Innovating with Segmental Caisson Construction to Build a New Pump Station in Wellington's CBD

Callum Allison – GHD Ltd

Caroline Anderson - Brian Perry Civil

Asset Owner – Wellington City Council

Client – Wellington Water

Designer – GHD Ltd

Contractor – Brian Perry Civil

GHD

Wellington Water

Absolutely Positively Wellington City Council
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water NEW ZEALAND CONFERENCE & EXPO
18–20 September 2019, Hamilton

Contents

- The Need
- Extent of Works
- Challenging the Conventional Approach
- Seismic Loading
- Complex Site Constraints
- Delivering Construction
  - Contaminated Water
  - Groundwater Drawdown Risk

The Need

Customer Outcomes

Safe & Healthy Water

- Protect public from untreated spills to ocean

Respectful of the environment

- Ensure water services in built environment comply with consents and unintrusive

Resilient networks support the economy

- Provide customers access to reliable wastewater services
- Provide wastewater networks that are resilient to shocks and stresses
- Plan to meet future growth and manage demand

Wellington Water

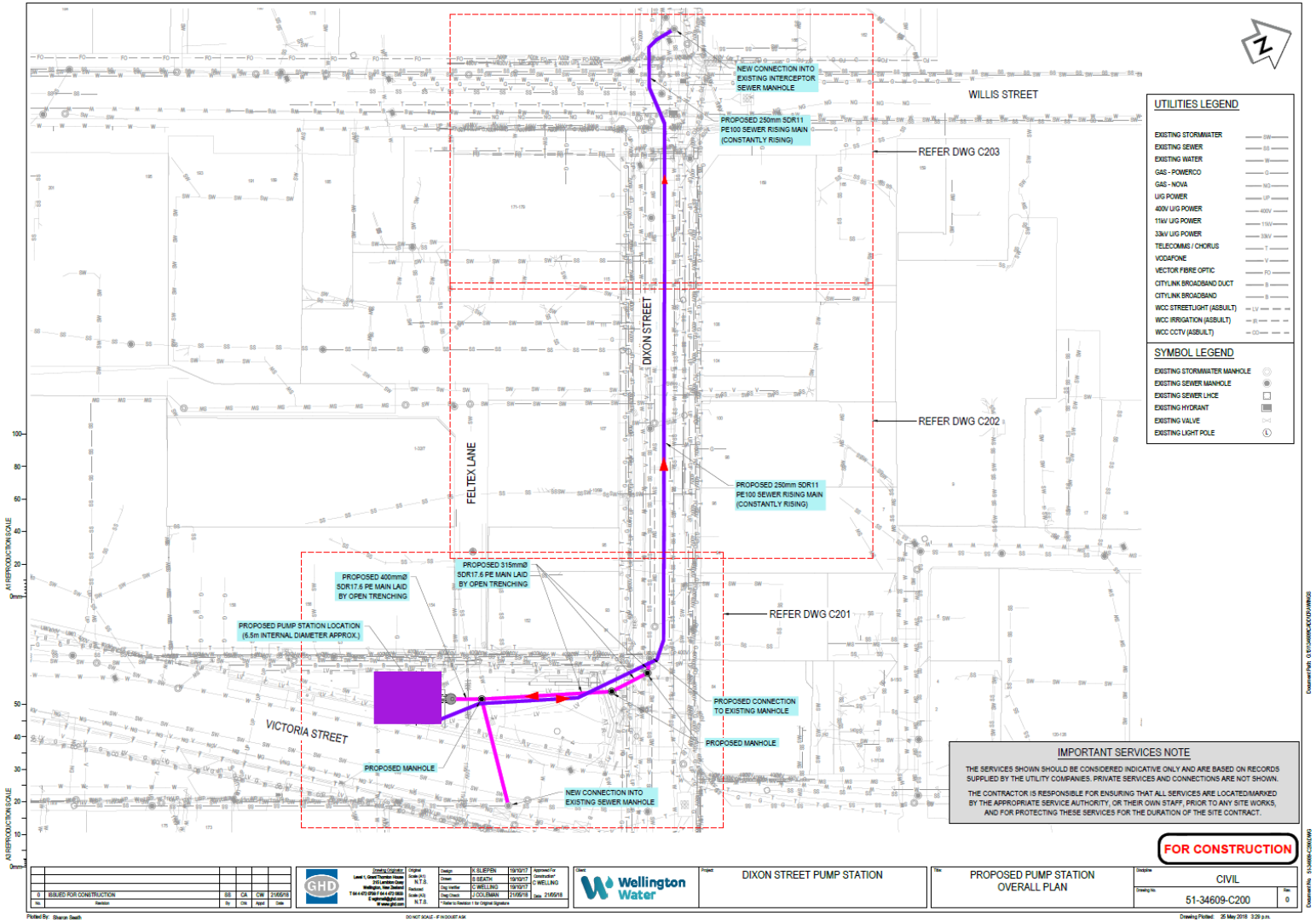
CHALLENGES

LOCATION?

- Existing sewer network at full cap
- 65,000 pop. increase (30y)
- 7300 new CBD dwellings
- **New Pump Station preferred solution to permit growth in the CBD**
- First new PS for 40 years
- Reduce overflow spills to harbour

Developments to be constructed by 2021

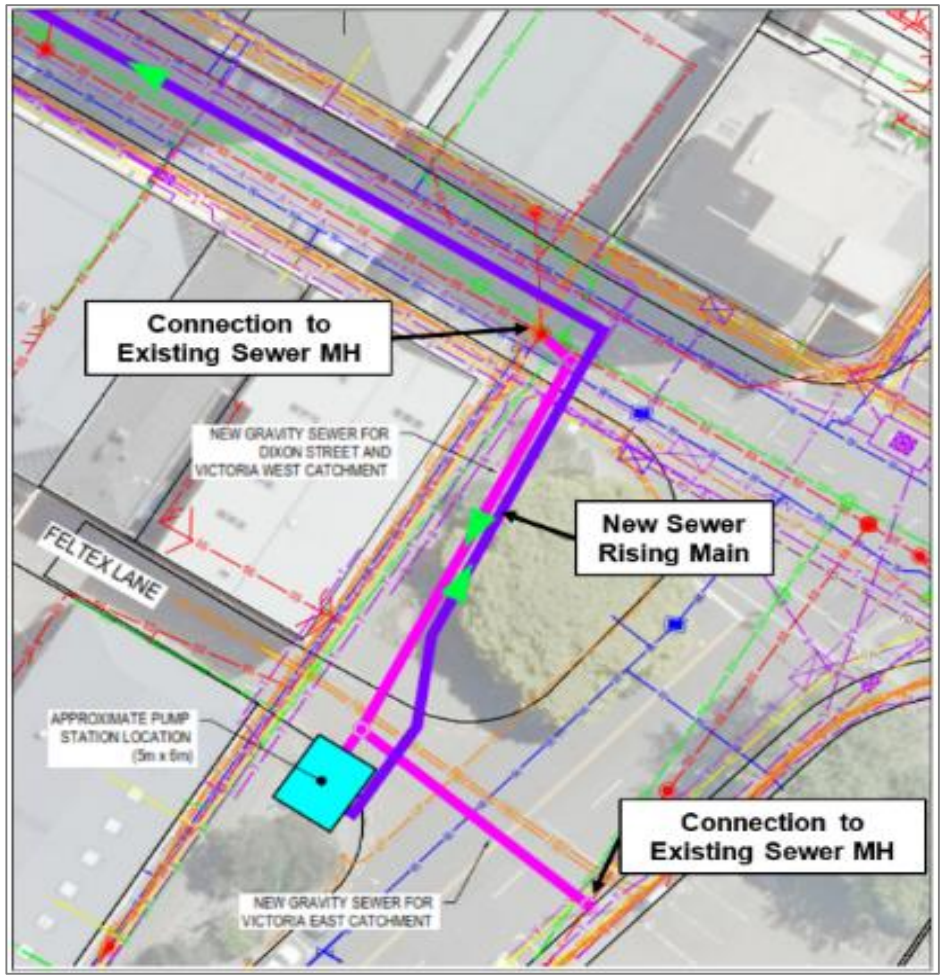
Extent of design



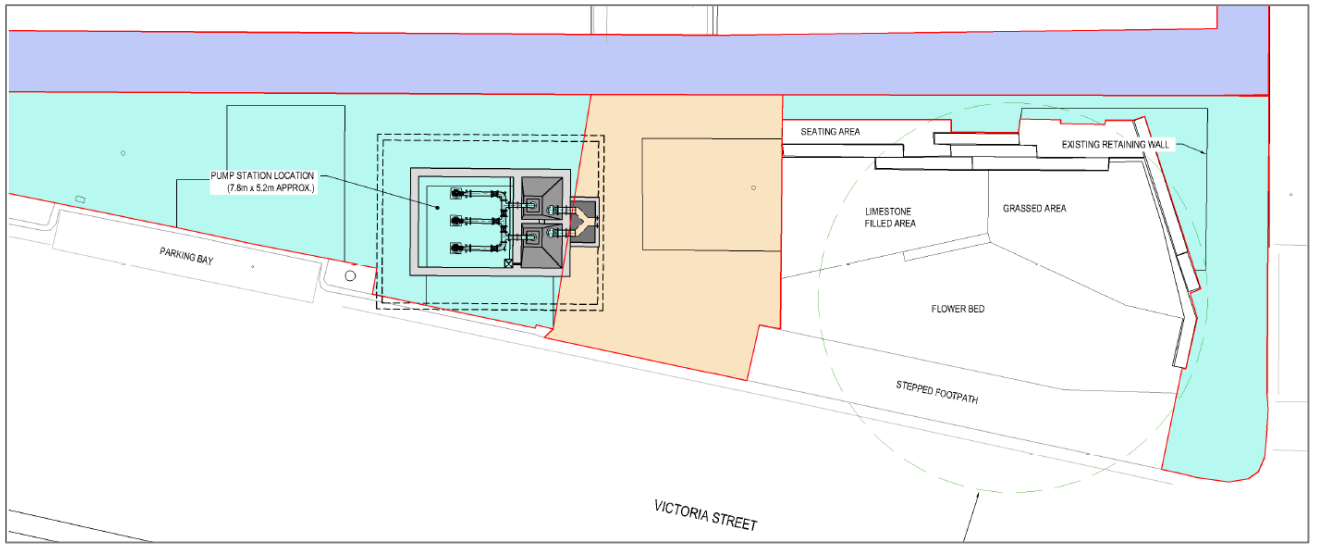
Analysis Basis	Average Dry Weather Flow ADWF (L/s)	Peak Dry Weather Flow PDWF (L/s)	Peak Wet Weather Flow PWWF (L/s)
2018 Flows	4.9	25.1	26.1
Fully Developed Flows	15.3	71.9	72.9

