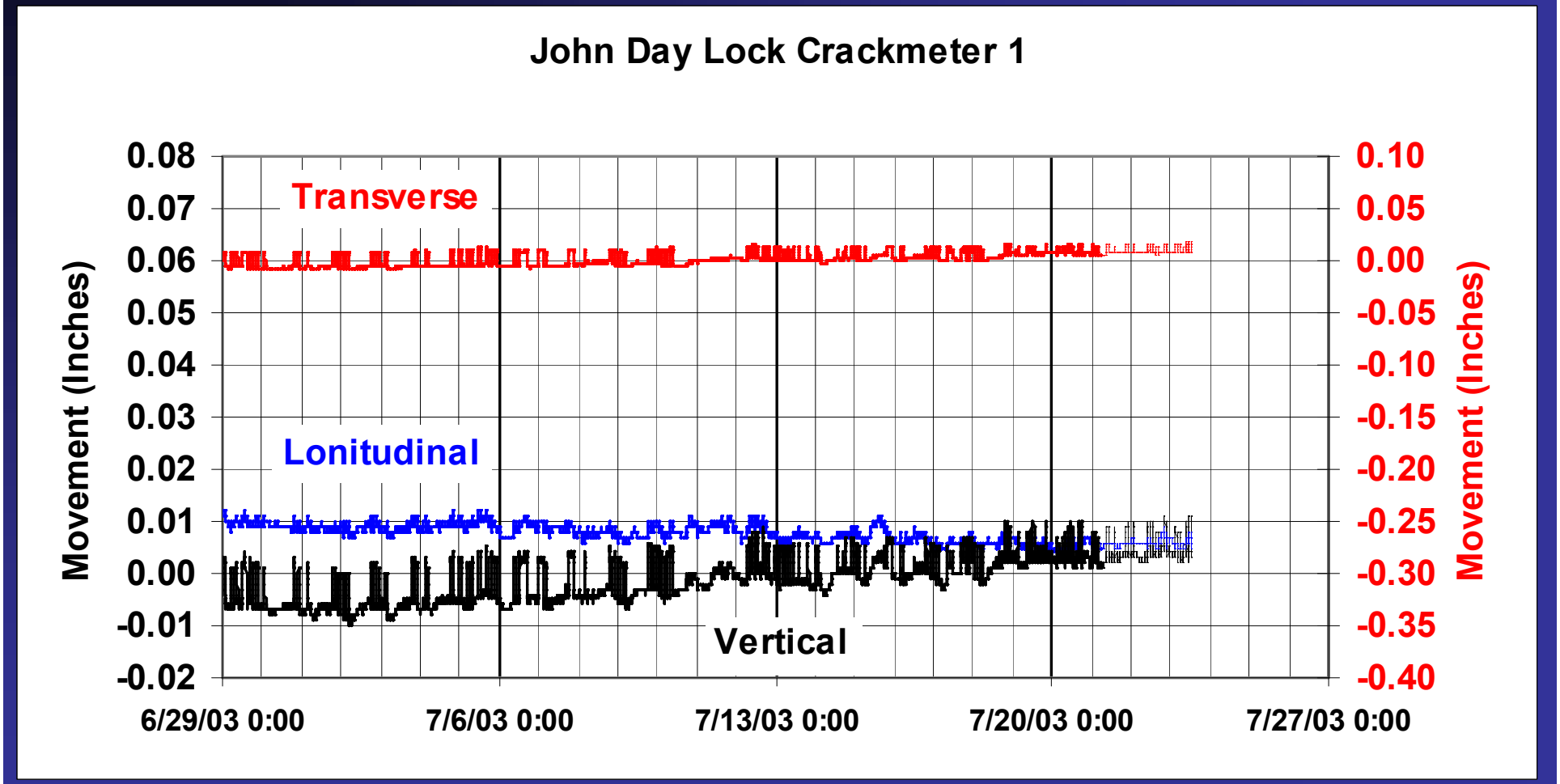
Boneyard Sink Hole

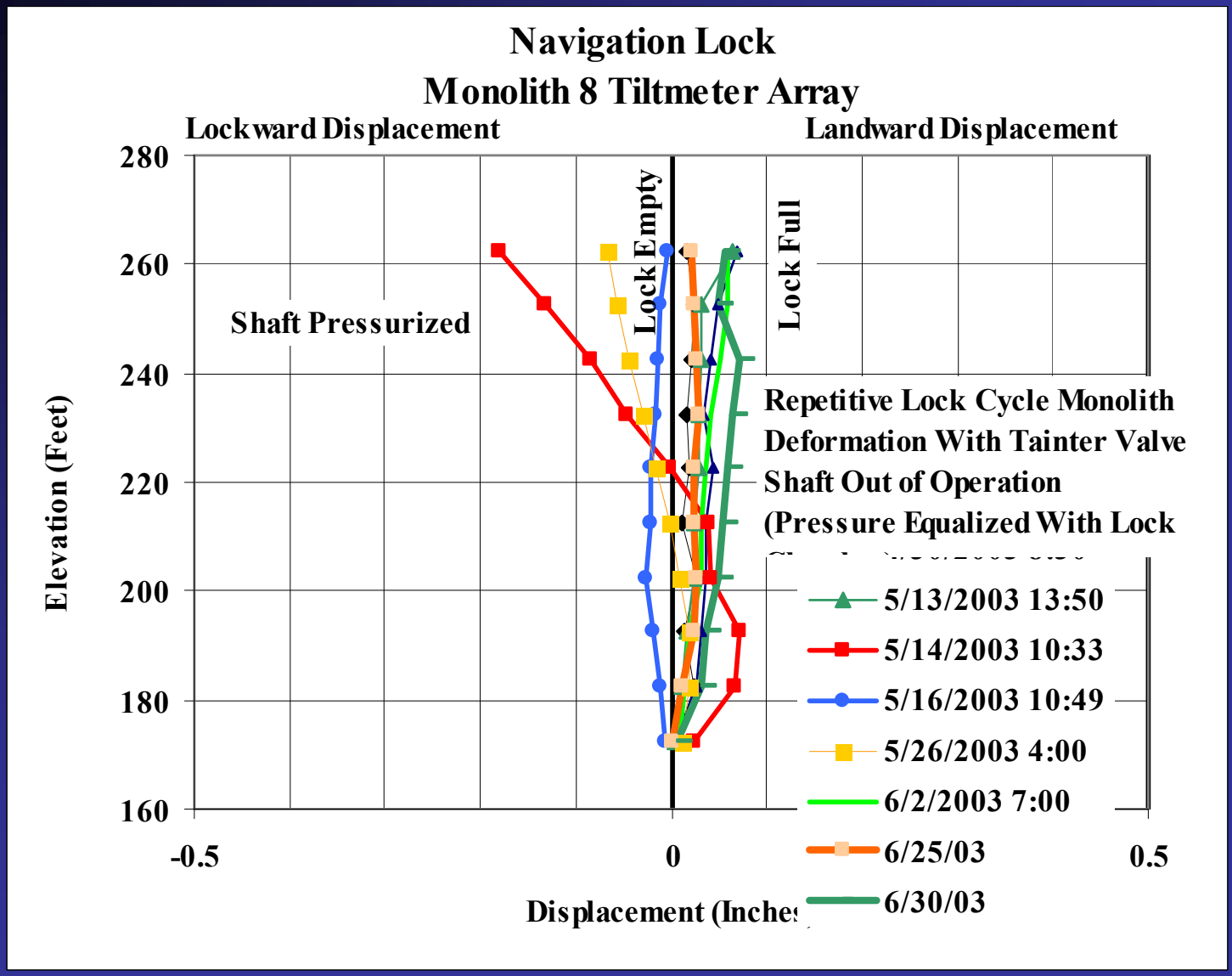
Settlement

Monolith 8 Service Gallery – Tainter Valve Shaft

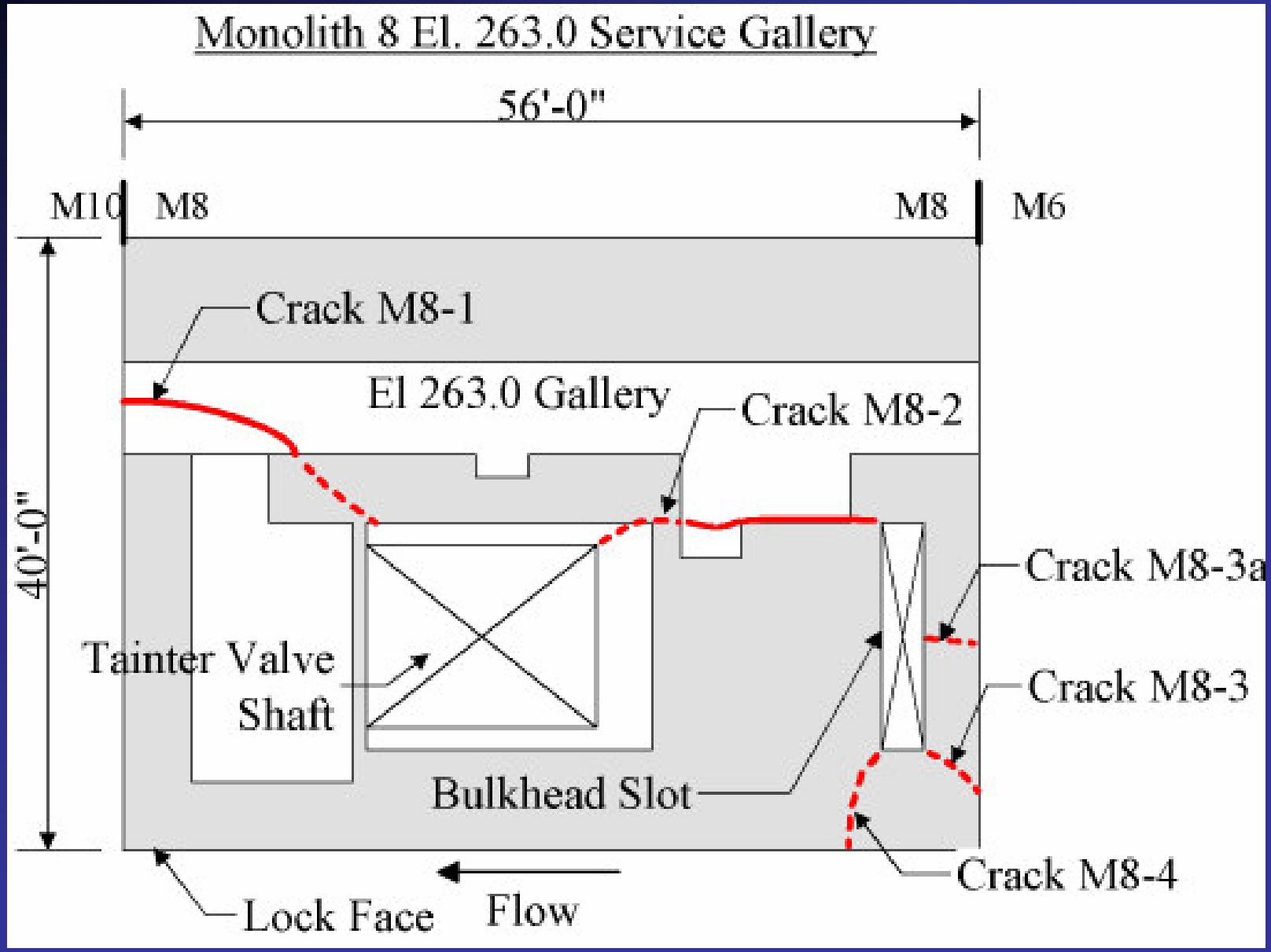
Monolith 8 Service Gallery

Concrete Cracking

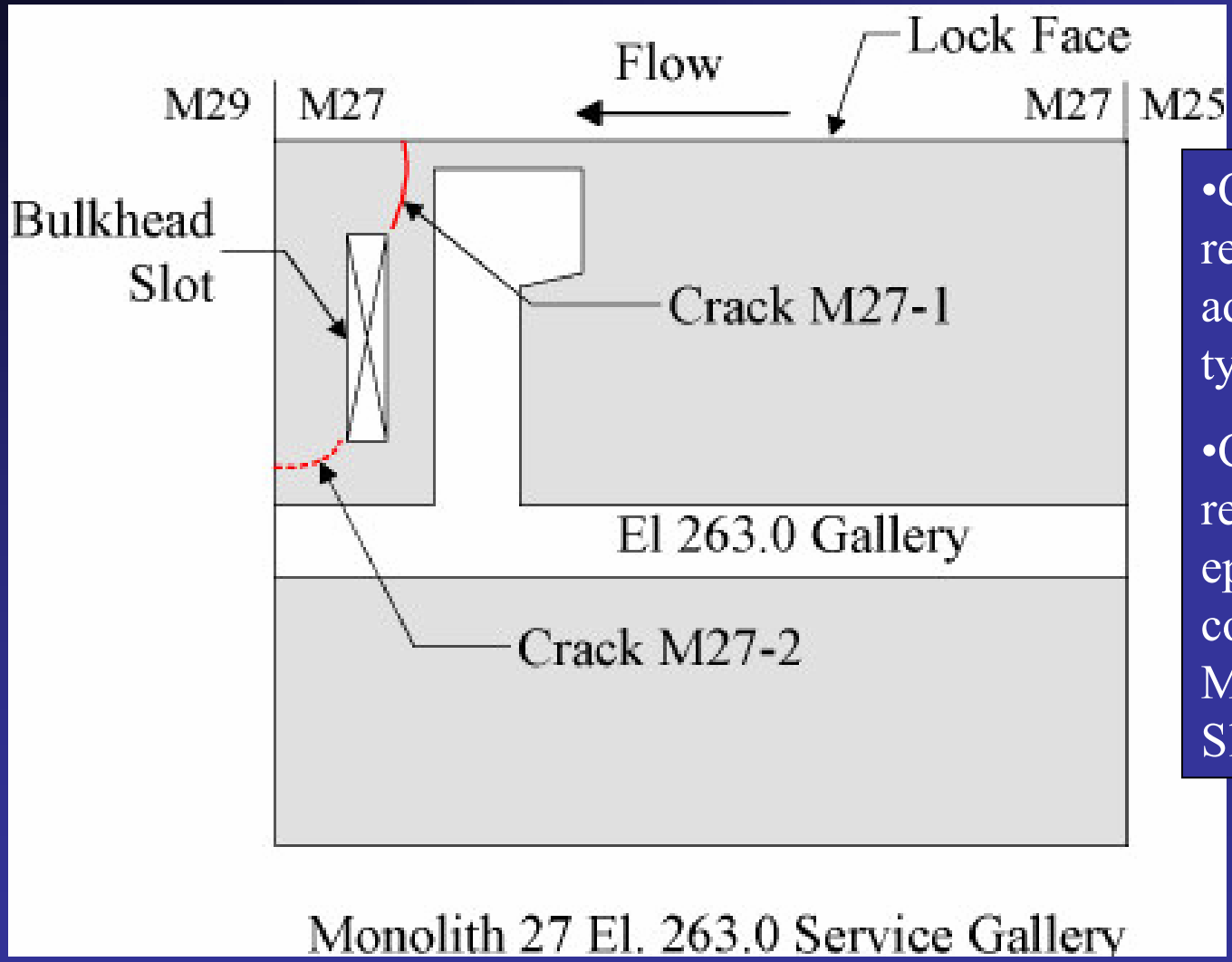

John Day Lock Crackmeter 1
Movement (Inches)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
-0.01
-0.02
Transverse
Lonitudinal
Vertical
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
-0.25
-0.30
-0.35
-0.40
Movement (Inches)
6/29/03 0:00
7/6/03 0:00
7/13/03 0:00
7/20/03 0:00
7/27/03 0:00


