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West Calgary Ring Road – DB1: Risk Management Through Design

Anwar Majid, M.A.Sc.,P.Eng.
Rob Laing, P.Eng., PMP
Kurt Weber, P.Eng.

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Introduction

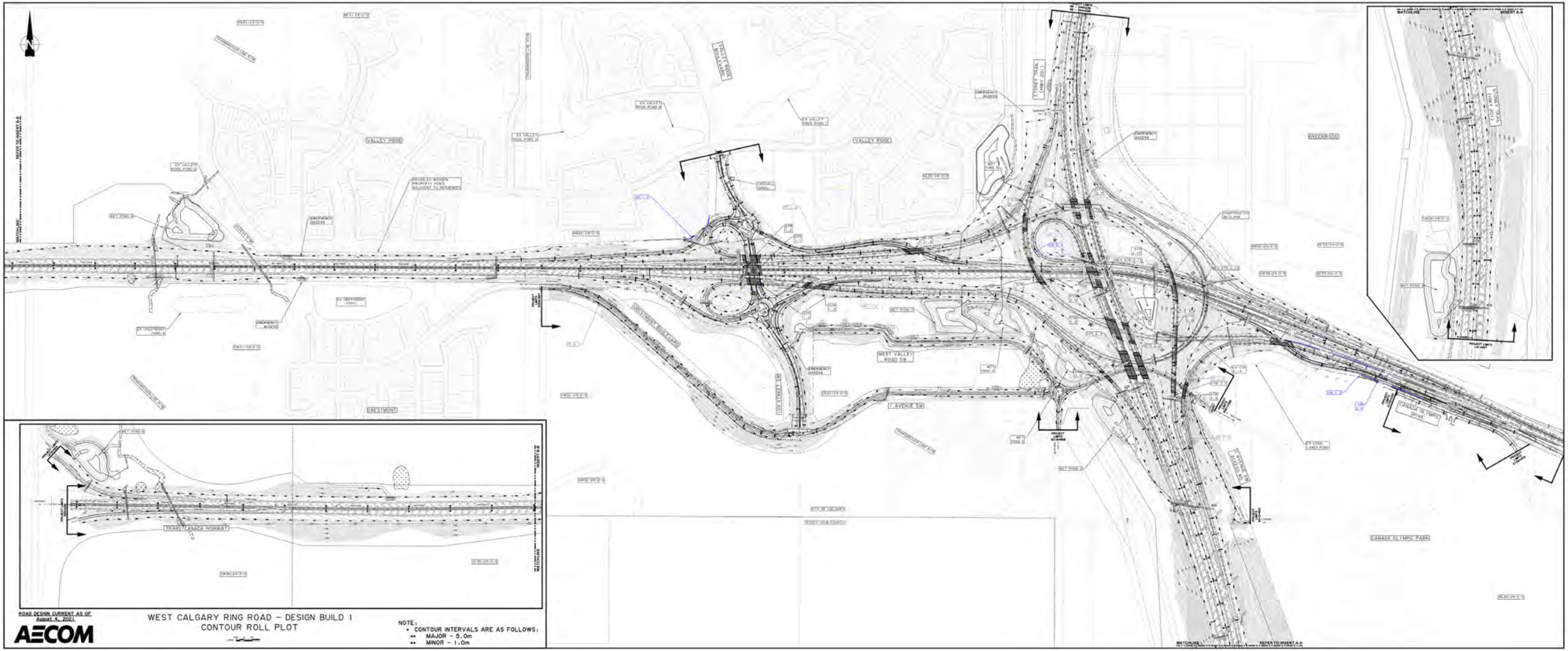
DB project – carries a different set of risks from conventional work.

- Consideration for boundary conditions
  - Brownfield construction.
  - TCH and Stoney Trail traffic.
  - Active community associations in Valley Ridge, Crestmont, Cougar Ridge, and WinSport. Community engagement continues into construction due to uncertainty of preferred proponent (and design) during pursuit.
  - Four-year construction window.
  - Paskapoo Slopes – large excavation with variable subsurface conditions.
  - Concurrent construction projects at north and south project limits.

- DB risks on this project
  - Incomplete geotechnical information and ability to access for investigation
  - Variable subsurface conditions
  - Quantity risk
  - Schedule
  - Scope creep
  - Relief events
  - Weather risk
  - Unforeseen scope, leading to cost increases
  - Escalation
  - Utility relocates by external parties.

How to manage these risks?

Project Overview



Geotechnical

Managing Geotechnical Risks

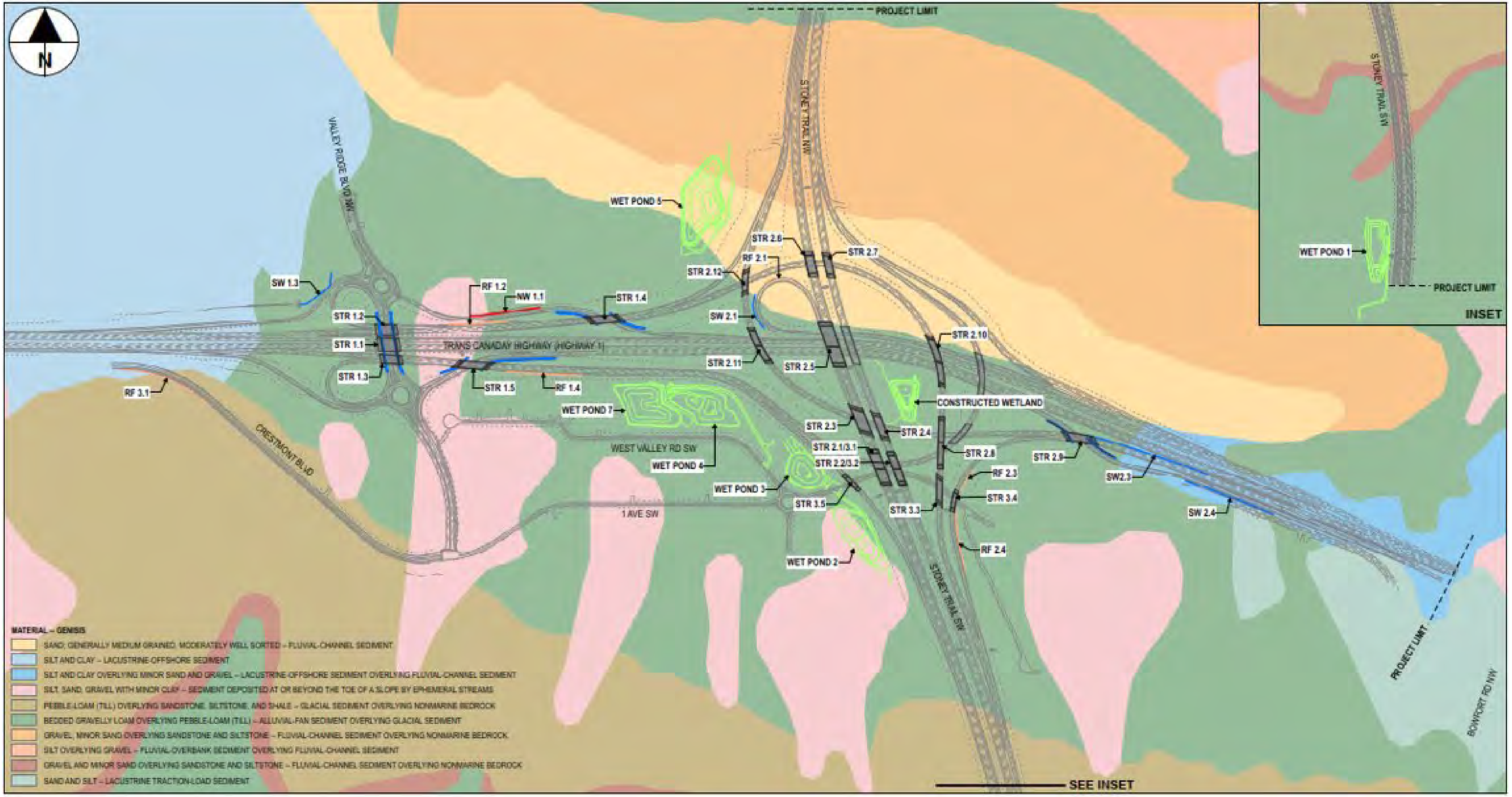
- Geotechnical engineering is fundamentally about managing risk
- Managing the geotechnical risk is not simple on conventional projects
- On Design-Build (DB) projects, managing geotechnical risk is even more difficult because the contract is awarded before a complete geotechnical investigation.