- PWWF – 73 l/s
- Below ground structure, 8m deep
- Divert 2 catchments
- Pipework
  - 60m x 300mm PE gravity
  - 170m x 250mm PE pressure
- Connect to interceptor gravity sewer
- Emergency Overflow weir structure

Challenging the Conventional



- Limited site locations and associated space
- Traditional approach
  - Cast in-situ – sheet piled excavation (or similar)
  - Cast on-site standard caisson structure
- Initial design – 7.8 x 5.2 x 6 m (d) concrete box



- Initial Construction Review Issues
  - Installation Noise / Vibration
  - Close proximity to roads, buildings and pedestrians

Tender Innovation Sought

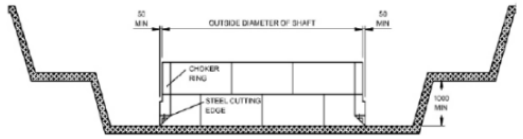
- Potential benefits of Precast Concrete Segmental Caisson

Common in Europe
Quicker installation
Safer – deep excavations
Quieter
Reduced footprint

- Complexities in New Zealand

Segment availability
Seismic performance
NZ Design Standards

1.



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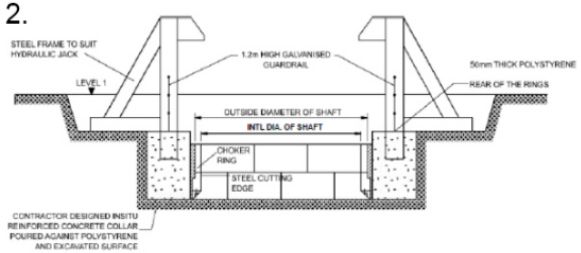

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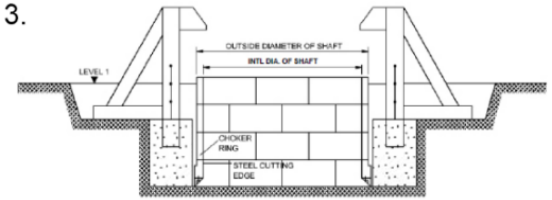

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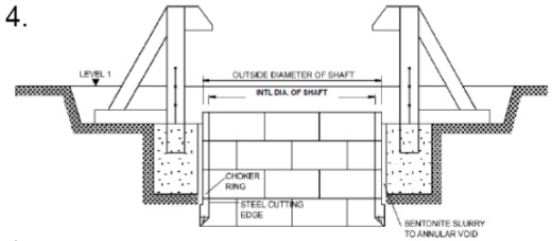

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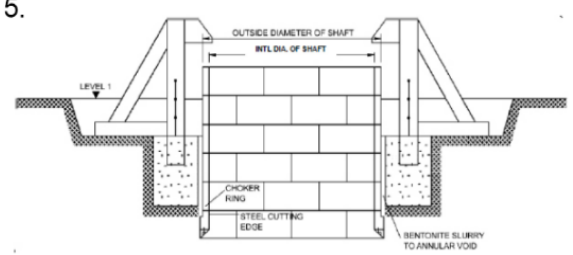

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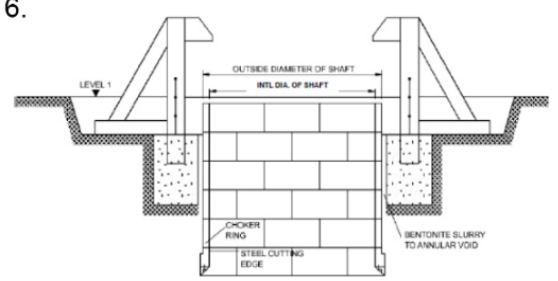
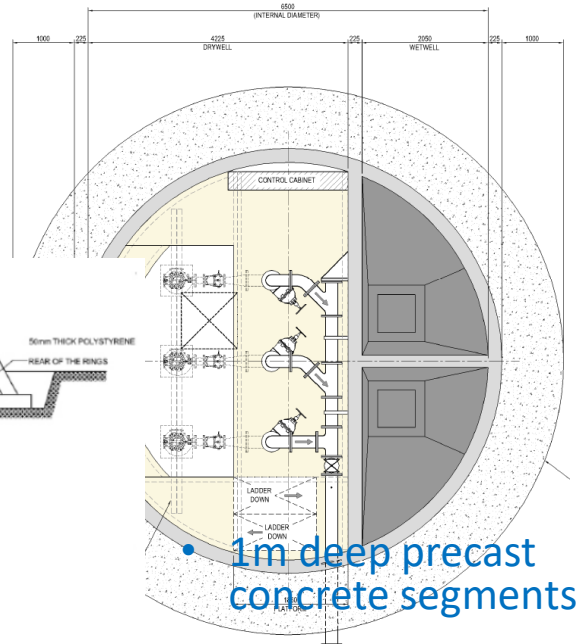
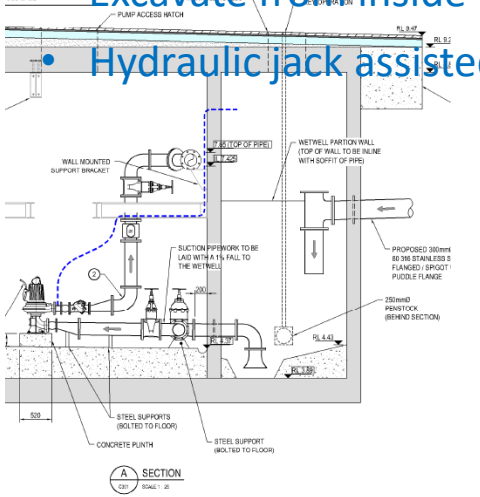




- 1m deep precast concrete segments
- Joined to form rings
- Excavate from inside
- Hydraulic jack assisted



Tender Innovation sought

- Potential benefits of Precast Concrete Segmental Caisson

Common in Europe
Quicker installation
Safer – deep excavations
Quieter
Reduced footprint

→ Cost Savings
Less Disruption

→ Invited innovation
Alternative design
6.5m internal dia.

- Complexities in New Zealand

Segment availability
Seismic performance
NZ Design Standards

→ POTENTIAL TENDER
Seismic Conditions
Can it be built?