Navigation Lock
Monolith 8 Tiltmeter Array
Lockward Displacement
Landward Displacement
Elevation (Feet)
280
260
240
220
200
180
160
-0.5
0
0.5
Displacement (Inches)
Shaft Pressurized
Lock Empty
Lock Full
Repetitive Lock Cycle Monolith Deformation With Tainter Valve Shaft Out of Operation (Pressure Equalized With Lock
5/13/2003 13:50
5/14/2003 10:33
5/16/2003 10:49
5/26/2003 4:00
6/2/2003 7:00
6/25/03
6/30/03

John Day Navigation Lock – Confirmed Crack Planes

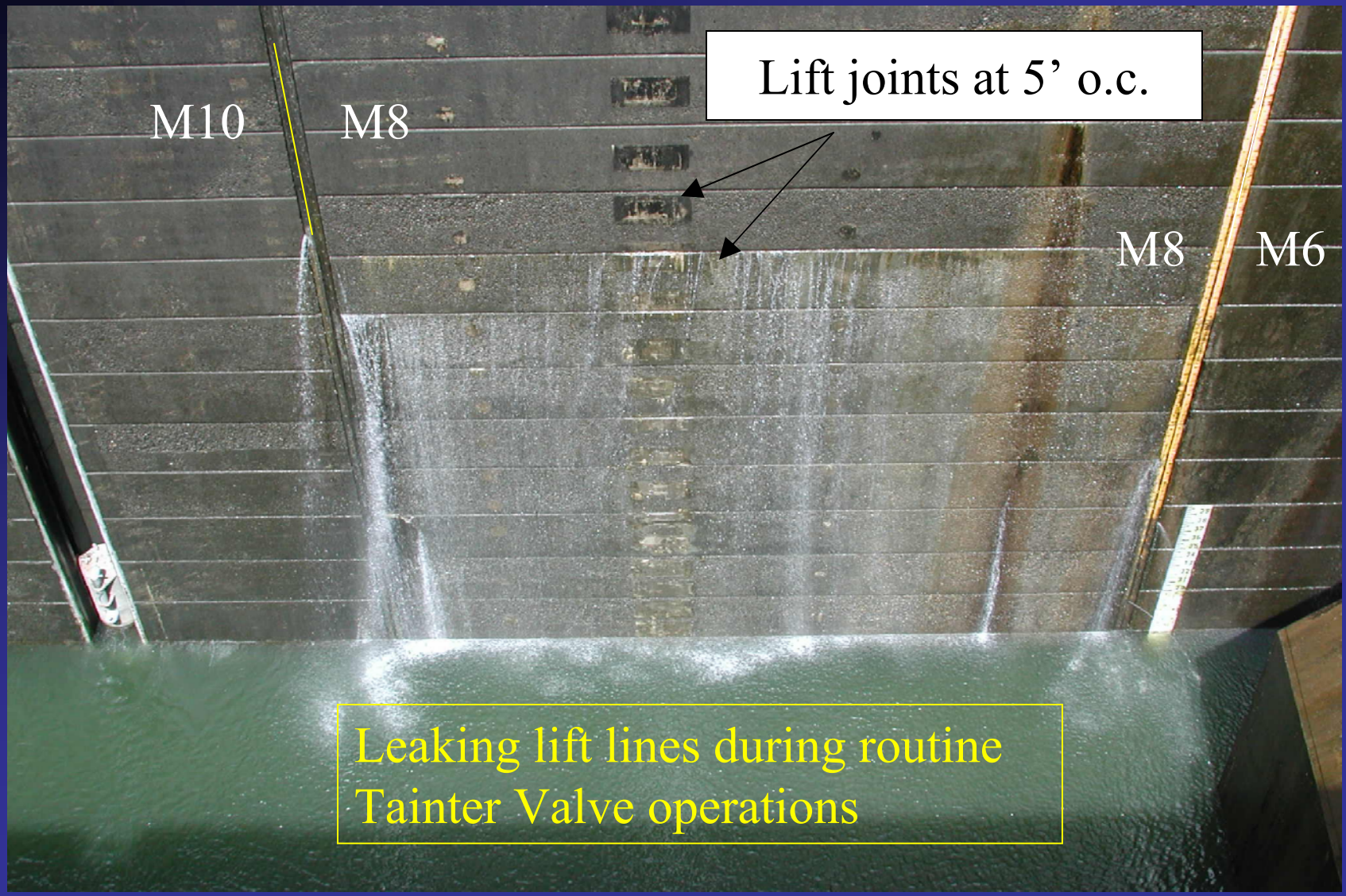


John Day Navigation Lock – Confirmed Crack Planes



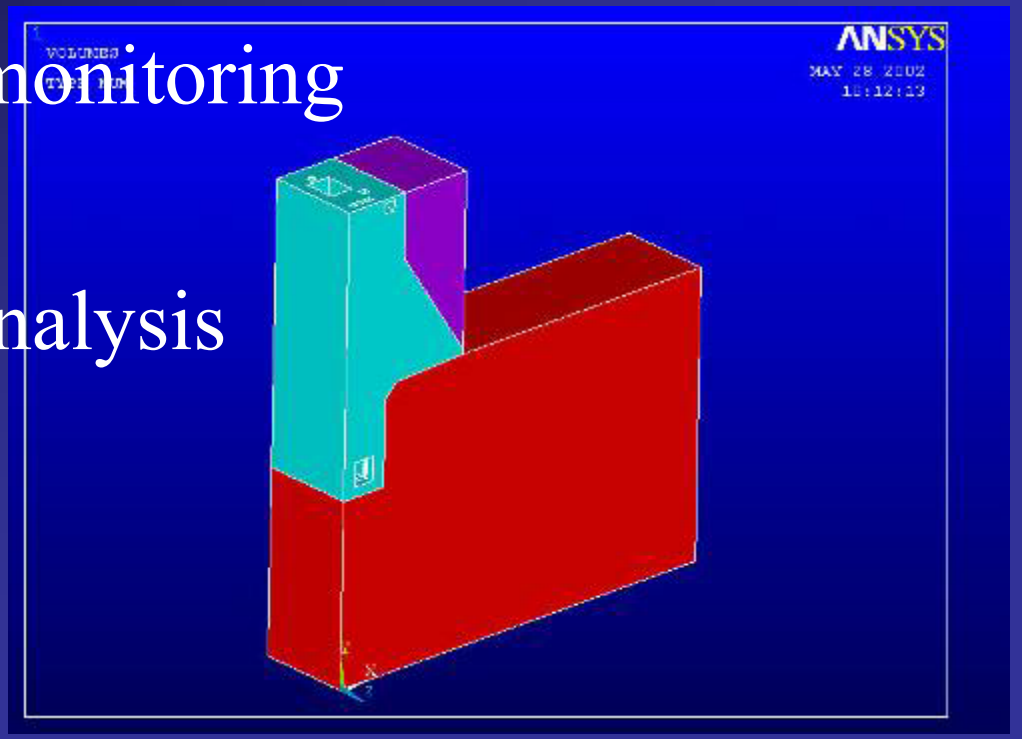
- Crack M27-1 to be repaired using epoxy adhesive grout in typical fashion.
- Crack M27-2 to be repaired using paste-epoxy adhesive for condition similar to Monolith 8 Bulkhead Slot

John Day Navigation Lock – Concrete Rehabilitation



John Day Monolith Repair Contract Investigation

- Stress analysis
- Monolith drilling for crack location
- Instrumentation/monitoring
- Concrete testing
- Finite Element Analysis



John Day Monolith Repair Contract
How/Why did this happen?