- Stages:
  - Managing pre-award geotechnical uncertainty
  - Managing post-award geotechnical risk.

Managing Pre-Award Geotechnical Uncertainty

- Uncertainty is lack of information.
- Uncertainty can be reduced by performing geotechnical investigation and testing
  - Owner provides geotechnical reports
  - Contractor performs supplementary geotechnical investigation
- Limited time and budget during pursuit stage (30% design).
  - Limited geotechnical investigation
  - Geotechnical risk allocation.

Managing Pre-Award Geotechnical Uncertainty – Surficial Geology



Managing Pre-Award Geotechnical Uncertainty – Surficial Geology

Managing Pre-Award Geotechnical Uncertainty – Pursuit Stage Geotechnical

- 18 testholes drilled by EllisDon
- 3 testholes drilled by Alberta Transportation in Paskapoo escarpment
- 9 testpits by EllisDon in Paskapoo escarpment – for bedrock surface
- Historical testholes at the existing bridge locations
- Total number of testholes available for pursuit stage design - 15% of the expected number of testholes for detailed design
- Spoke to contractors involved in construction of storm system at the existing interchange.

Managing Pre-Award Geotechnical Uncertainty – Pursuit Stage Findings

- Subsurface conditions variable within short distances and with depth
- High groundwater
- Potential presence of underground springs and buried channels
- Running and flowing ground conditions in the upper 5m
- Buried debris north of TCH – concrete, metals, etc.
- Highly variable bedrock surface in Paskapoo escarpment
- Soft ground conditions
- Settlement
- Slope stability
- Impacts on adjacent infrastructure – residential area, underground utilities, transportation infrastructure.

Managing Pre-Award Geotechnical Uncertainty – Risk Mitigation

- Selected driven steel piles for all bridges – existing bridges are on straight shaft and belled cast-in-place concrete piles
- Heavy steel pile sections and piling shoes if debris (concrete, metals, etc.) encountered at pile locations
- Vibration and settlement monitoring to identify and mitigate impacts of pile driving on nearby residential neighbourhood
- Subcut and basal reinforcement at approach fill and MSE wall locations to mitigate settlement and stability
- Reinforced slopes to mitigate restricted right of way
- Uniaxial geogrids to achieve factor of safety against slope stability.

Managing Post-Award Geotechnical Risk Mitigation

- Detailed geotechnical investigation in accordance with AT guidelines
  - About 200 testholes along roads and at each structure location
  - Geophysical survey to delineate bedrock surface
  - Extensive laboratory testing on soil and bedrock samples
- Detailed settlement, seepage and slope stability analyses
- Observational approach to mitigate risks during construction.

Managing Post-Award Geotechnical Risk Mitigation – Driven Steel Piles

- 800 driven steel piles
- Provided embedment during pursuit stage
- Pile embedment increased during detailed design
- Increased pile lengths and number of splices – cost and schedule risk
- Managed risk by terminating piles shorter than design depth, performing EOID and Restrike PDA testing, and using pile set up
- The pile set up varied from 6% to 80%
- Performed detailed WEAP analysis after PDA testing to confirm each pile achieved the required capacity.

Managing Post-Award Geotechnical Risk Mitigation Reinforced Slopes

- Restricted Right-of-Way at five locations requiring retaining walls
- Reinforced slope options was considered in place of retaining walls to reduce cost and use available material
- Slope heights - 4m to 14m
- Slope inclination - 1.3H:1V to 2.9 H:1V
- High strength uniaxial geogrids as primary reinforcement, secondary geogrids, low maintenance seed mix, with or without wrap around.