→ TENDER
REVIEW

- 6.5m dia not available in NZ
- Shipped direct from UK

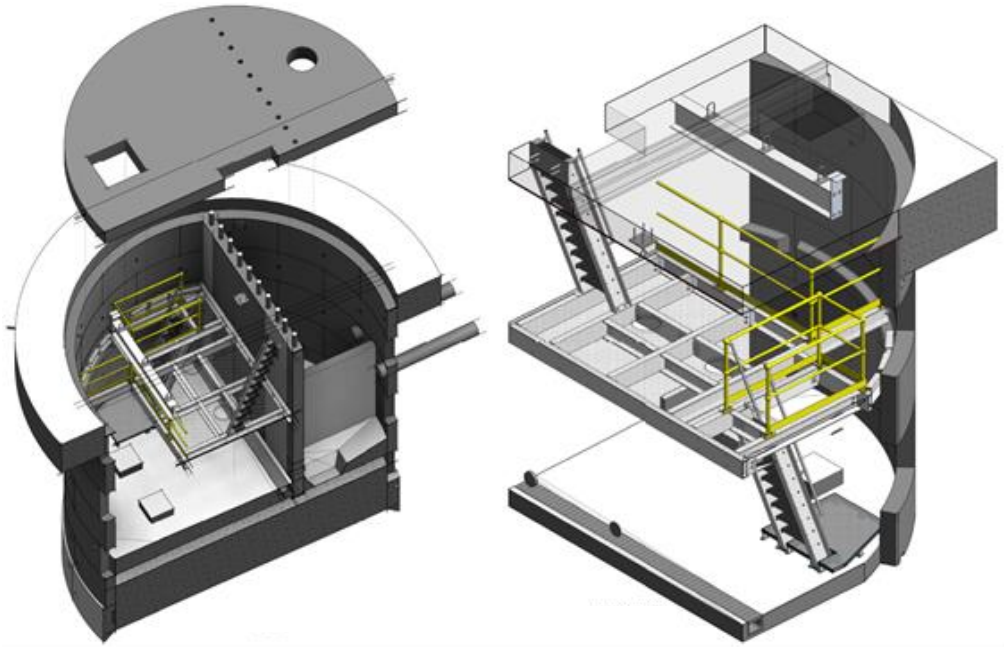
- Successful Contractor Methodology

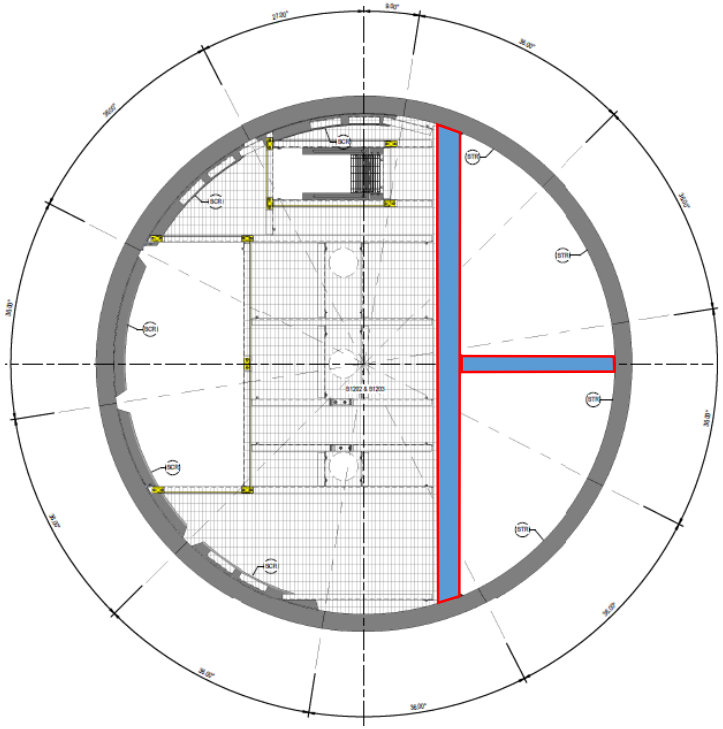
TENDER AWARD
Preconstruction stage
Collaboration
Designer / Contractor

- Perfect for site constraints
- Preserve pedestrian and vehicle access
- Reduce disruption to businesses
- Retain existing urban streetscape and vegetation

Internal Walls – Seismic Loading – Critical Asset

- Wetwell / dry well configuration
- Internal wall design to NZ Building Code
- Fire assessment
- Access and egress
- 3D Model brought design to life





- Water retaining structure
- Importance Level 4
- 100y durability
- 1 in 2500y ULS event
- Internal walls

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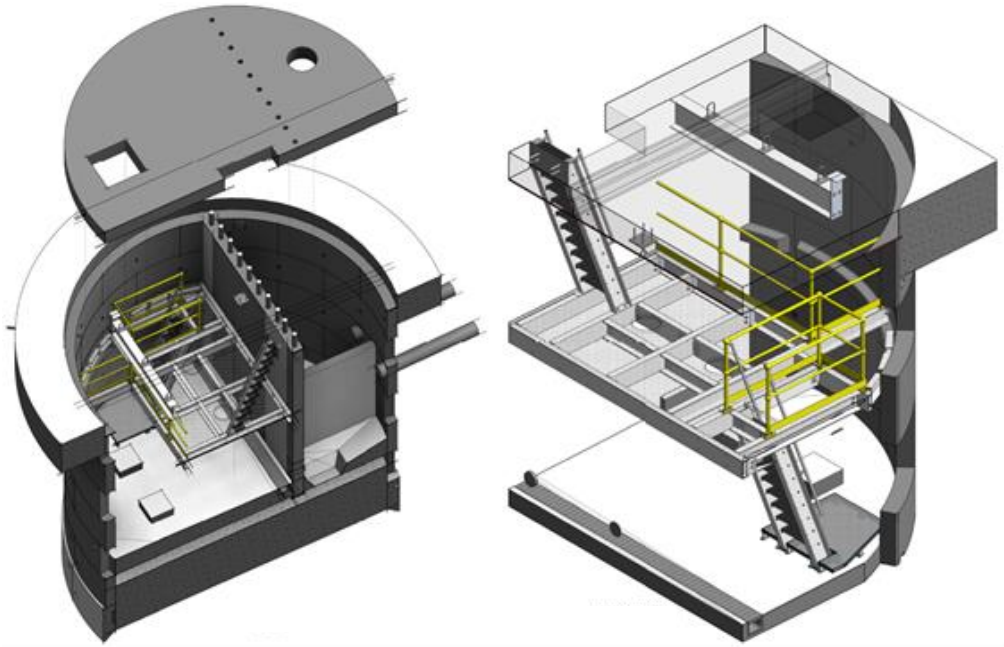
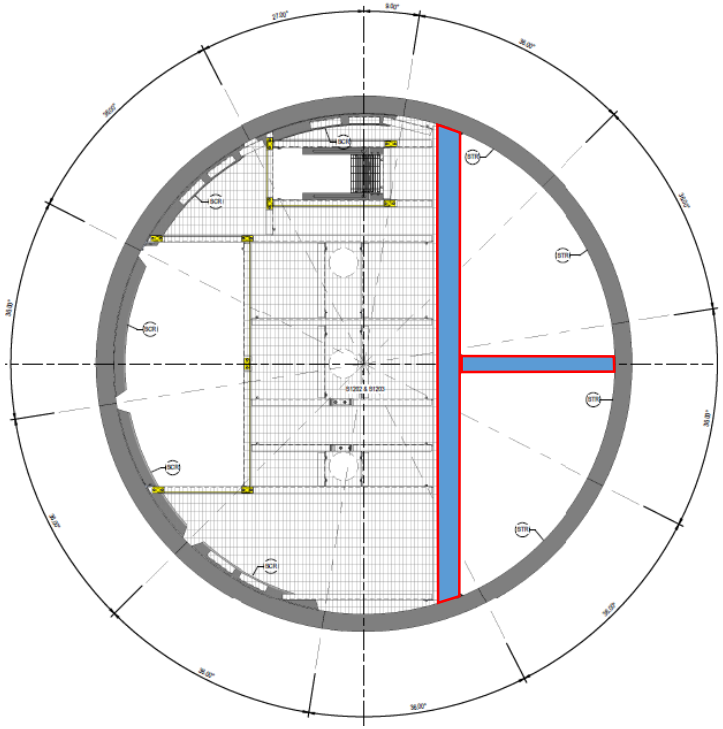
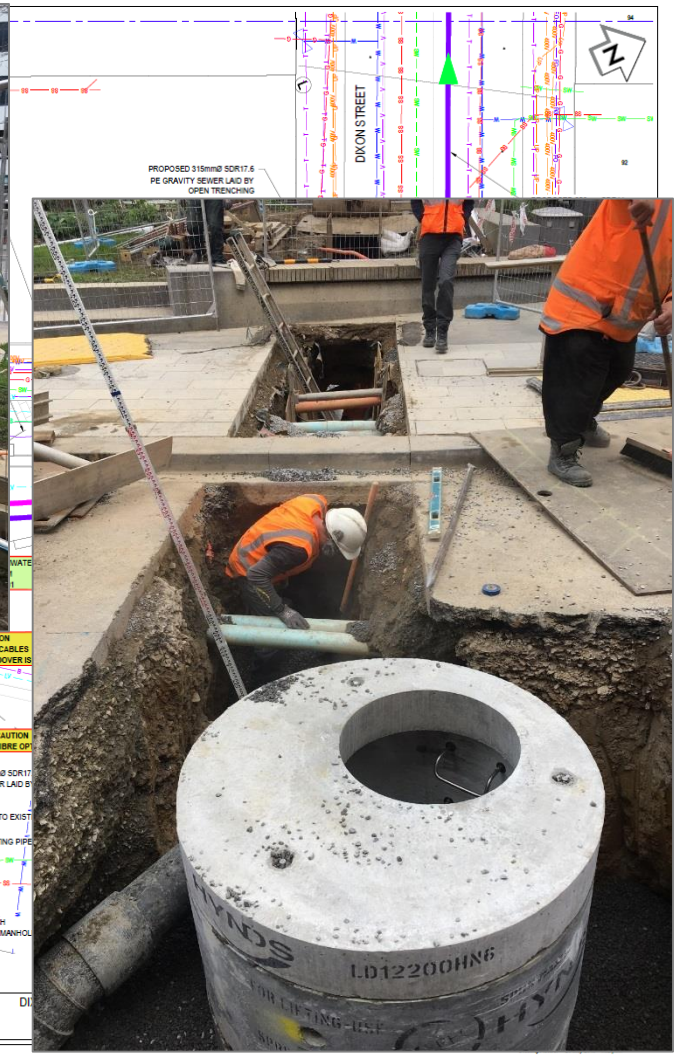


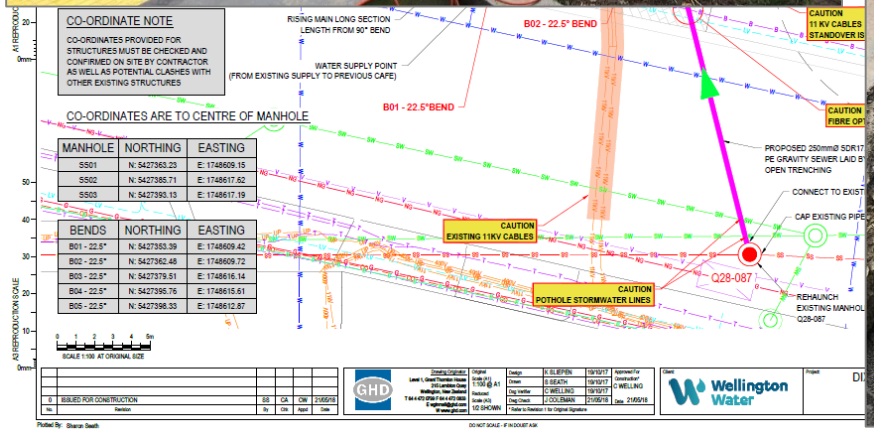


- Water retaining structure
- Importance Level 4
- 100y durability
- 1 in 2500y ULS event
- Internal walls