- Navigation Lock is not reinforced adequately
- Concrete strength/quality is variable
- Foundation is inconsistent and of questionable quality
- Previous repair measures may have caused cracks which have progressed
- Waterstop failure due to movement of monoliths allows water into monolith

Monolith Repair - Contract

Lift Joint Repair, Monolith 6&8 Crack Repairs

Monolith 8 Structural Repair

Monolith 27 lift joint and Structural Repair

Concrete Removal and Precast Panel Installation

John Day Monolith Repair
Construction issues

- Construction scheduling/considerations of high concern due to lock outage impacts
- Schedule shift due to Anchor testing
- Lock outage in march to be extended to 1 month to perform below tailwater drilling
- 12 hour outages above tailwater after outage
- Best Value contracting method determined in best interest of the Government
- Critical Contract/Last chance for repair

John Day Navigation Lock Monolith 8

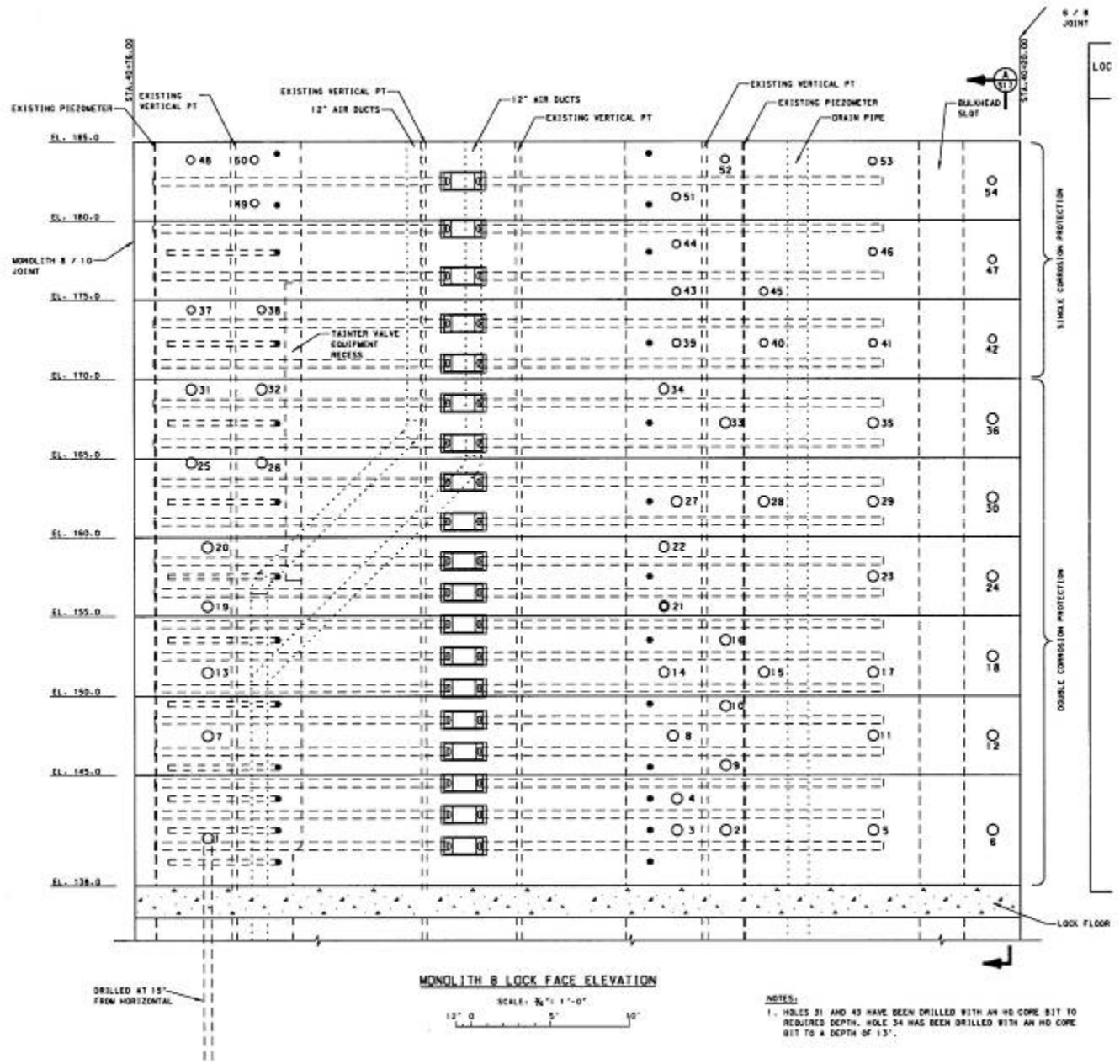
- Post Tensioning Design
  - Solid A722 150 ksi Anchors were selected for design.
  - Anchors were designed to resist the hydrostatic load at 0.6Fy.
  - An additional 40% increase in required number of bars was then allocated.
  - In addition, drilling tolerances have been reduced to ½ a degree – or within 4” in a 40’ deep core.
  - Tight tolerances will also help prevent hitting existing PT, existing shafts, existing voids, etc.

John Day Navigation Lock Monolith 8

- Anchor Stressing
  - Every anchor is proof tested to 150% of the design load (0.6Fy).
  - Several anchors in rock are creep tested to 150% DL for 8 hours.
  - 150% DL is the Corp's single anchor failure criterion. (PTI Criteria 133% DL)
  - Anchors locked off at 0.6Fu.

John Day Navigation Lock Monolith 8/27

- Anchor Details
  - Double corrosion protection for anchors installed in rock.
  - Single corrosion protection for anchors installed in concrete.
  - Recessed Anchorage zones with tensile zone reinforcement.
  - Removable anchor caps to allow for retensioning/lift off testing.