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Roadway / Geometric Design

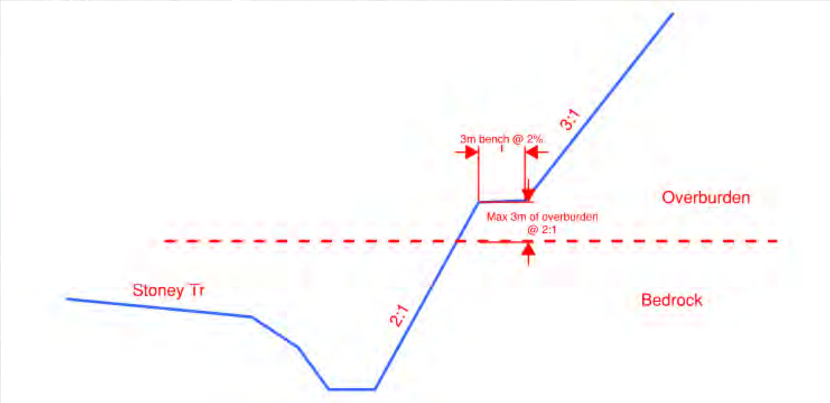
Roadway / Geometric Design

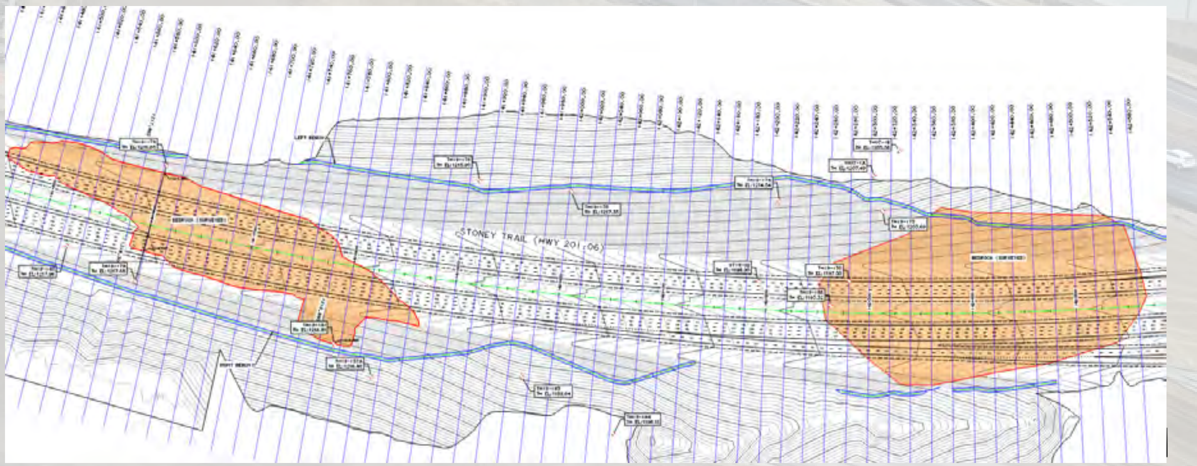
How did the geotechnical risks impact the roadway design and bridge geometry?

- Paskapoo Excavation
- Stoney Trail Profile
- TransCanada / Valley Ridge Blvd.

Paskapoo Excavation

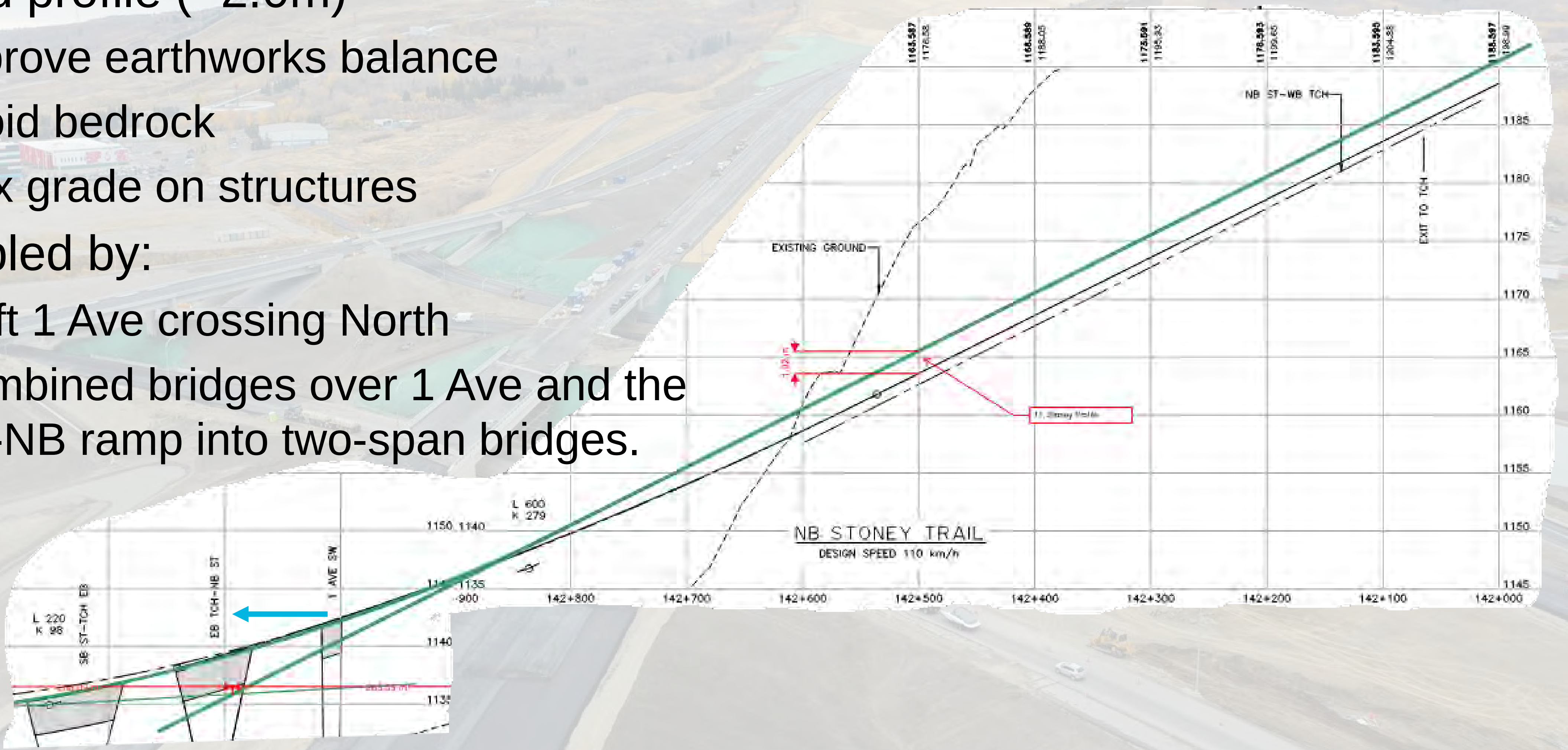
- Risk
  - Bedrock excavation (quantity and rock strength), confirmed location unknown.
  - Groundwater springs.
- Design - mitigate risk through lifting profile.
- Construction – sideslope changes.
  - A bench required at transition from 3:1 to 2:1 slope. Excavation starts at top of slope and works down making location of bedrock critical.
  - Detailed investigation using probe holes.





Stoney Trail Profile

- Lifted profile (~2.0m)
  - Improve earthworks balance
  - Avoid bedrock
  - Max grade on structures
- Enabled by:
  - Shift 1 Ave crossing North
  - Combined bridges over 1 Ave and the EB-NB ramp into two-span bridges.