- Seismic model assessment by contractor sub-consultant
  - Connections of internal walls and their effect on segments
    - Continuous wall (full height)
    - Movement of individual segments
  - Maximum limit of joint displacement

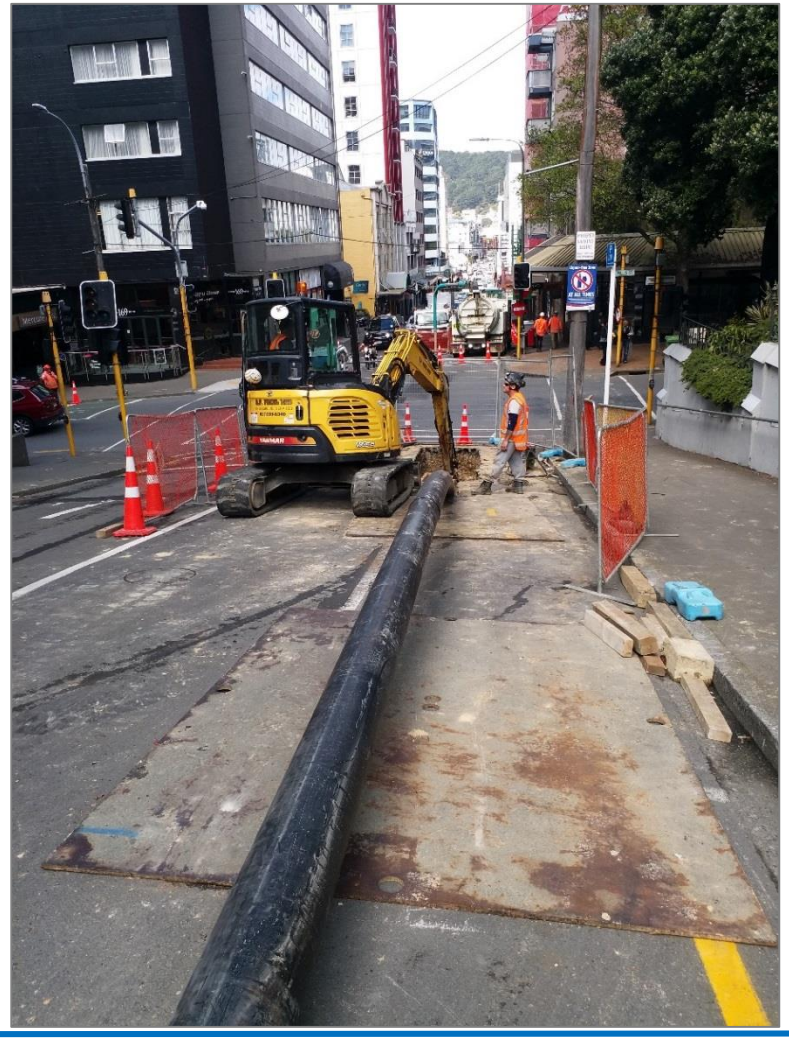
Challenging Site Constraints





- Small site footprint
- Shallow Foundation buildings (5m)
- Live road (1m)
- Existing trees
- Consents
  - Contaminated Land
  - Dewatering Consent
  - Building Consent
- Noise Management

Rising Main and Gravity Pipeline Construction



- Horizontal Directional drilling of rising main
- Traffic management in Wellington CBD
- Construction site loading zone

Site Establishment

- Service Diversions
  - Storm water
  - HV Power
  - Telecom
- Tree
  - Moved PS 300mm further away
- Streetlight
- Traffic Management
- Pedestrian Safety

Cutter Ring

- Precast segments
- 10 segments = 1 ring
- Taper on cutter ring
- Shear Key for concrete base plug

First Standard Ring

Construction of Reinforced Concrete Collar

Collar Benefits:

- Trench support
- Reaction mass for Hydraulic Jacks
- Vertical Guide
- Anti-flotation structural mass

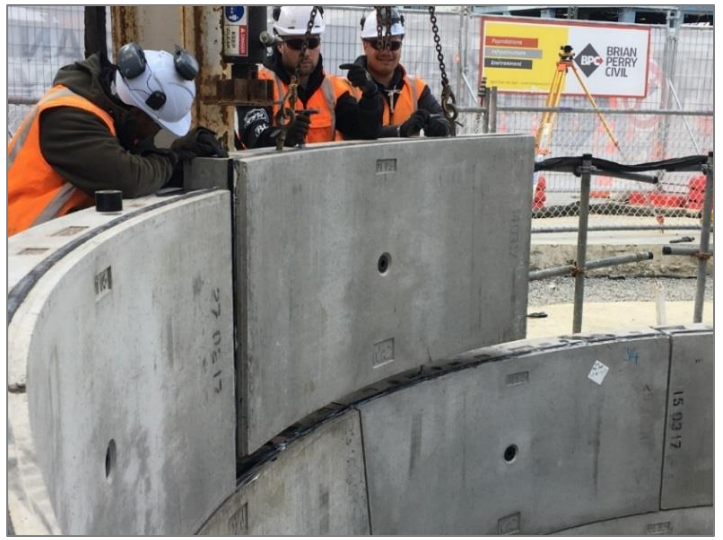
Caisson Build, Excavation and Sinking

- 24t “no swing” excavator
- Sandy Silt
- Spoil transferred to trucks on road

Caisson Build, Excavation and Sinking

- Custom-made Clamshell Bucket
- Caution working around tree
- Groundwater reached (4.5m BGL)

