Mt. Washington Landslide, Emergency Response, and Wall Design

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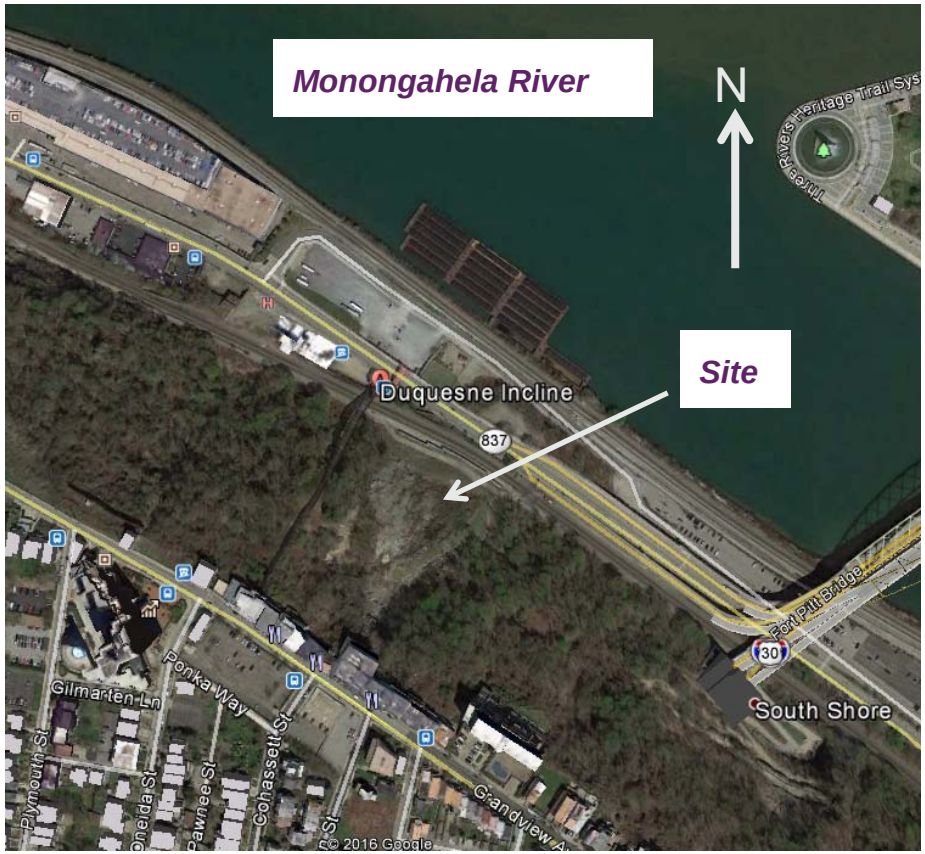
Overview

- Introduction
- Landslide Review
- Emergency Response Activities
- Site Investigation & Assessment
- Retaining Wall Design
- Retaining Wall Construction
- Survey Monitoring
- Summary & Lessons Learned

(Charles Bertram – Lexington Herald Ledger)

Site Location & Information

- Landslide Occurred on April 8, 2014 ≈ 3:00am
- Affected Parties
  - Norfolk Southern Railway
  - City of Pittsburgh
  - Duquesne Incline
  - LeMont Restaurant
  - Other Residents