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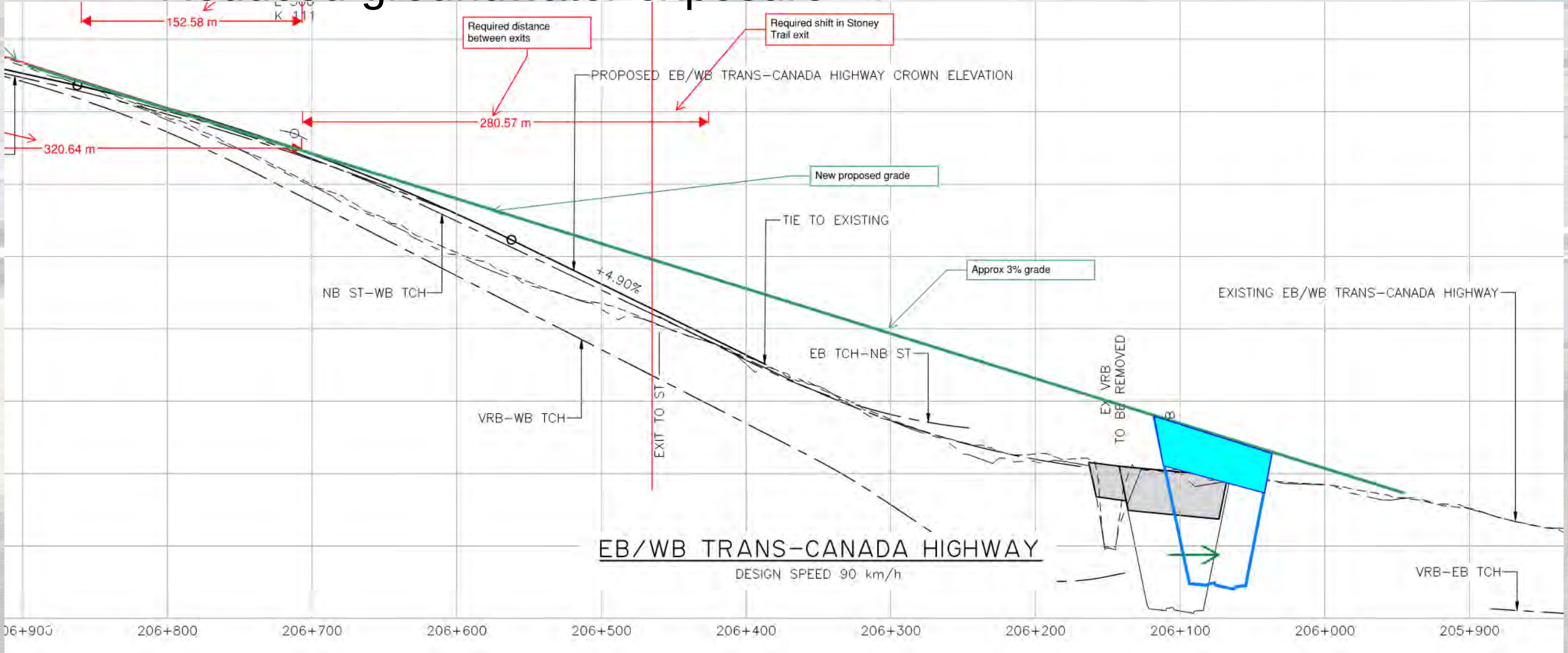
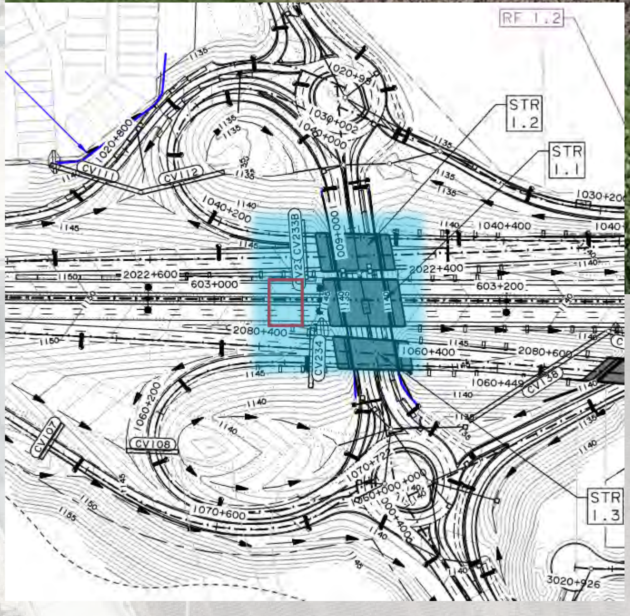
Bridge 2.2/3.2 – NB Stoney Trail over 1 Avenue and EB-NB Ramp

TransCanada / Valley Ridge Blvd

- Lifted profile at Valley Ridge Blvd (up to 6.0m)
  - Improve earthworks balance
  - Enabled lifting of Valley Ridge Blvd and 109 Street by up to 3.5m).
  - Raised “bath tub” in VRB profile
  - Reduced groundwater exposure
- Roundabouts at Valley Ridge Blvd.
  - Reduced bridge span
  - Valley Ridge Blvd shifted east
  - Proposed bridges away from existing structure



Bridge Construction
TCH over Valley Ridge Blvd.



Bridge Design

Bridge Design Challenges

- Foundation selection – limited borehole information
- Contractual requirements
  - Structures along ramps and alignments were required to have the same superstructure material and abutment type (open vs closed).
  - Required to use concrete on tight radius curves
- Aggressive design schedule
- Challenging geometry associated with systems interchanges.

Bridge Design Risk Management

- Risks were managed based on the best choice for the individual structure
- Similar but different structures
  - 3 steel, 17 concrete
  - 14 open abutments, 6 closed
  - 7 single span integral abutments, 2 dual span semi-integral, 2 dual span conventional abutment, 7 single span conventional abutment
  - 9 prestressed, 4 single stage PT, 4 two-stage PT superstructures
  - 4 structures on horizontal radius of 300m, max span 58m
- Combined four single span bridges into two 2 span structures
- Foundation selection – driven piles
  - Represented the lowest risk option.