Connecting Segments




PILEHIRE
PILEHIRE

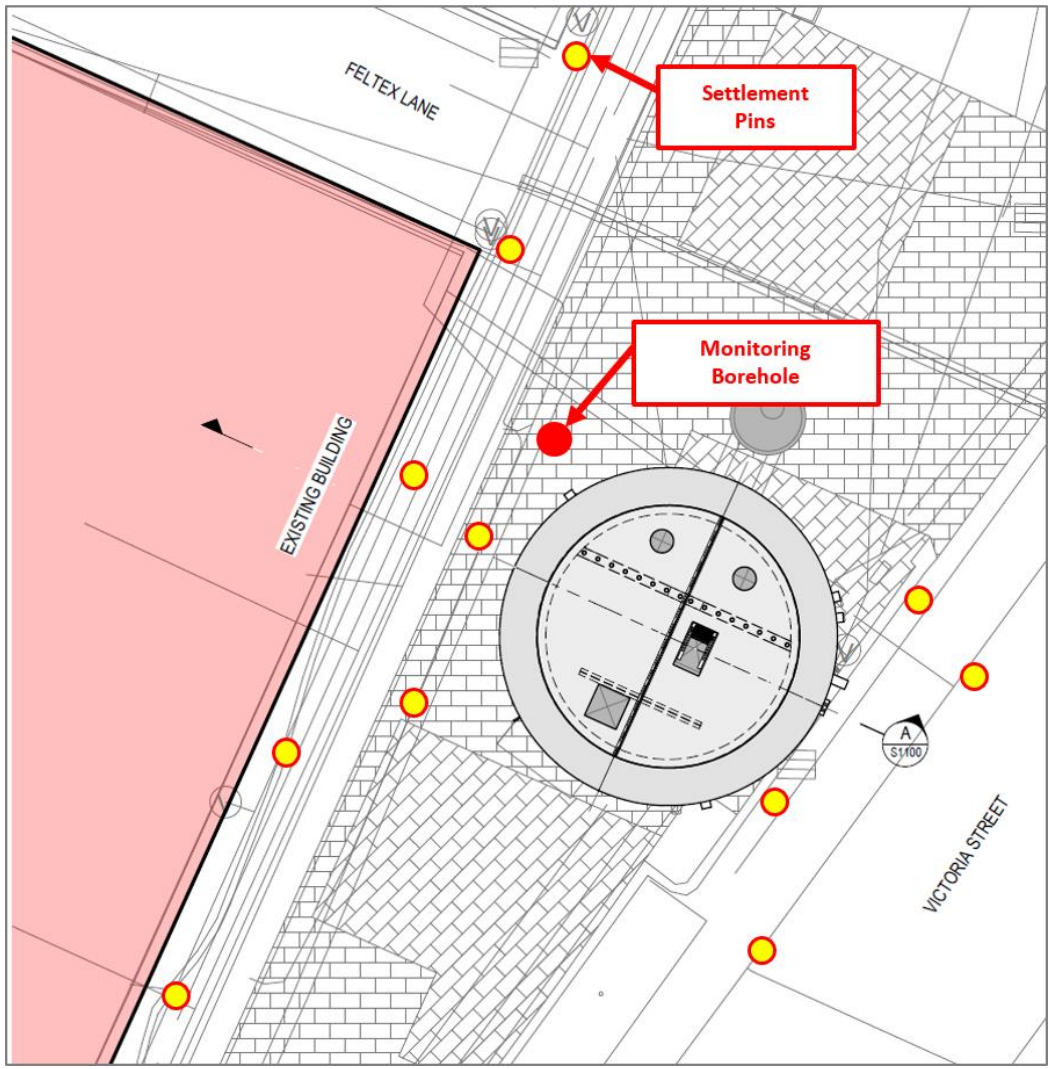
Formation level reached

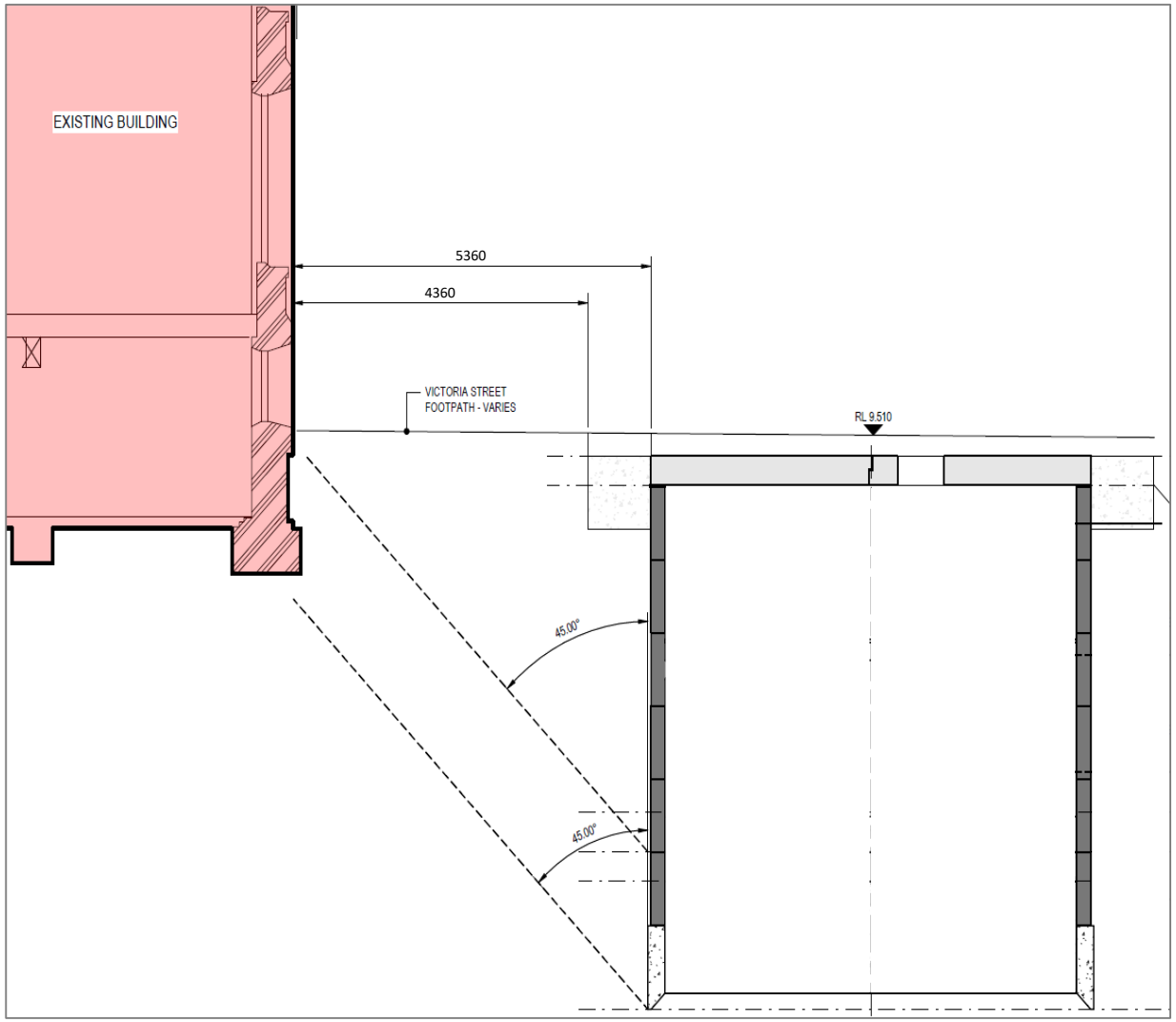
- 7 Rings in 21 days
- 7.8m deep
- 700t soil excavated

Caisson concrete base plug and dewatering

- Managing contaminated groundwater
  - Hydrocarbons > Trade Waste Consent limit
  - No discharge to sewer permitted
  - Mobilised 3 x 40m^3 storage tanks
  - Time to settle before discharge
  - Significant cost implications
- Groundwater drawdown risk to surrounding buildings

Concrete base plug – Groundwater drawdown & risk of settlement in buildings





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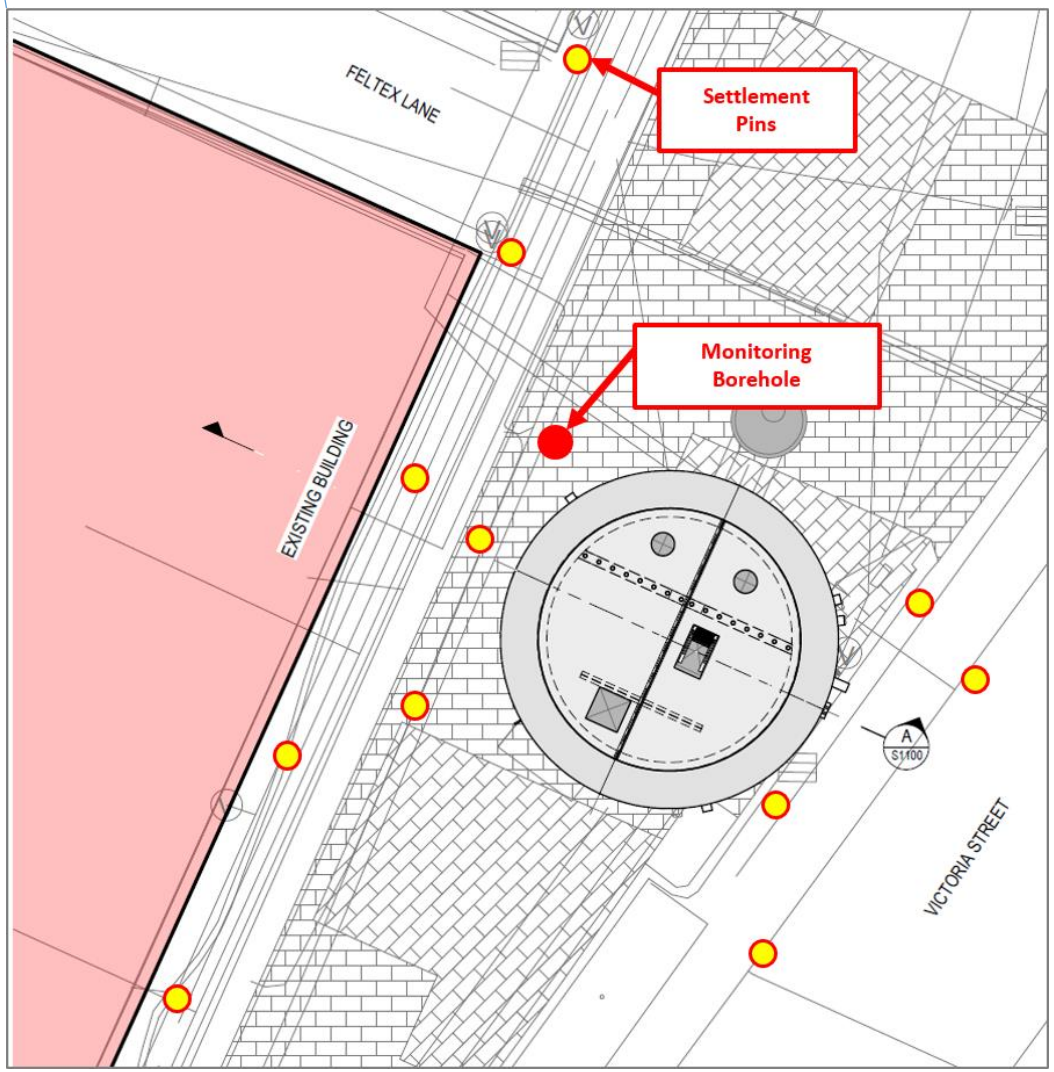
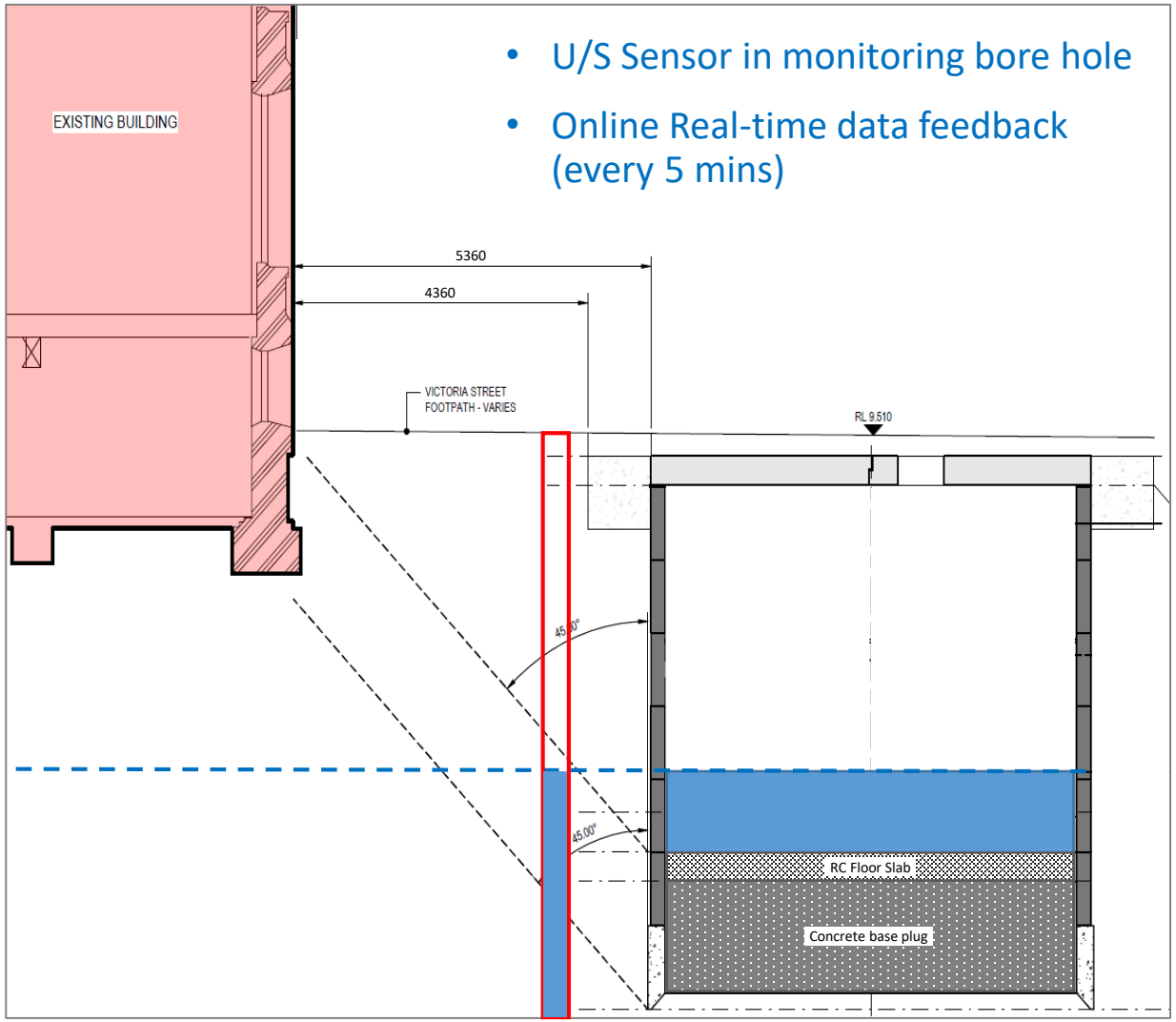