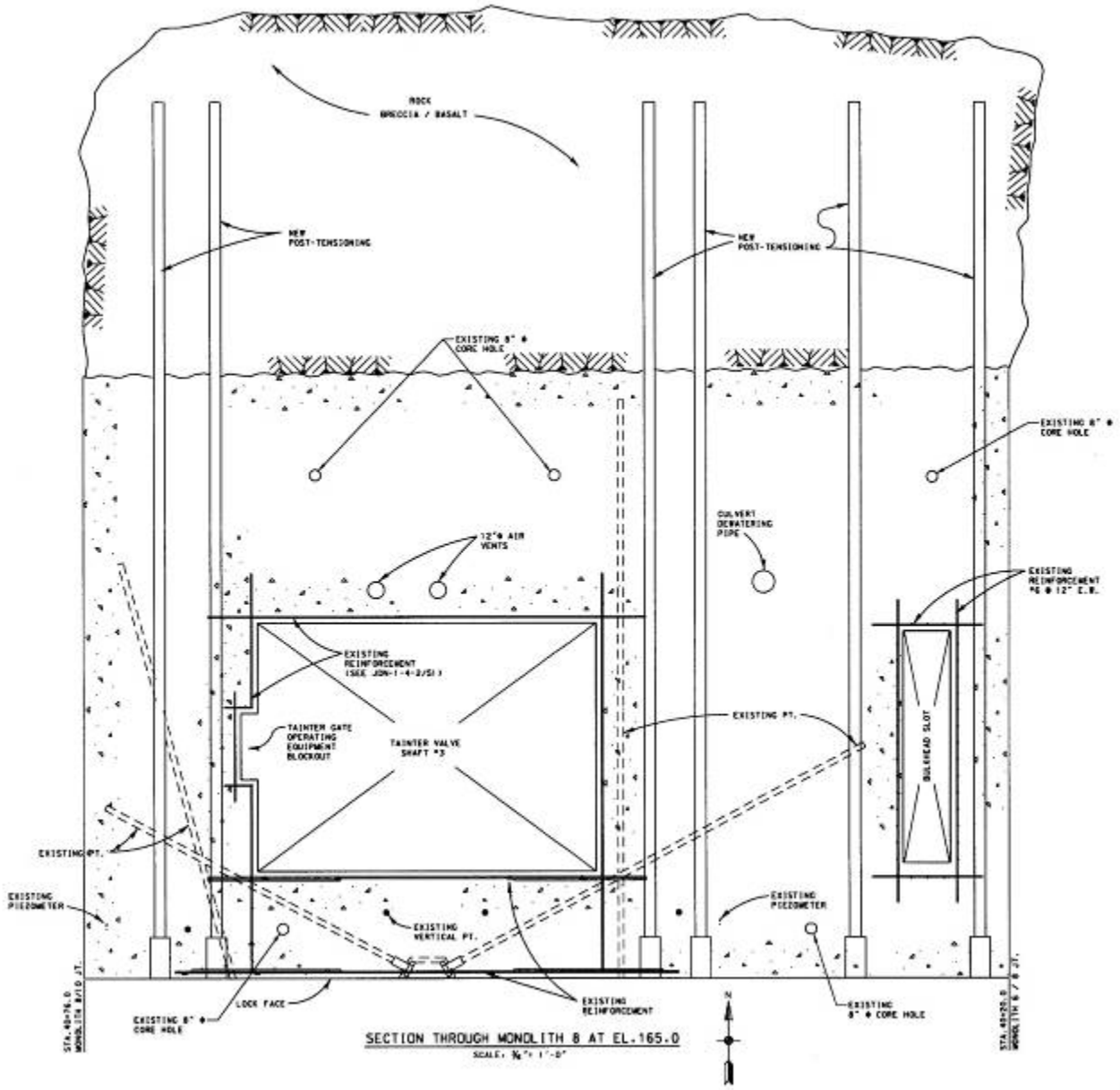


MONOLITH 8 LOCK FACE ELEVATION

SCALE: 3/8" = 1'-0"

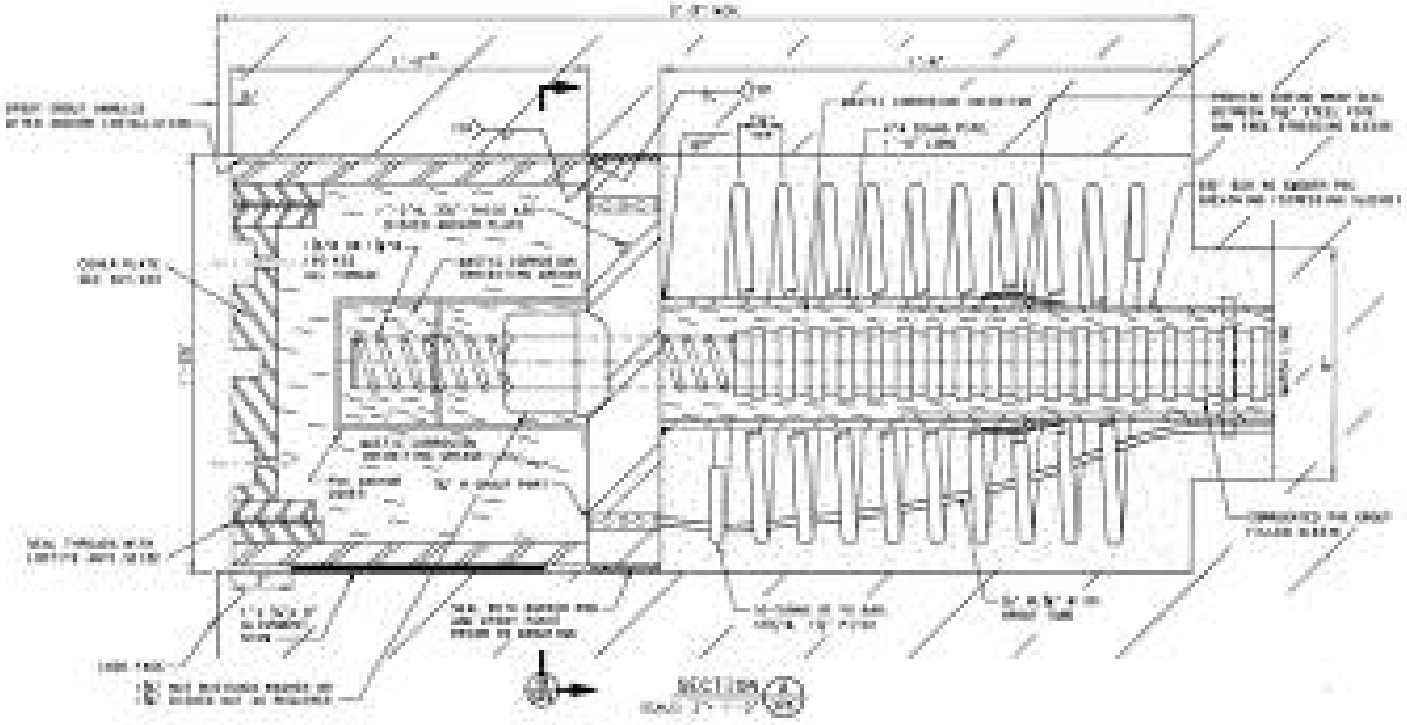
NOTES:

1. HOLES 31 AND 43 HAVE BEEN DRILLED WITH AN HQ CORE BIT TO REQUIRED DEPTH. HOLE 34 HAS BEEN DRILLED WITH AN HQ CORE BIT TO A DEPTH OF 13'.



SECTION THROUGH MONOLITH 8 AT EL. 165.0

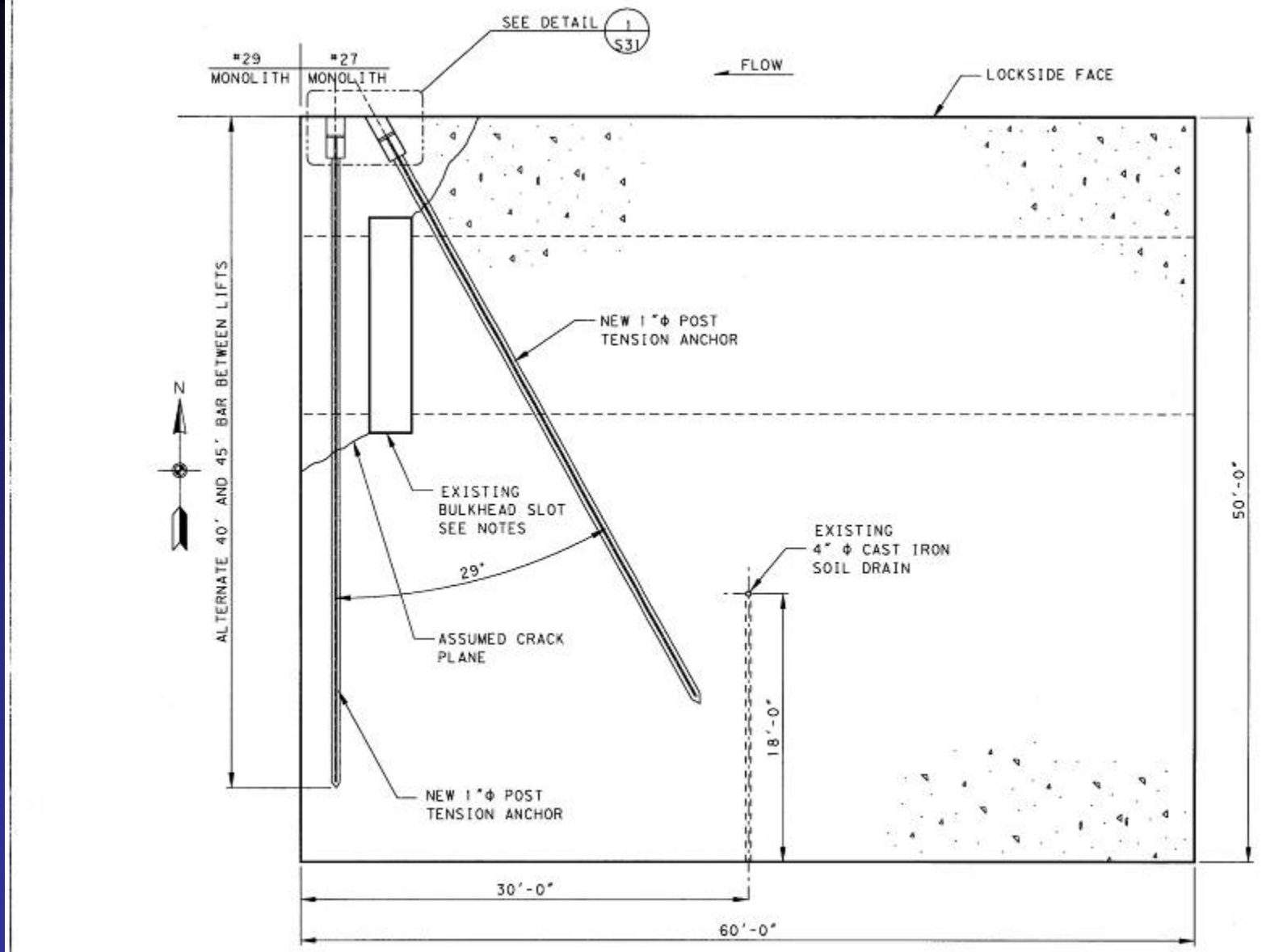
SCALE: 1/4" = 1'-0"