Introductory Videos

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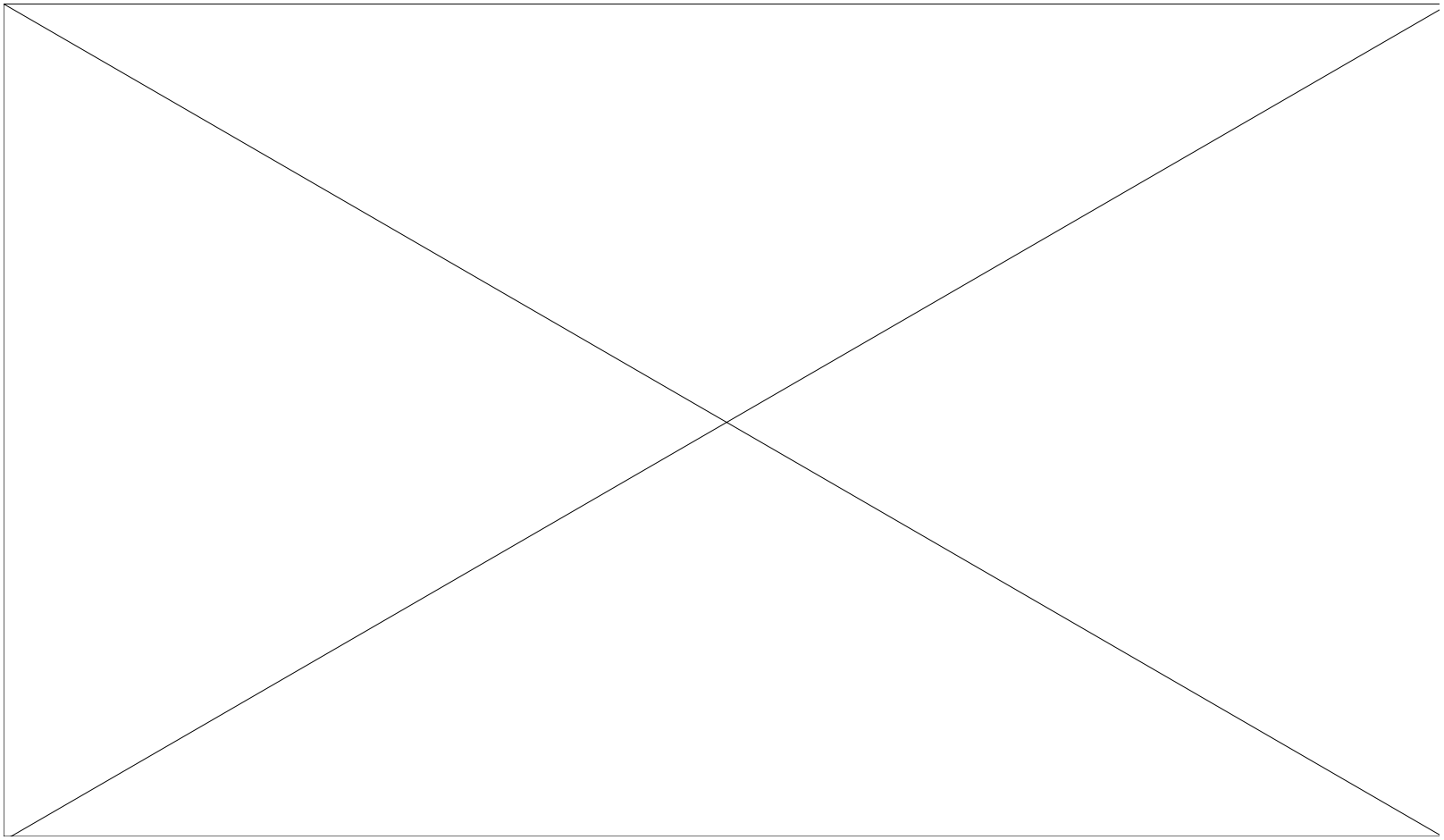


Landslide Statistics/Impacts

- Total Slide
  - 350-feet by 600-feet Slide Mass
  - Estimated 450,000 CY
  - Initiated ≈ 500-feet upslope of track
- Norfolk Southern
  - Double Mainline Tracks Covered in Debris
    - 75’ stretch of Main Track #1
    - 230’ stretch of Main Track #2
    - Up to 15’ deep

(Darrell Sapp – Pittsburgh Post-Gazette)

Emergency Response Activities

- Objective: Safely Restore Freight Operations
- Remove Debris & Restore Traffic on Main Track #1
- Remove Debris & Restore Traffic on Main Track #2
- Total of 3,000 CY Removed from Track
- Continue Observation of Slide Mass
- Begin Site Assessment & Investigation

(Darrell Sapp – Pittsburgh Post-Gazette)

Site Investigation & Assessment

Site Investigation:

- Walk accessible sections of slope and slide mass.
- Geotechnical Borings
  - 4 total
    - 3 at track Level, 1 on slide mass.
- Survey of lower slope

Assessment:

- Colluvial soils
- Wet Conditions
  - Fluctuating groundwater conditions
  - Abnormally cold winter
- Slide toe located at track level
- Embankment supporting track is not moving

Retaining Wall Design

- Objectives:
  - Protect track operations
  - Provide a system with advanced warning of additional movement

- Multi-phase approach
  - Provide design for immediate protection (Phase 1)
  - Continue to monitor slope conditions
  - Provide design for alternate reinforcement (Phase 2)
- Design timeline
  - Conceptual design in 5 days
  - Preliminary design in 10 days
    - Owner & Contractor review
  - Final documents/begin construction in 20 days
  - Phase 2 design in 6 weeks

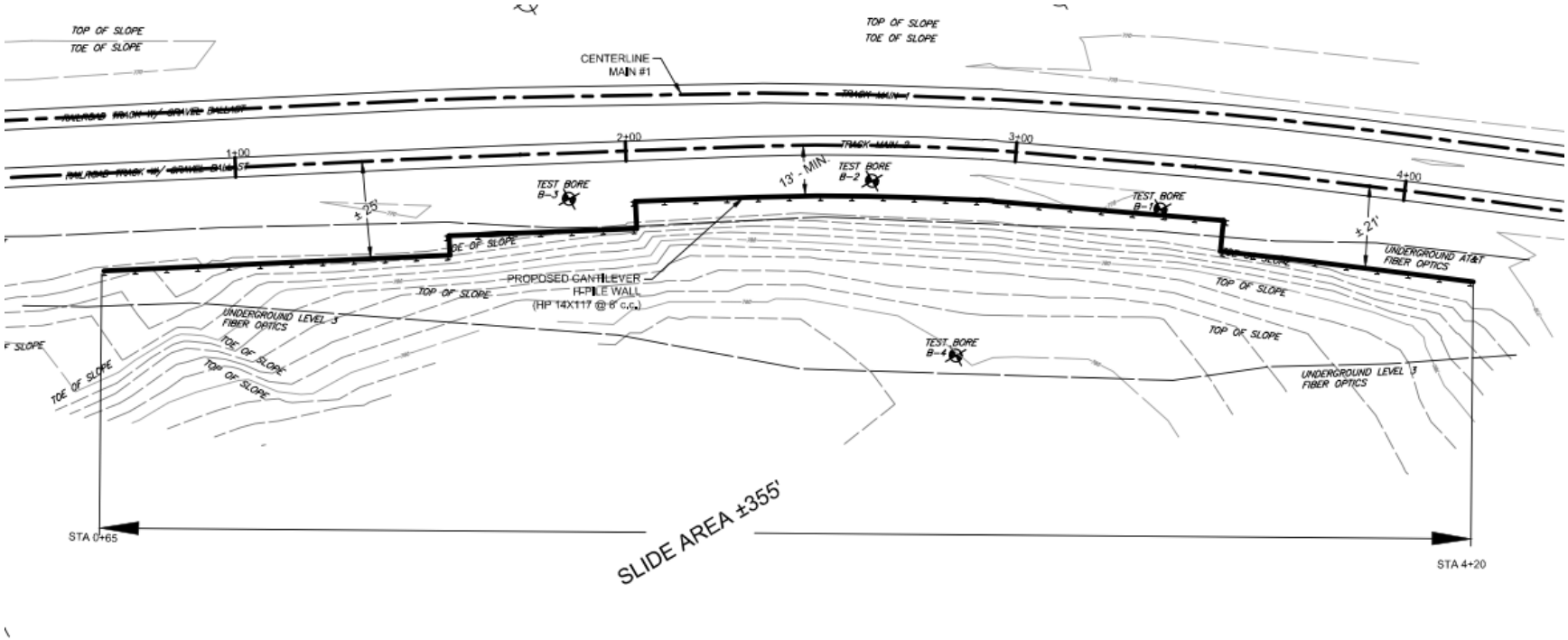
Retaining Wall Design (continued)