- U/S Sensor in monitoring bore hole
- Online Real-time data feedback (every 5 mins)



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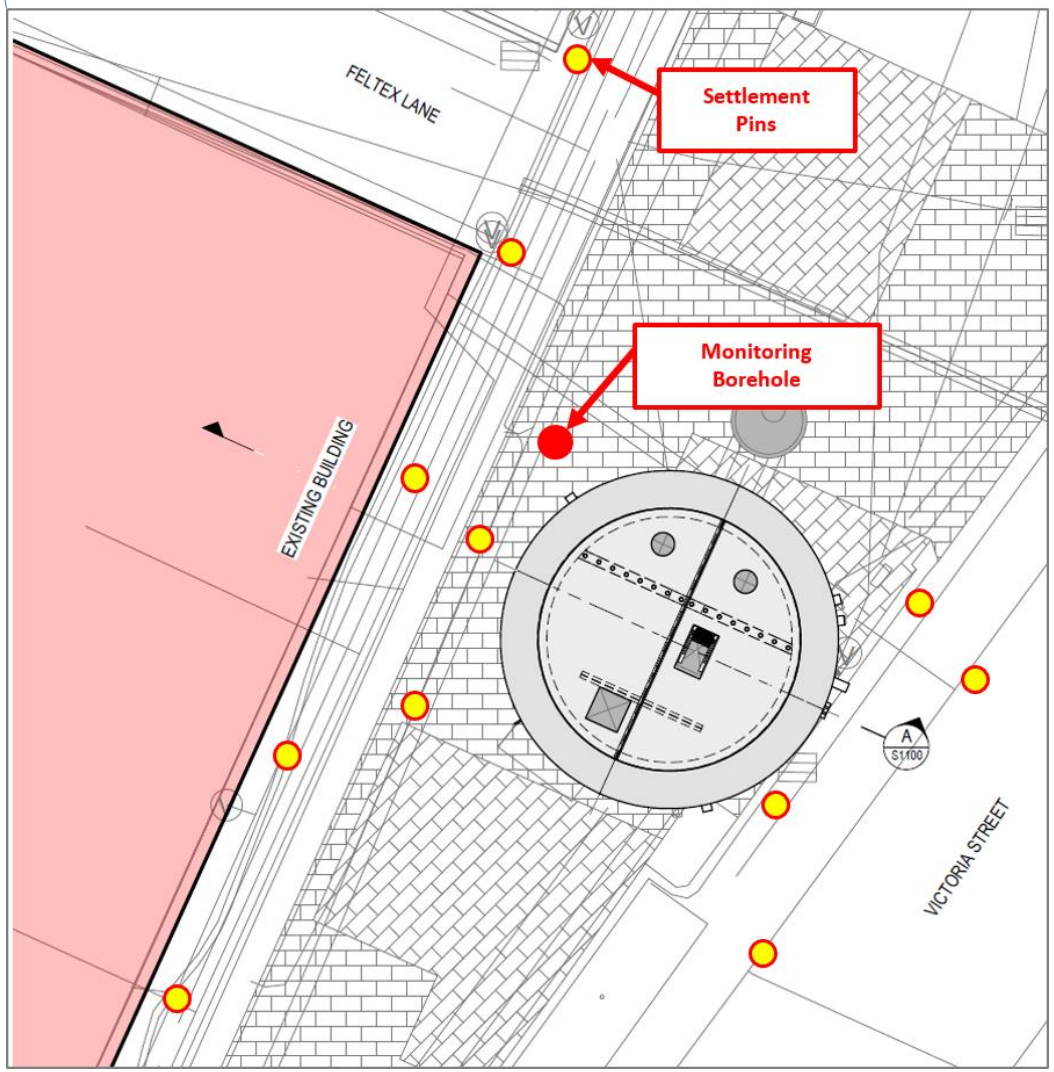
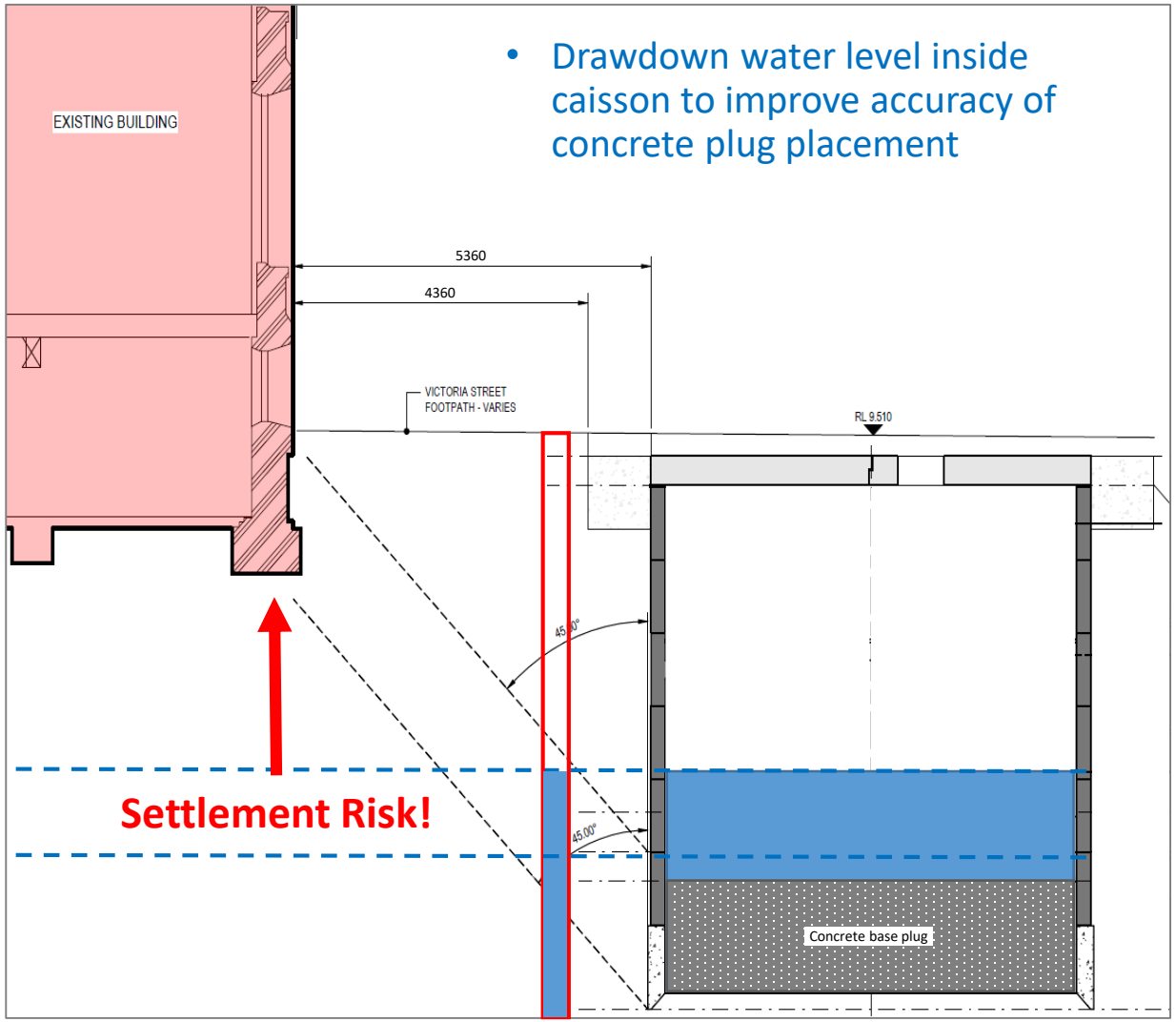
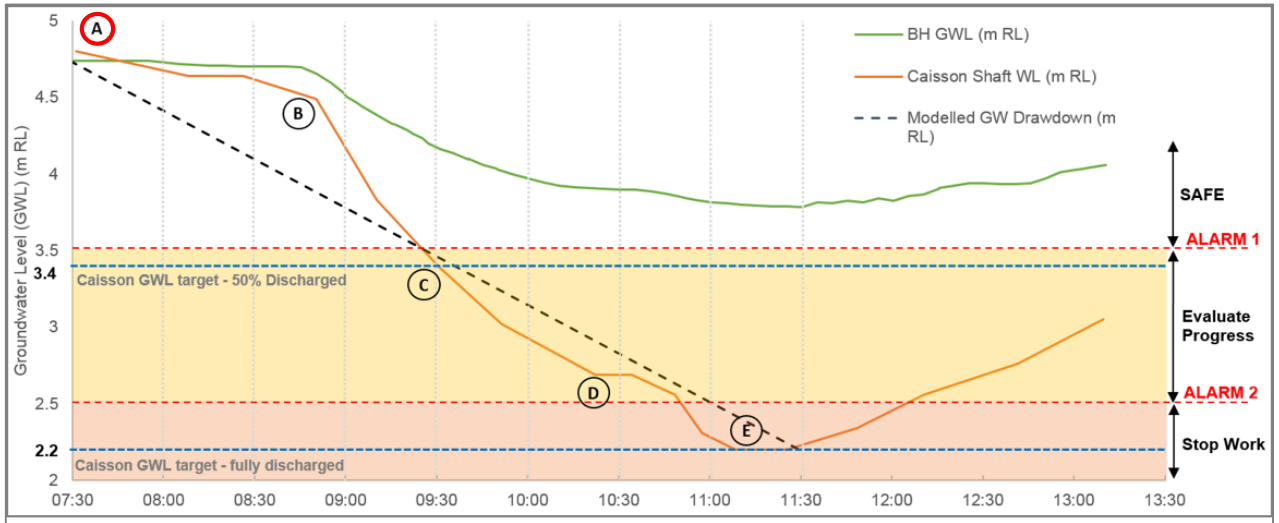