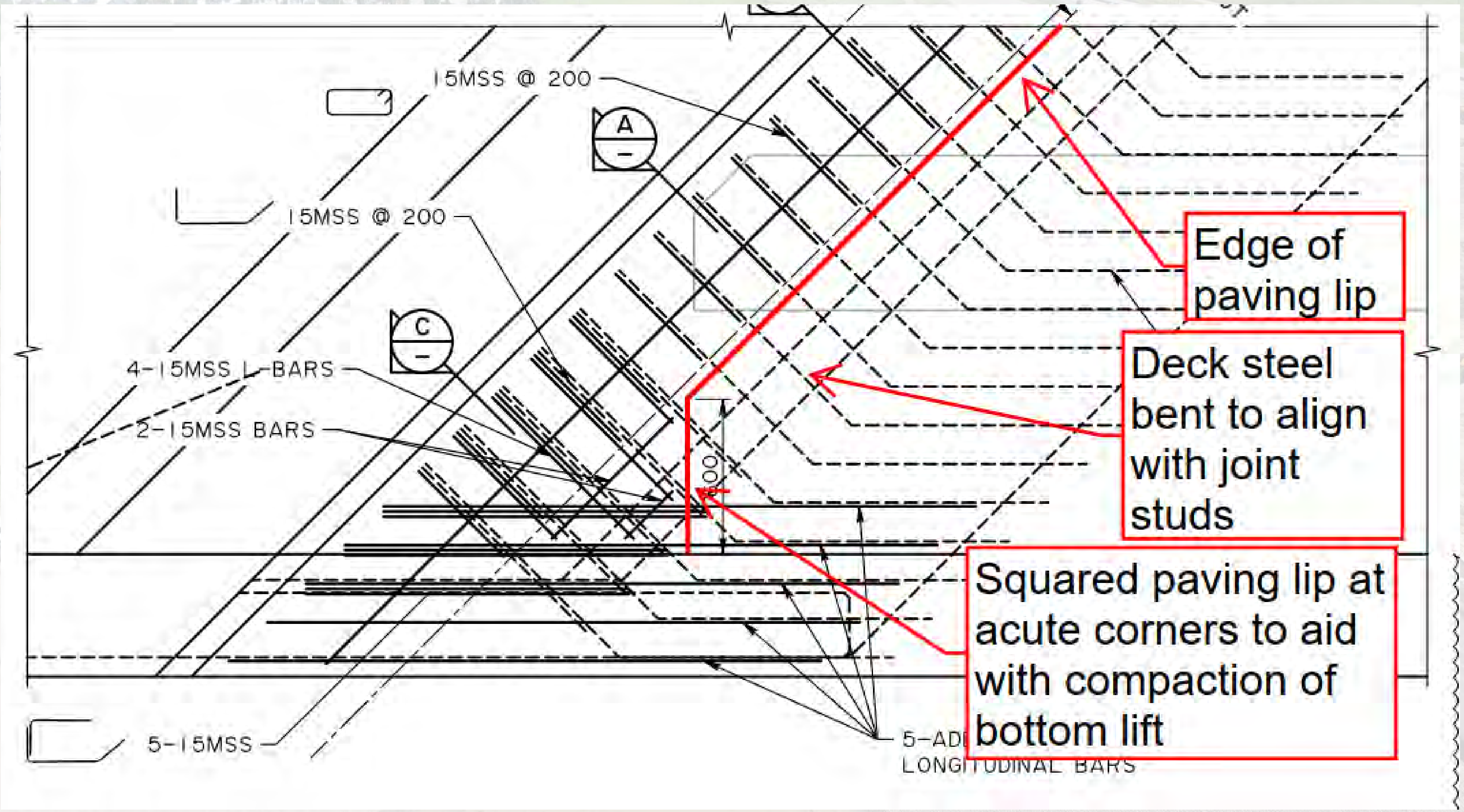
Bridge Design Risk Management

- Avoided MSE walls
  - Schedule risk
  - Excavate to backfill again
- Minimize girder lines
  - Reduced deck formwork time > material cost of thicker deck
- Maximized PT when practical
  - Extended span length
  - Reduced girder lines
  - Avoided on integral abutments
- Keep girders parallel
  - Reduced fabrication complexity for deck formwork, intermediate diaphragms
  - Easier to build tapered bridges
- Reduce skew to eliminate joints
  - Slightly longer bridge without changing girder depth (4 bridges).

Bridge Design Risk Management

- Chording curved decks
  - Simplified deck formwork and barriers on large radii
- Keep the design team compact
  - Develop consistency through this avenue
- Revised deck joint installation procedure
  - Re-aligned deck steel parallel to the joint anchor studs to reduce conflicts
  - Preloaded the deck instead of paving in advance of joint installation
    - Permitted construction joints to be moved away from water capture areas
    - Provided flexibility of loading conditions if formwork had not been removed
    - Better control of blockout elevations
    - Trade-off of longer construction schedule for reduced installation risks
- Generally successful in meeting the tighter AT tolerances.

Bridge Design Risk Management
Revised Deck Joint Installation Procedure



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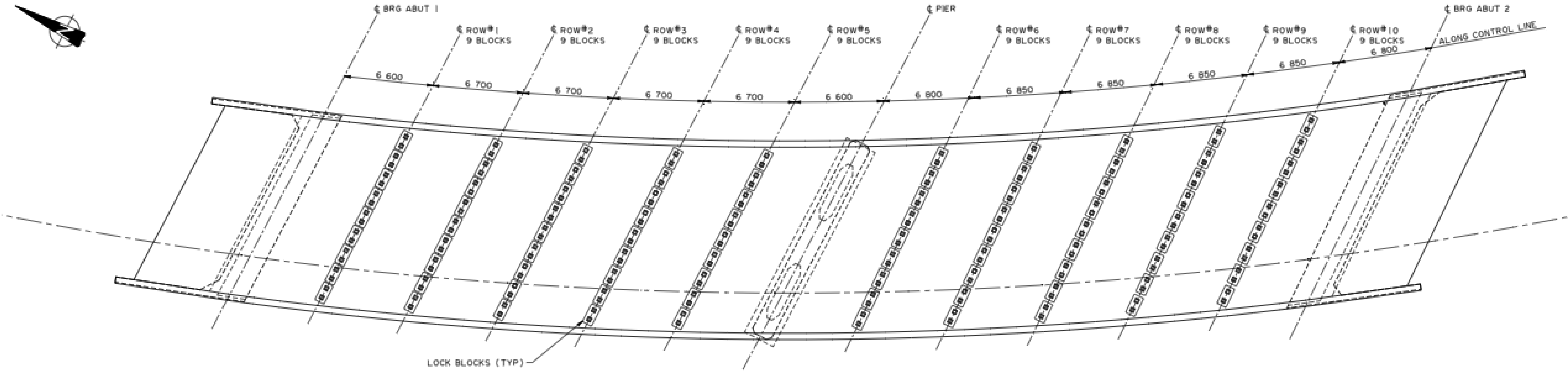
Bridge Design Risk Management
Revised Deck Joint Installation Procedure

- Lock blocks were used to create a UDL to mimic ACP and barrier deflection



LAYOUT OF CONCRETE LOCK BLOCKS PLACEMENT
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Bridge Design Risk Management
Revised Deck Joint Installation Procedure

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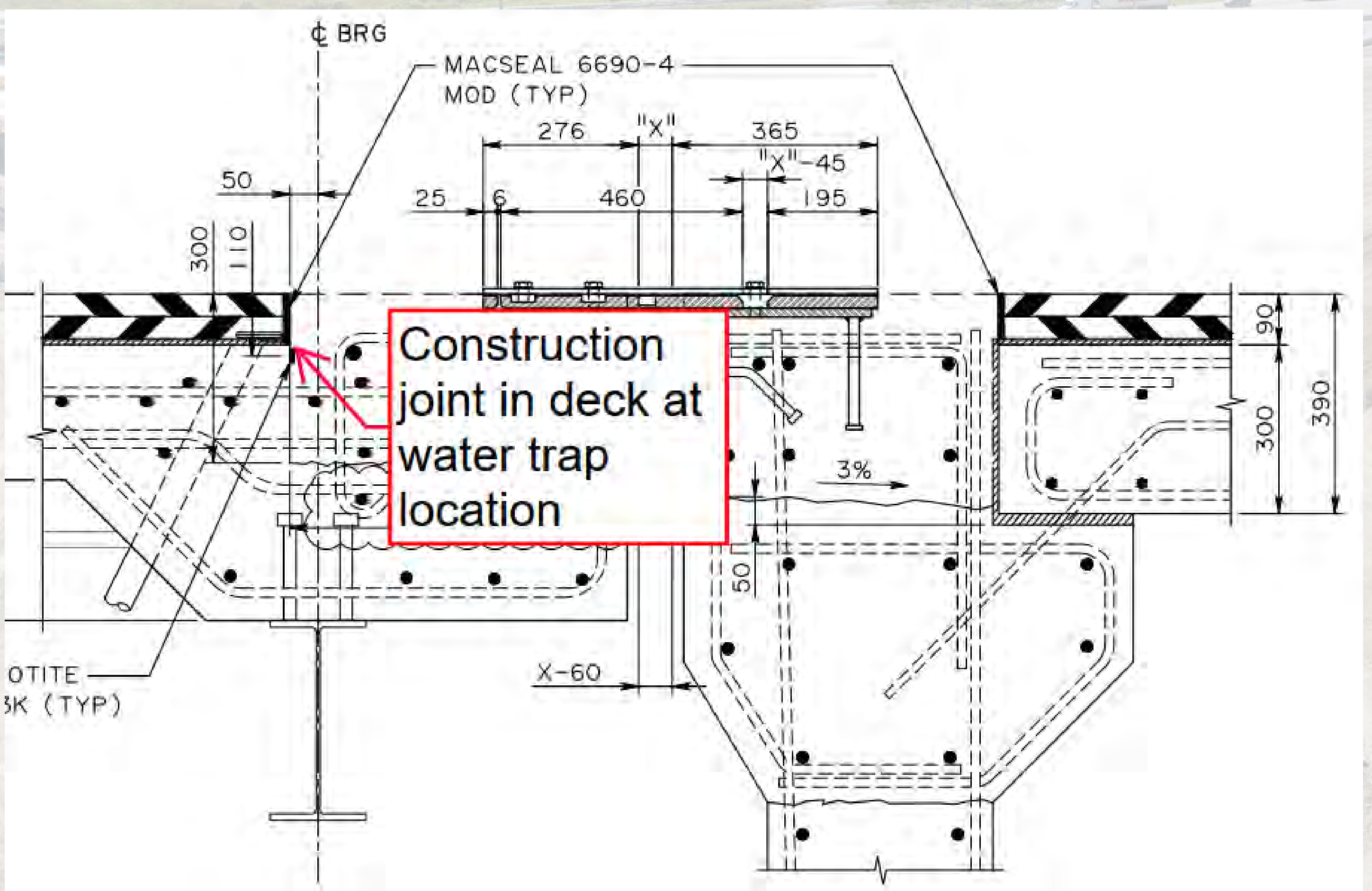
Bridge Design Risk Management
Revised Deck Joint Installation Procedure