John Day Monolith Repair - Construction

John Day Navigation Lock Monolith 27

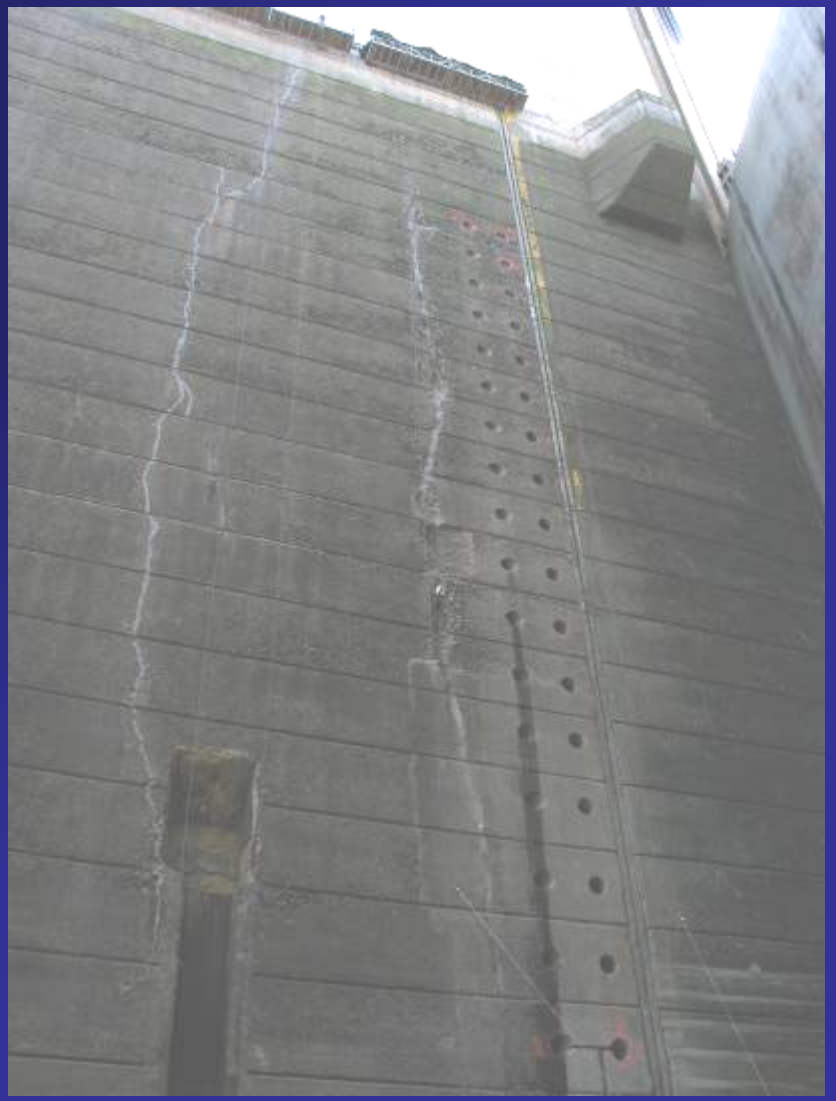
- Monolith 27 Post Tensioning Design Cont…:
  - New PT was angled and smaller bars were used to eliminate the need to develop bars in the rock strata.
  - Fewer monolith penetrations and the no existing PT made the location of these new anchors much less complicated.
  - Anchorage details similar to monolith 8 repairs.



PLAN EL. 250.0

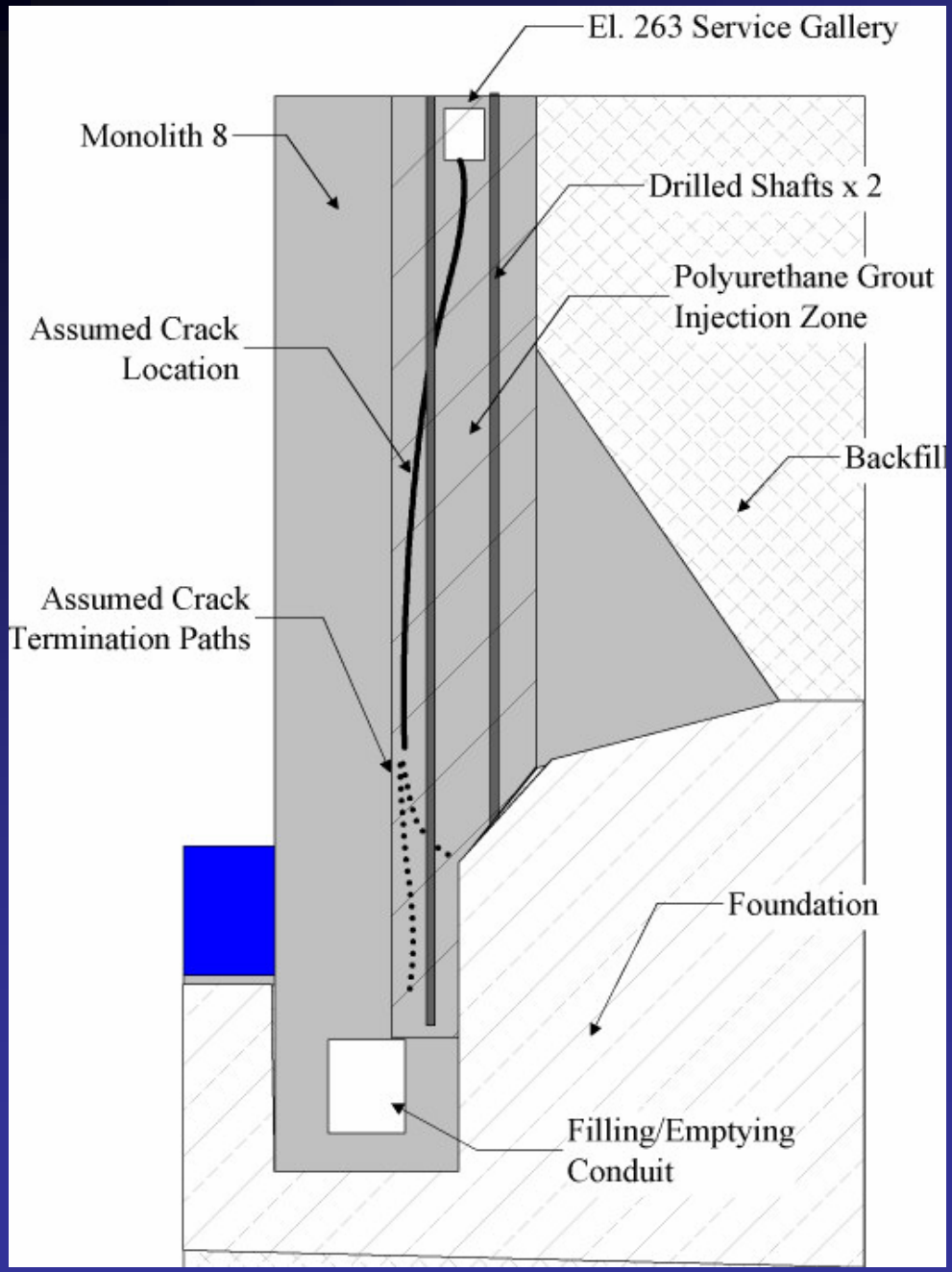
SCALE: 1/32" = 1'-0"