- Design Concept Phase 1
  - Soldier Pile Wall
    - 12’ typical design height
    - 6’ stickup above stone backfill
    - 355’ wall length
  - HP14x117 Soldier Pile (60’ Length)
    - 24” diameter socket
    - Backfilled with concrete
  - HP12x53 Continuous Waler
  - Precast Concrete Lagging
- Design Concept Phase 2
  - 225-kip Anchors
  - 2 anchors every other bay
  - Double HP waler connected to wall face

- Benefits of design
  - Meets objectives
  - Small footprint
  - Easily altered alignment
  - Short construction timeline
  - Phase 1 easily adapted to incorporate phase 2

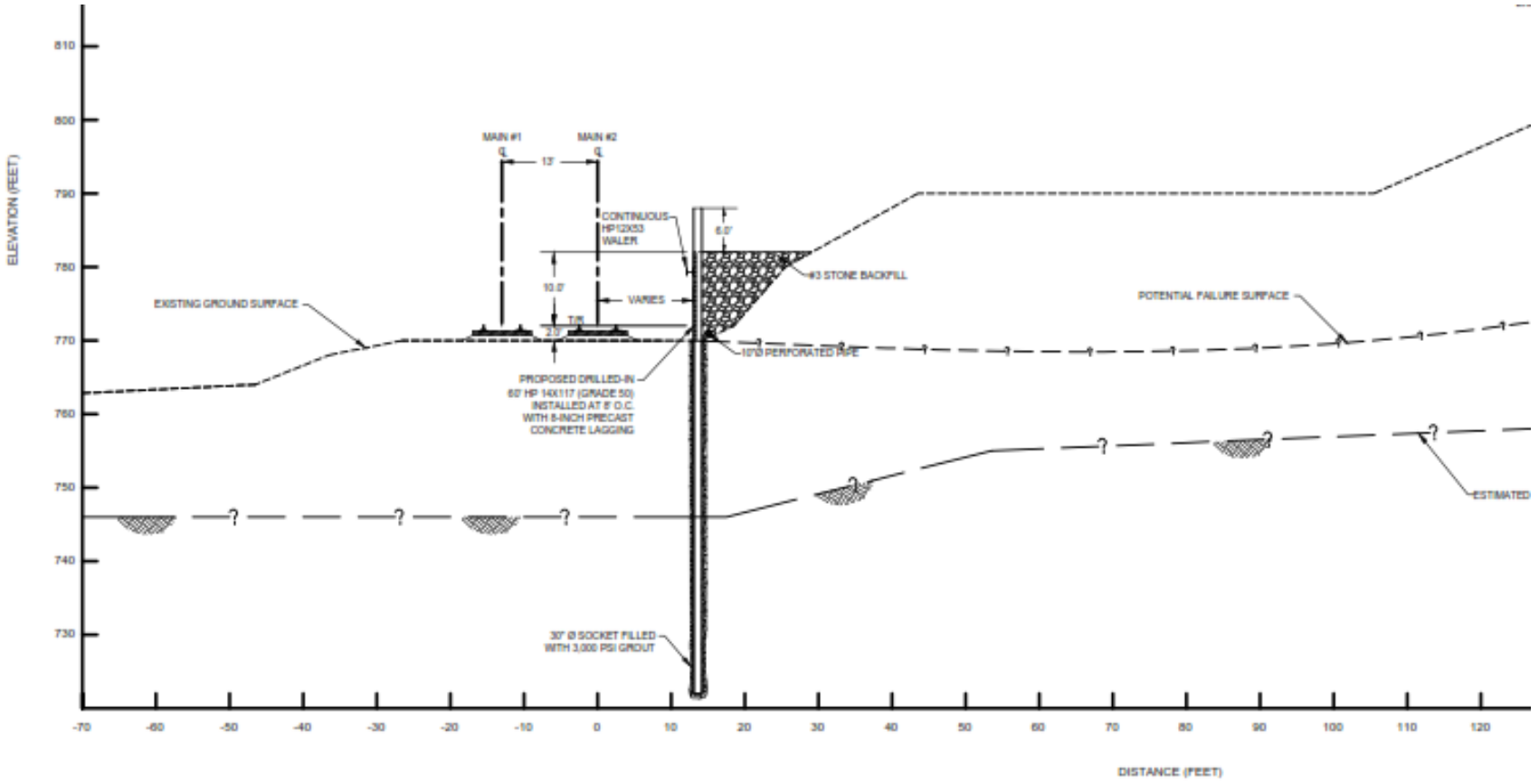
Retaining Wall Design (continued)