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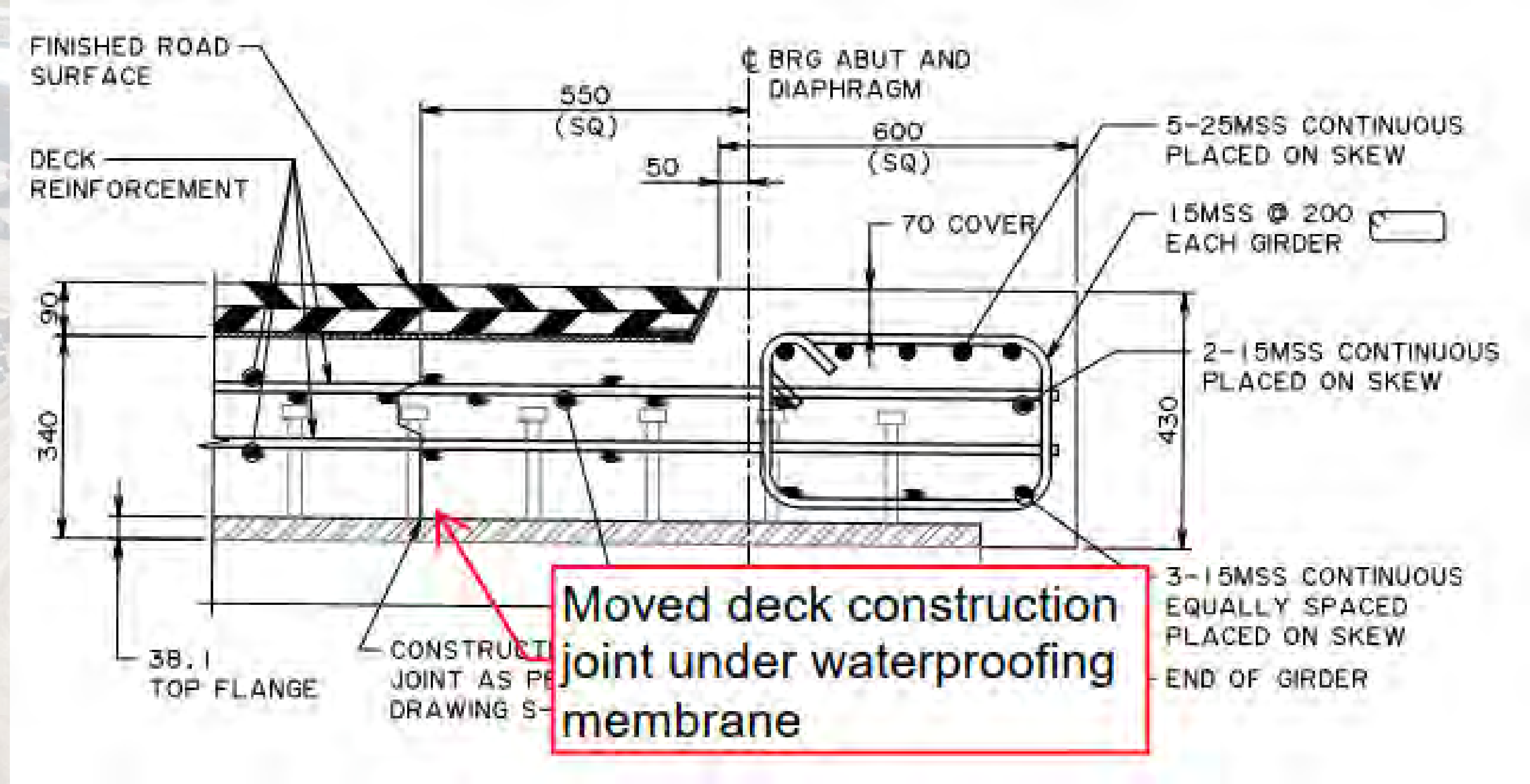
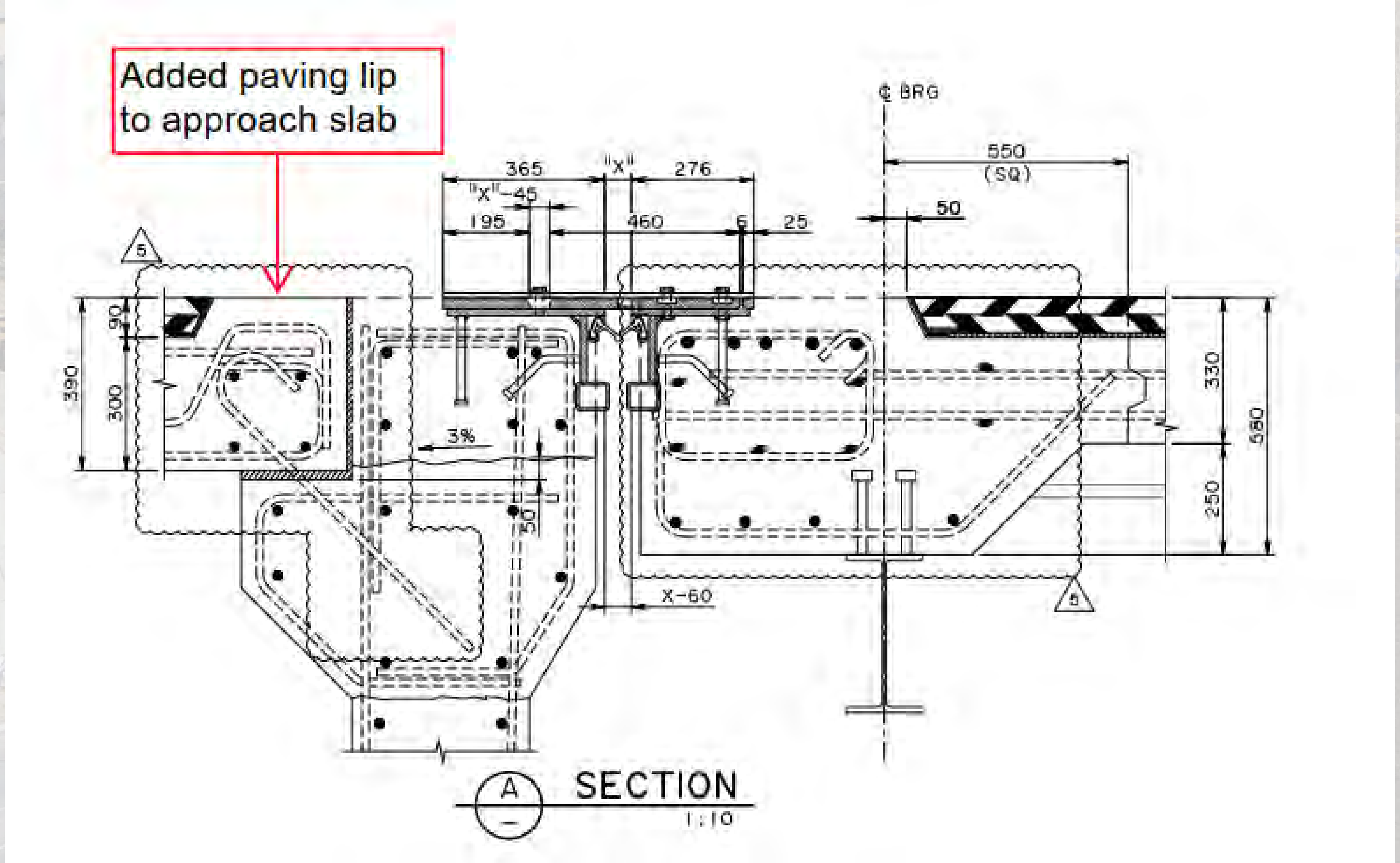
Bridge Design Risk Management
Revised Deck Joint Installation Procedure