John Day Navigation Lock
Monolith 27



John Day Navigation Lock Concrete Rehabilitation

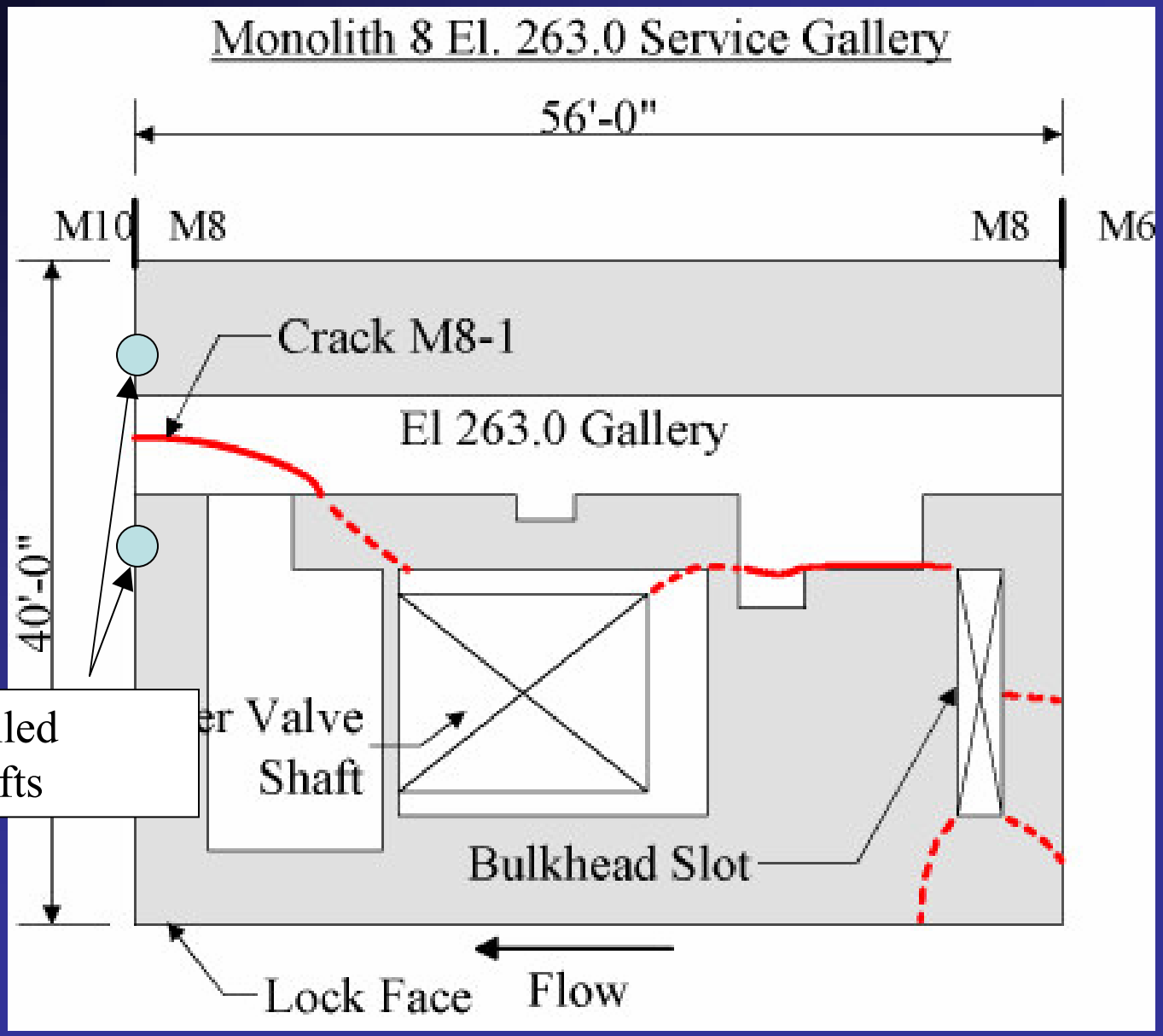
- Monolith Joint Isolation/Sealing
- Concrete Repair Monolith 6
- Concrete Lift Sealing
- Crack Sealing/Repair
- Backfill Drain Rerouting



Monolith 8/10 Joint Isolation

1. Isolate joint from crack to prevent epoxy grout from bonding joint.
2. Drill two vertical 10-inch dia access shafts.
3. Place expanding chemical "foaming" grout to fill Polyurethane Injection Zone
4. Grout Crack.