Wall Alignment



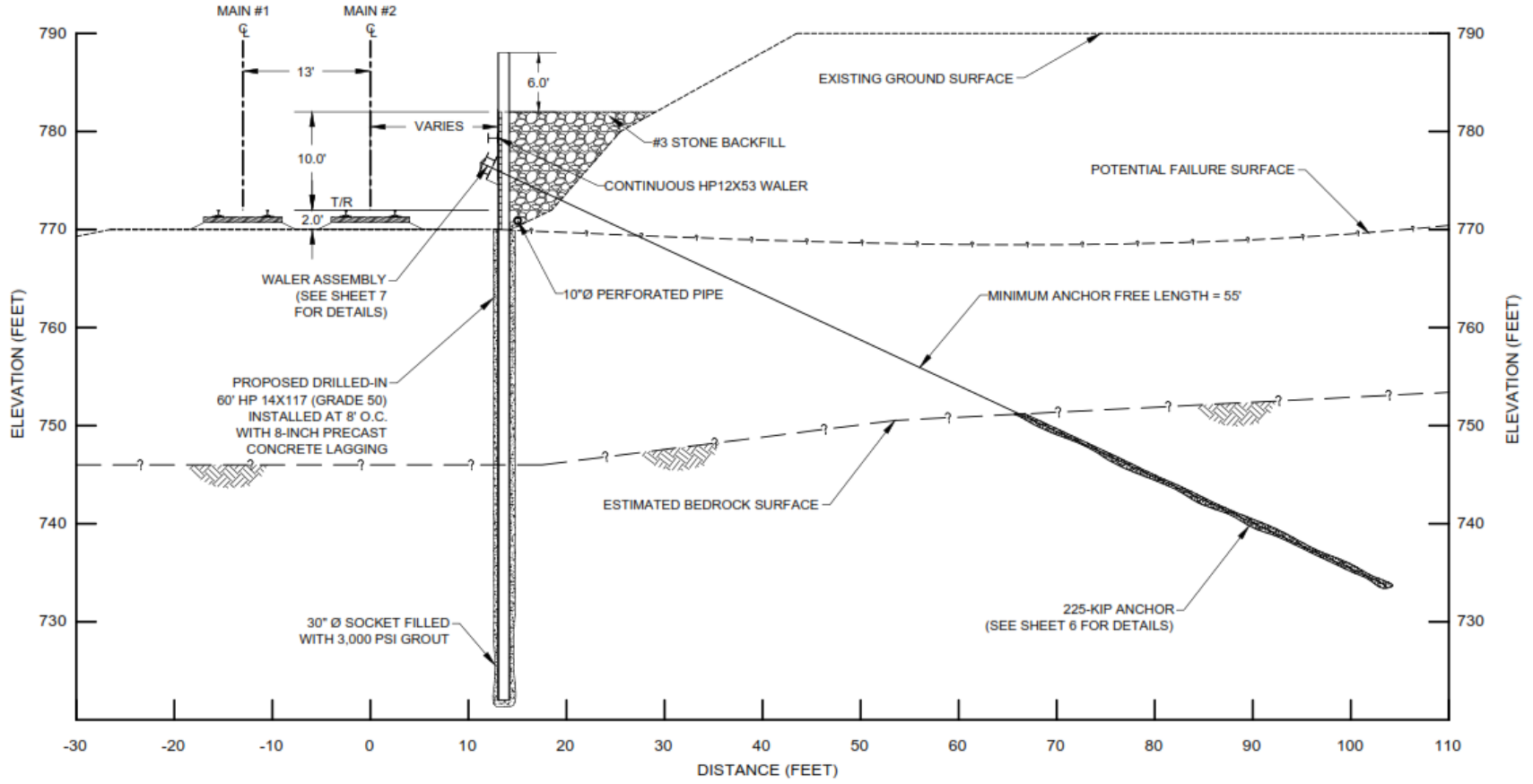
Retaining Wall Design (continued)