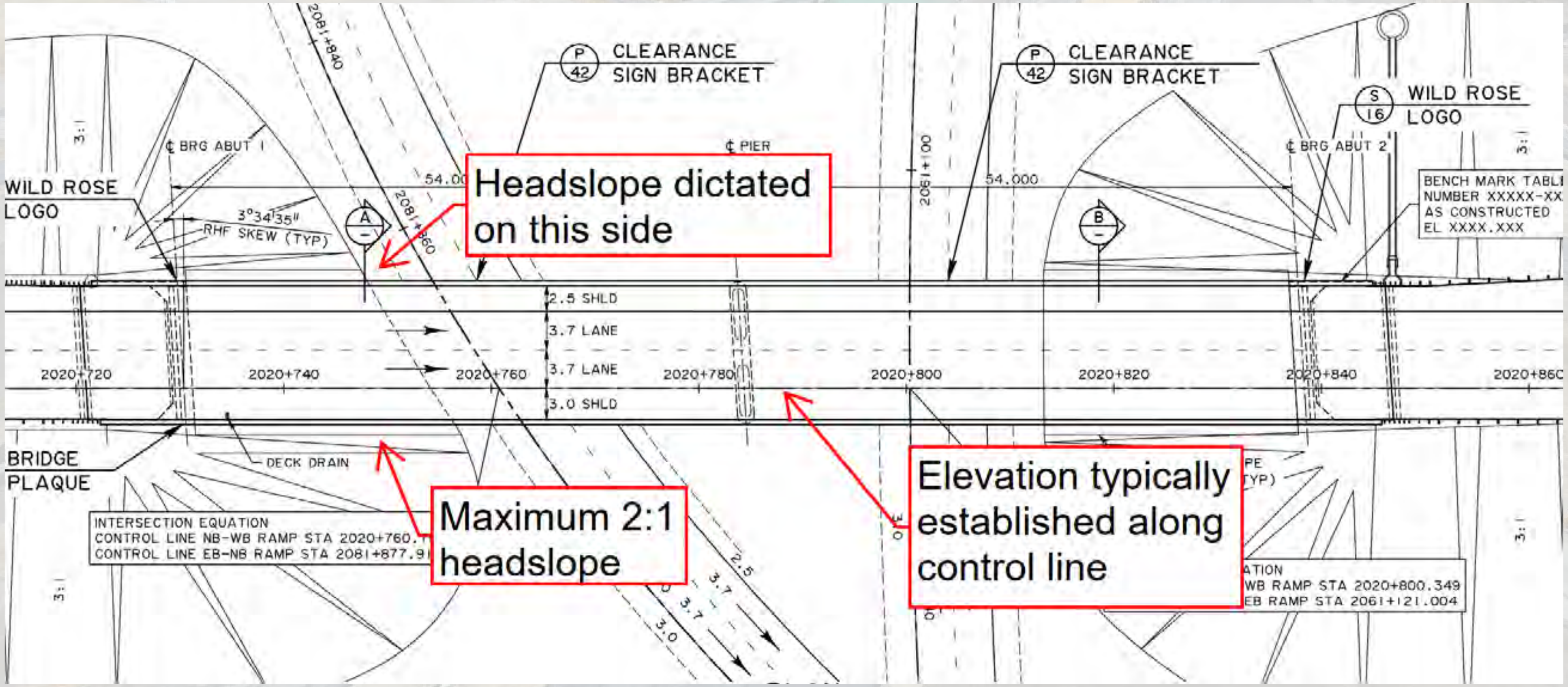


Bridge Design Risk Management
Revised Deck Joint Installation Procedure



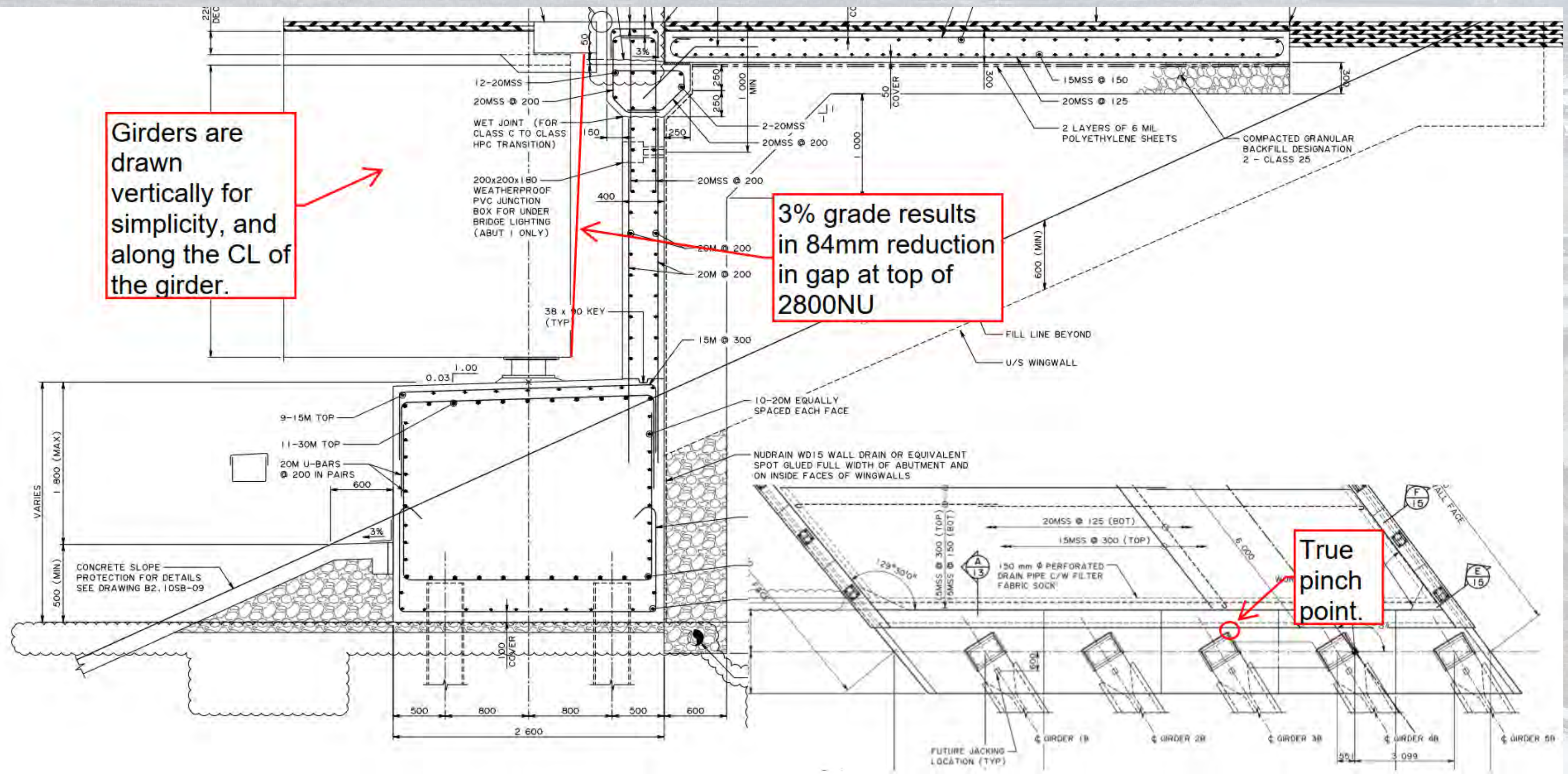
Bridge Design Lessons Learned

- Bridge elevation view vs. curved underpassing roads
  - Bridge geometry is typically established along control line
  - Curved underpassing roads add complexity
  - Needs to be captured during pursuit.



Bridge Design Lessons Learned

- Longitudinal grade and skew effects at expansion gap