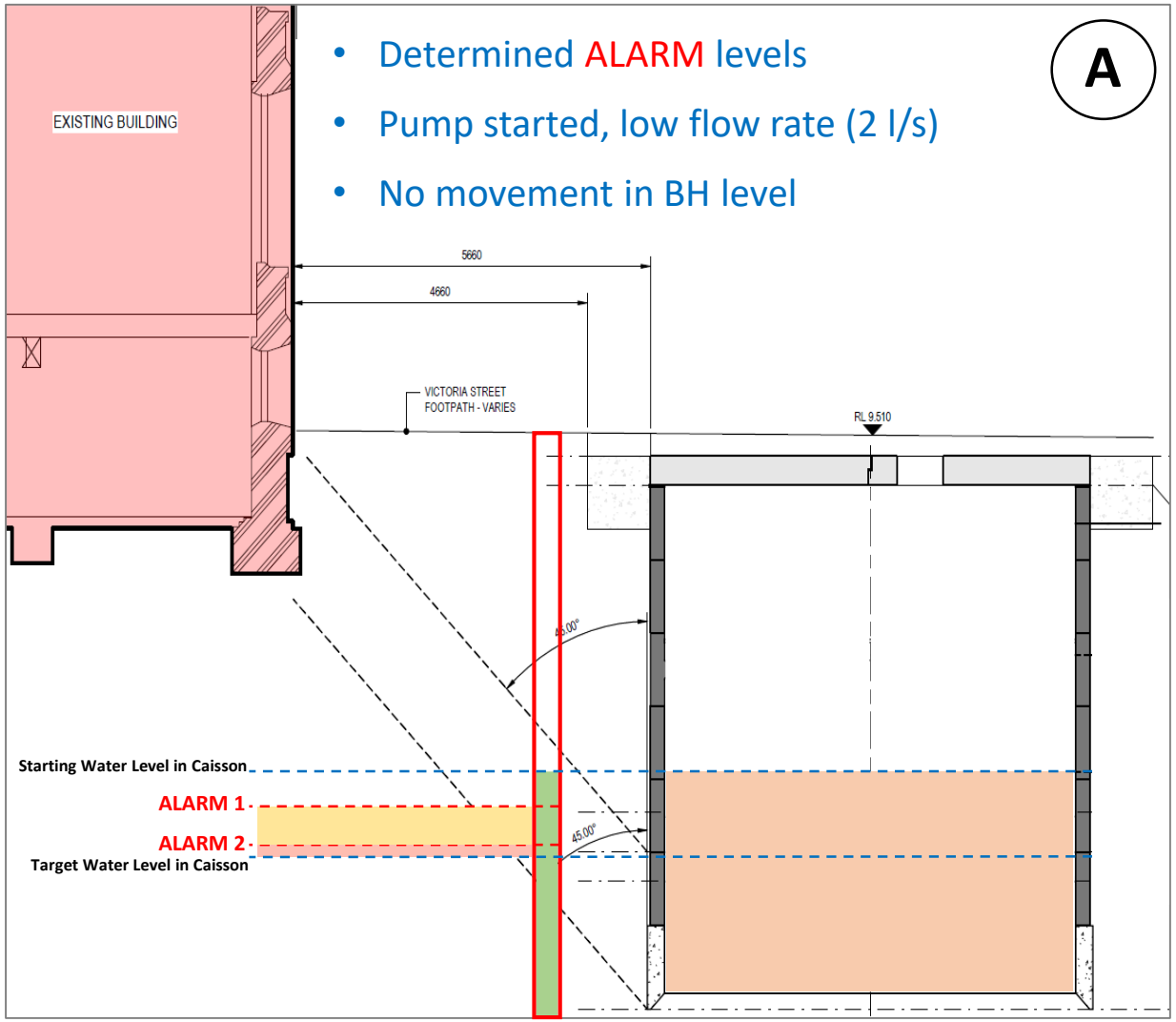


- Drawdown water level inside caisson to improve accuracy of concrete plug placement

Concrete base plug – Groundwater drawdown & risk of settlement in buildings



Stage	Total Time	Comment
A	0 mins	- → Pump started at 2.0 l/s to monitor initial water level changes
A – B	60 mins	- → No significant change, therefore pump increased to max output of 5.7 l/s
B – C	120 mins	- → 50% target water level in caisson - → BH water sensor level tracking above estimated drawdown profile, no risk of settlement - → Tracking line of water levels in BH v's caisson were diverging which increased confidence - → Confirmed safe to proceed with 56m^3 concrete delivery to complete base plug installation
D	160 mins	- → Pump failure, switched over to standby pump
E	220 mins	- → Target water level in caisson reached - → BH water sensor level remained above alarm level 1 confirming no risk of settlement



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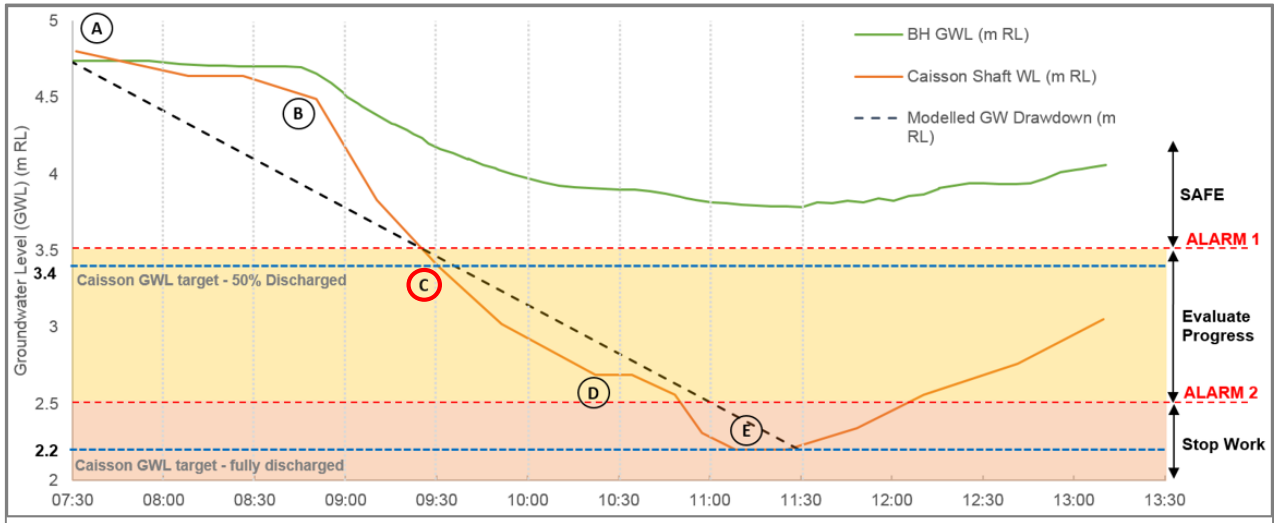