John Day Navigation Lock – Concrete Rehabilitation

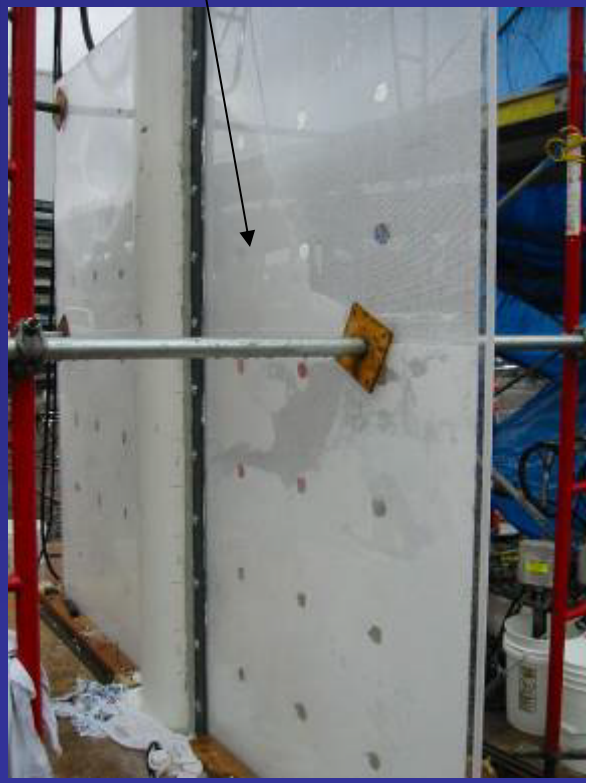


John Day Monolith Repair Contract
Joint Sealing Mock-up Testing

Drilled shaft

Simulated monolith joint

Effectiveness of joint filler



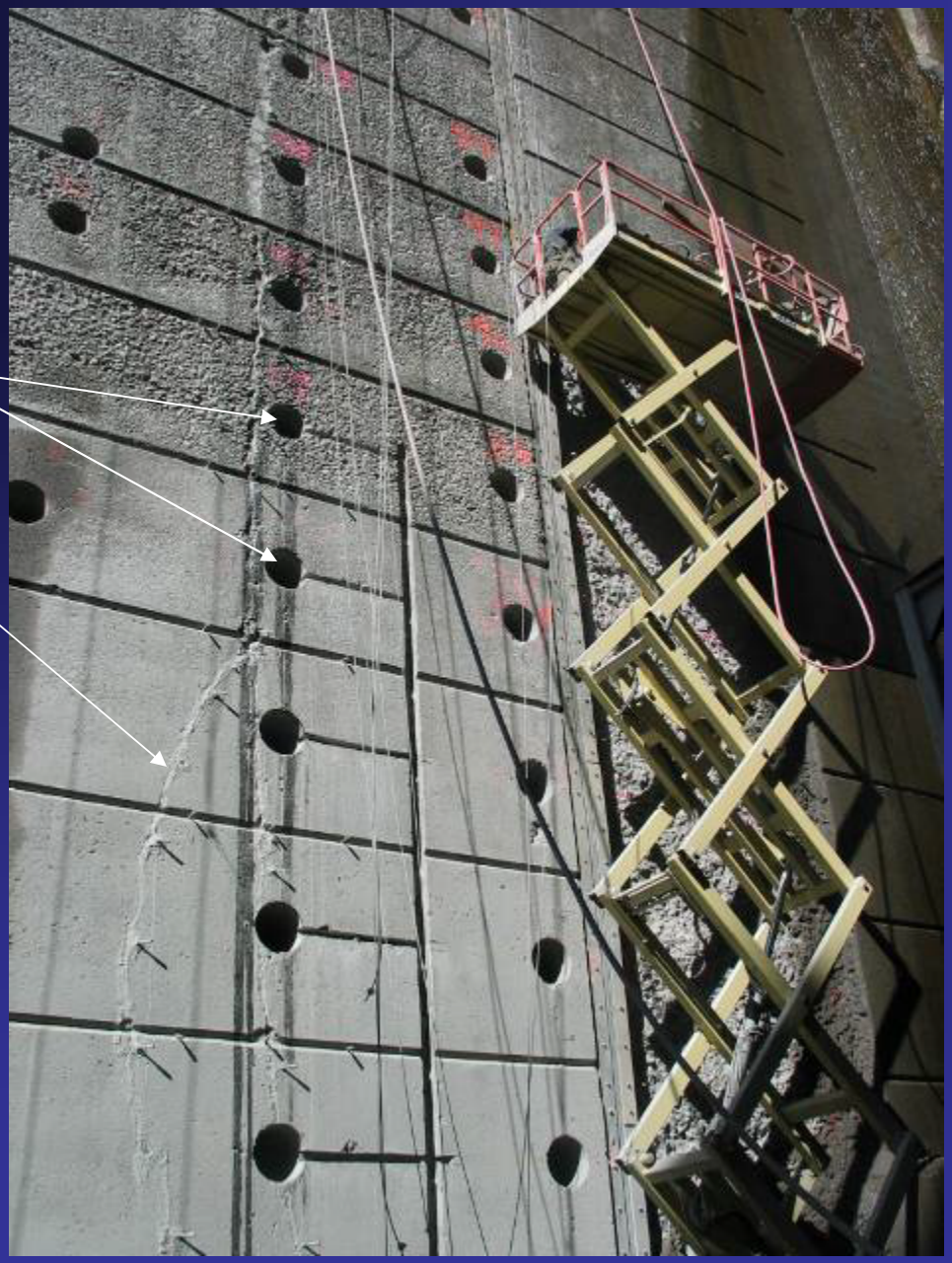
Monolith Joint - Paste Epoxy Injection

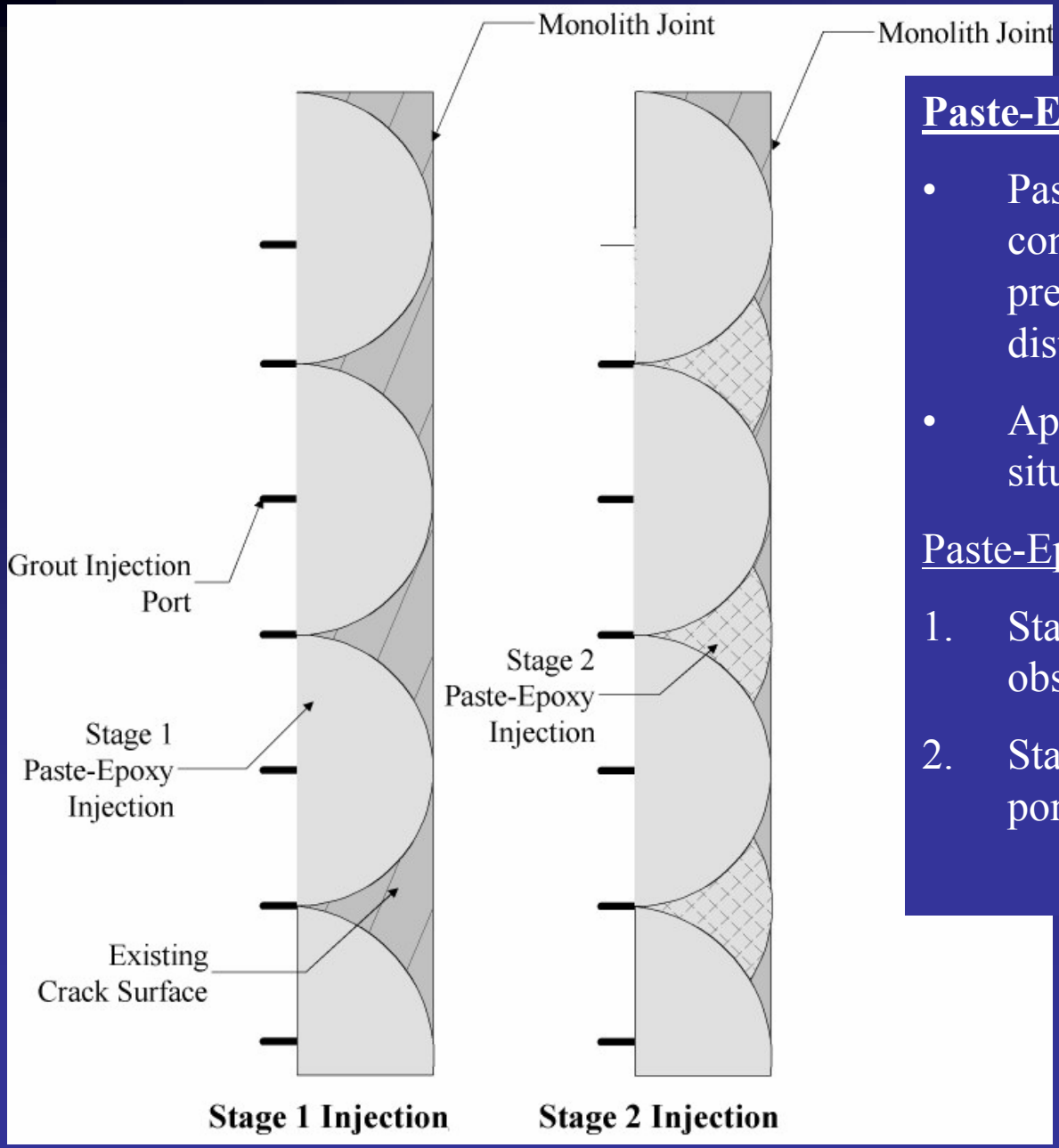
Monolith joint

Injection Ports

Post Tension anchor holes

Epoxy Injection Ports





Paste-Epoxy Injection

- Paste-Epoxy injection allows a controlled placement due to a predictable and consistent epoxy distribution "bulb."
- Applicable in a "blind" crack situation

Paste-Epoxy Injection Procedure

1. Stage 1 injection until epoxy is observed at 2nd port above.
2. Stage 2 injection at intermediate ports.

John Day Navigation Lock Monolith Repair Successes

- Structural Integrity restored
- Normal Lock Operation
- Leakage to backfill reduced
- Leakage to lock face reduced
- Joints/cracks sealed
- No significant contract claims

John Day Navigation Lock Monolith Repair Costs

- Original contract estimate $5.6 million
- Contract Cost $11.7 million

High cost due to

Tight timeframe

Tight Construction Tolerances

Work Within an Operating Lock

John Day Navigation Lock

Portland District
Corps of Engineers

Thanks for
Listening

Questions ?