  - Girder is typically shown plumb, and drawn along centerline of girder
  - Grade and skew take up expansion gap space.



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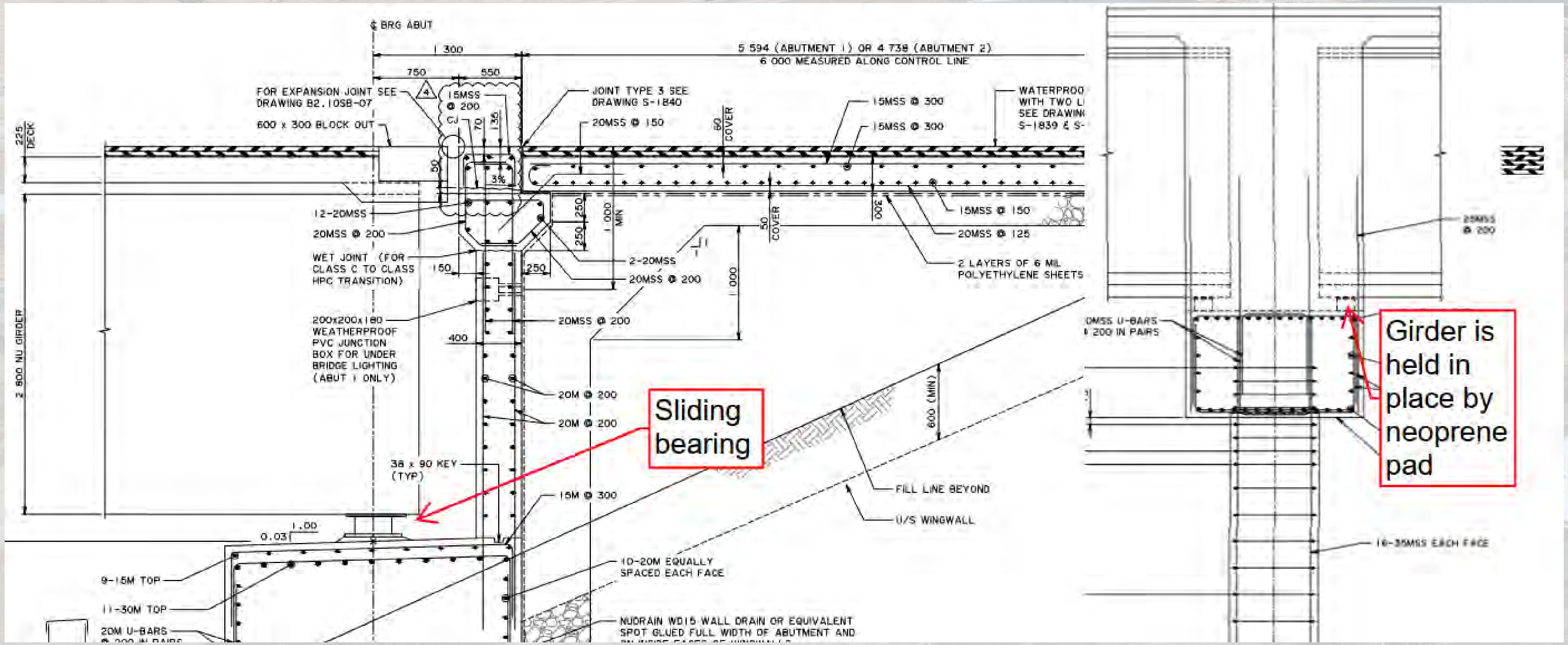
Bridge Design Lessons Learned

- Longitudinal restraint of girders during construction
  - 2 span bridges have sliding bearing at abutment
  - Girder is held in place by neoprene pad glued to plinth, sitting on 3% grade.



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Questions?