Phase 1 Typical Section



Retaining Wall Design (continued)

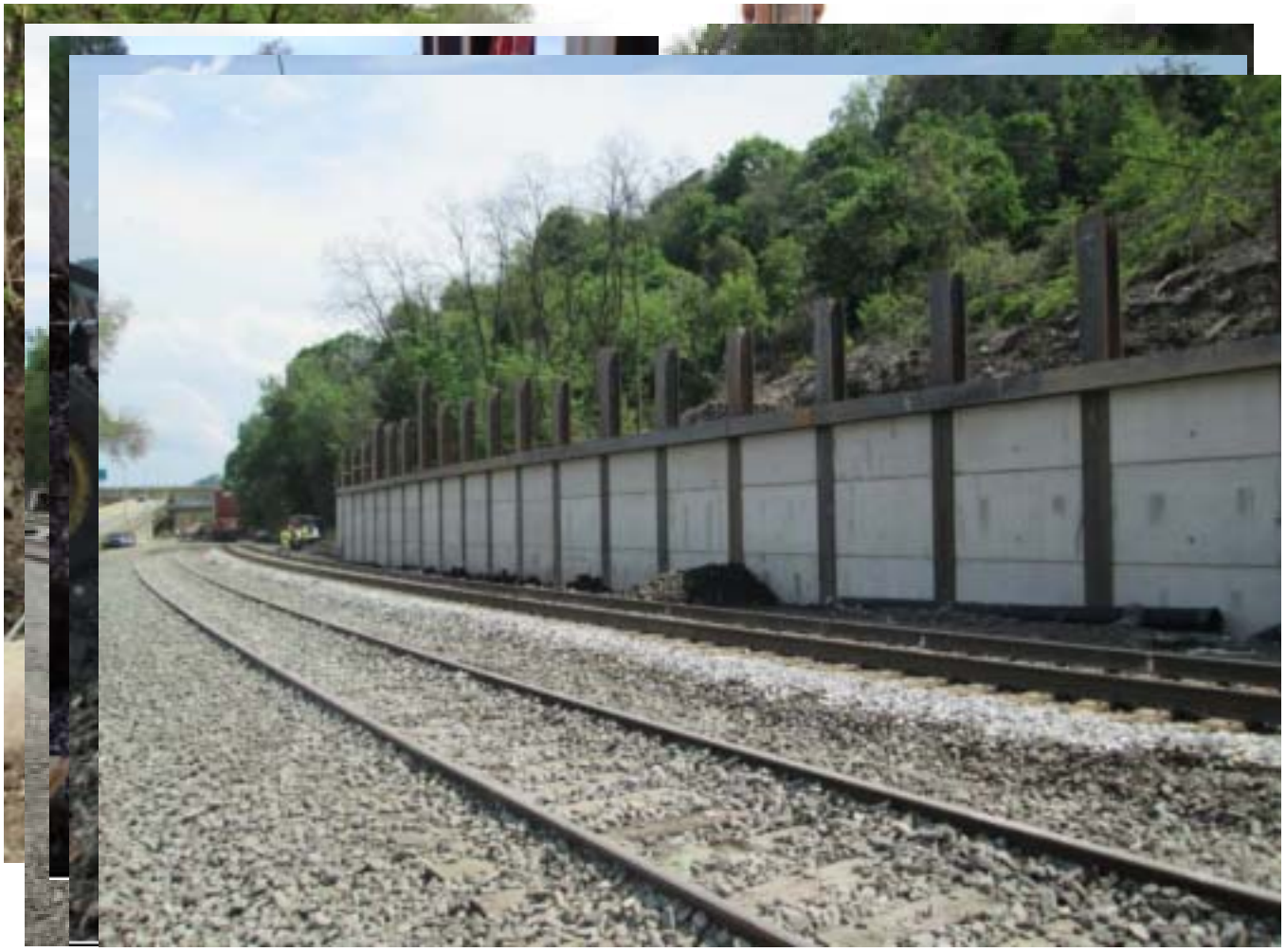
Phase 2 Typical Section



Retaining Wall Construction

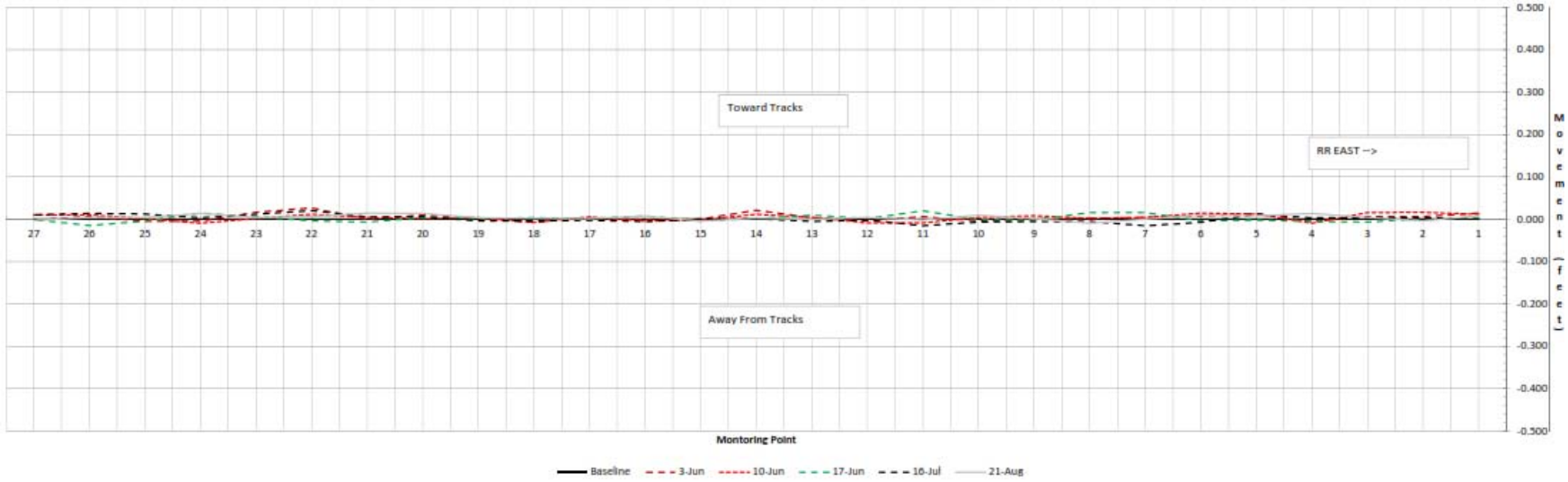
- Construction Notes
  - Wall Alignment changed to expedite construction and accommodate utilities
  - Some lagging sections were cast-in-place
  - Grading upslope of wall to assist drainage
  - Construction completed within one month.

Construction Photos



Survey Monitoring

- Monitoring Program
  - Movement monitored for 12 weeks after completion.
  - Final readings August 2014
  - 27 monitoring points along top of wall
  - Max movement ≤ 0.25”
  - As result Phase 2 was not constructed



Summary and Lessons Learned

- Revisit Objectives
  - Protect track operations
  - Provide a system with advanced warning of additional movement
- Design and Construction complete within two months
- Wall Monitored for Movement
  - Minimal movement observed over three months
- Phase 2 Not Constructed
  - Saved approximately $400,000 in construction costs.

- Lessons Learned
  - Comfortable with limited information & changing conditions
  - Provide flexible designs

Questions?

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