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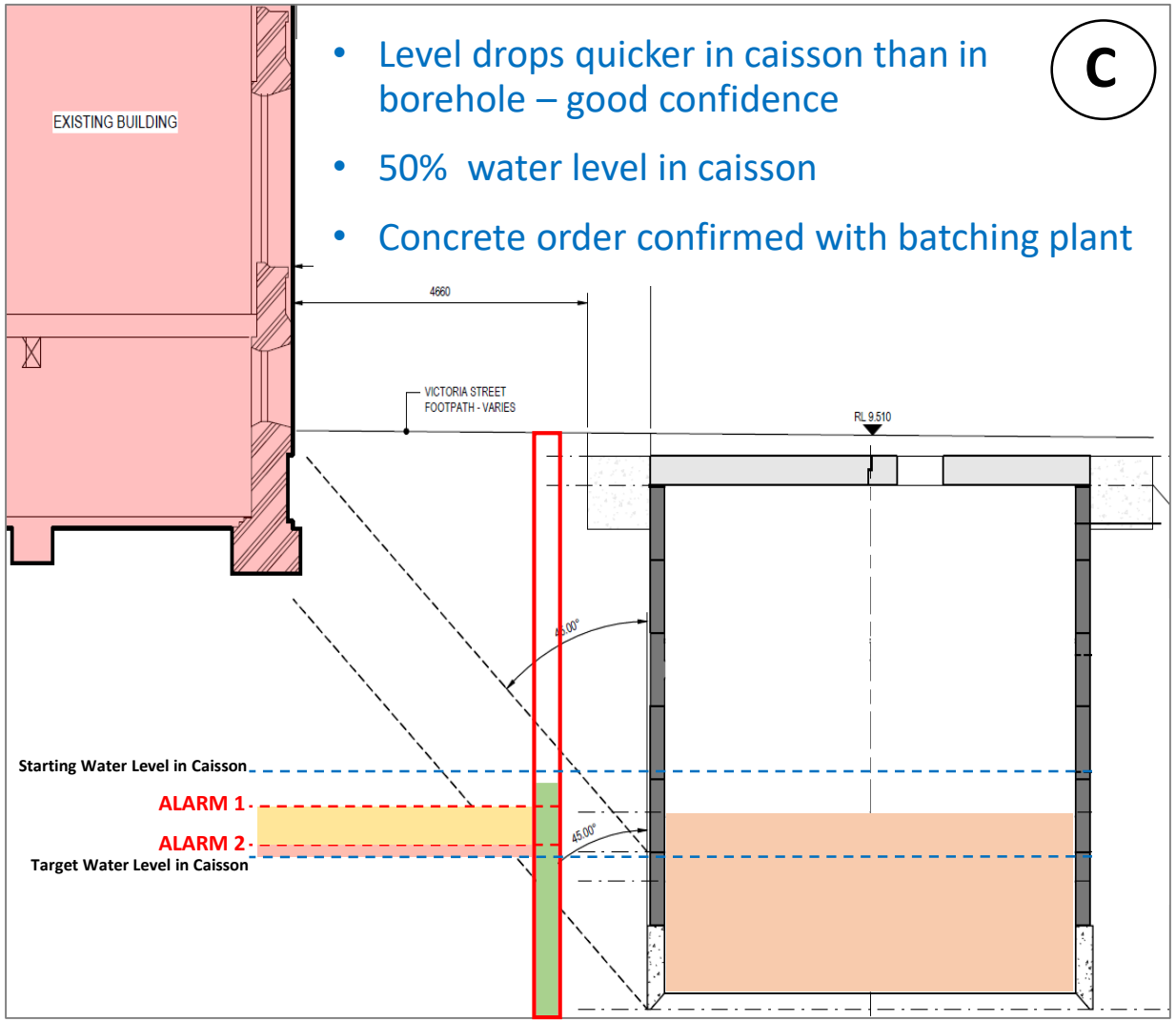
- Level drops quicker in caisson than in borehole – good confidence
- 50% water level in caisson
- Concrete order confirmed with batching plant

C



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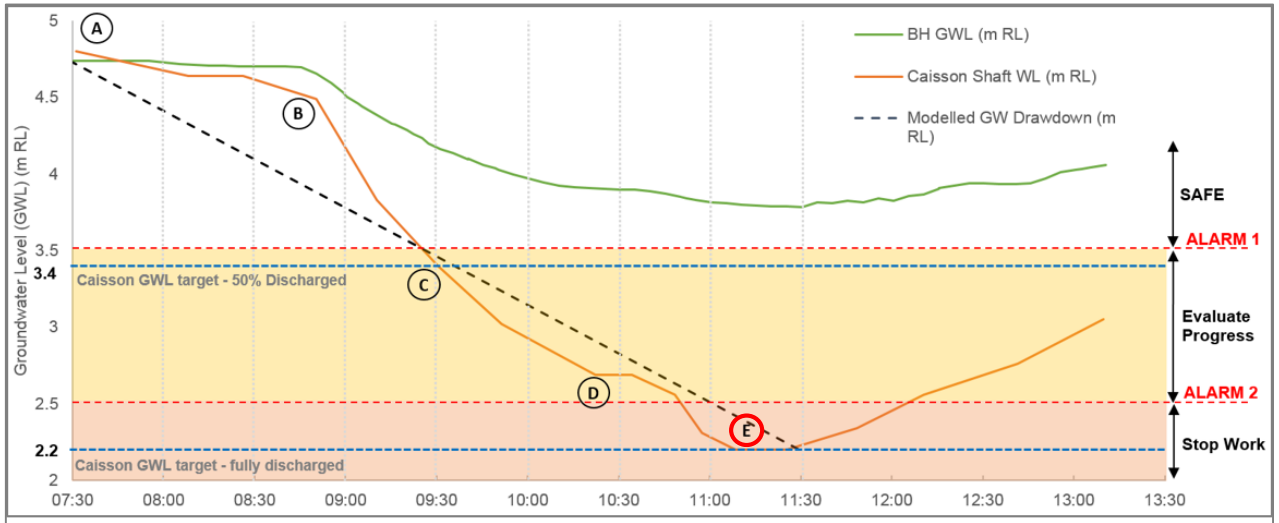

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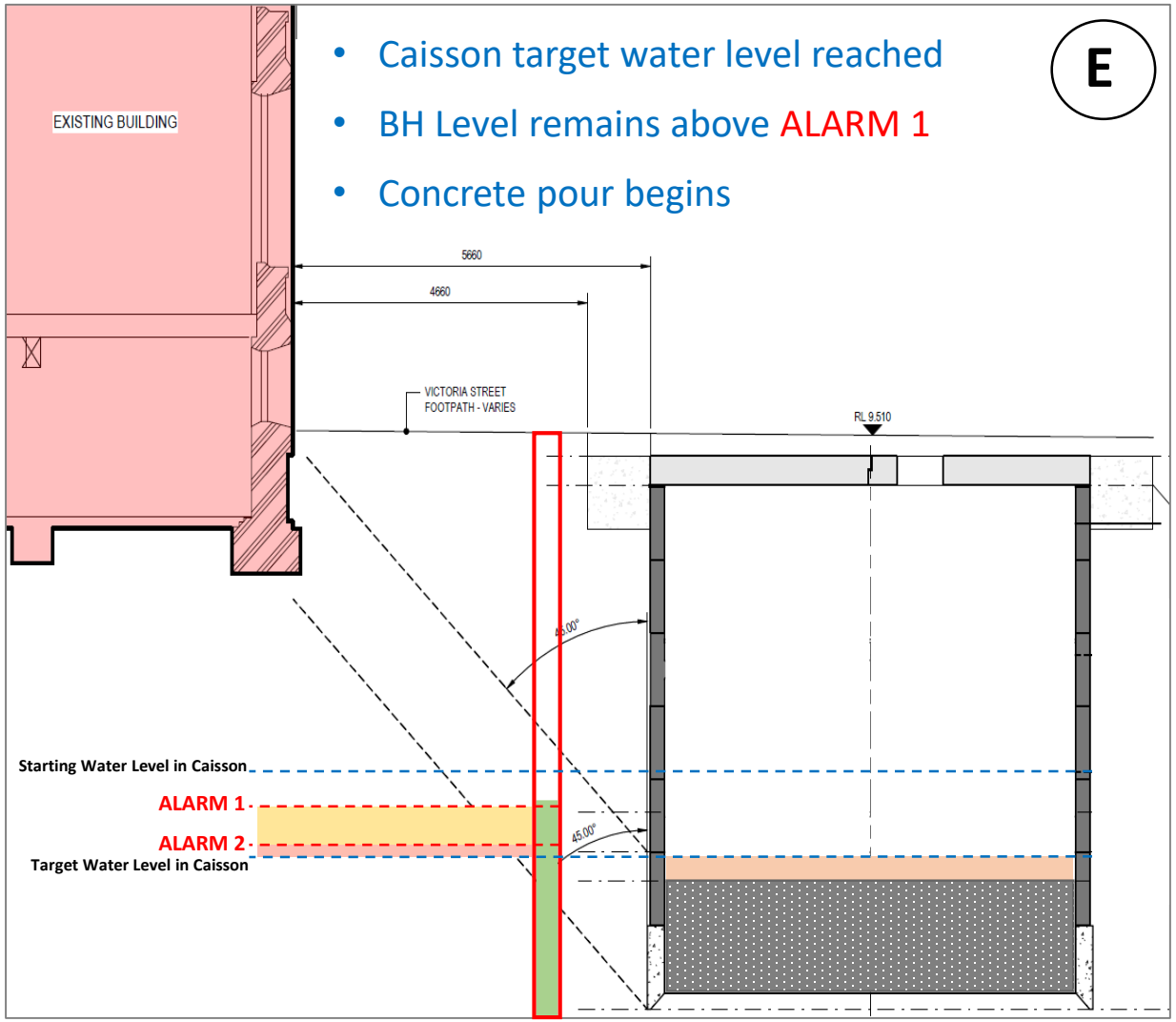

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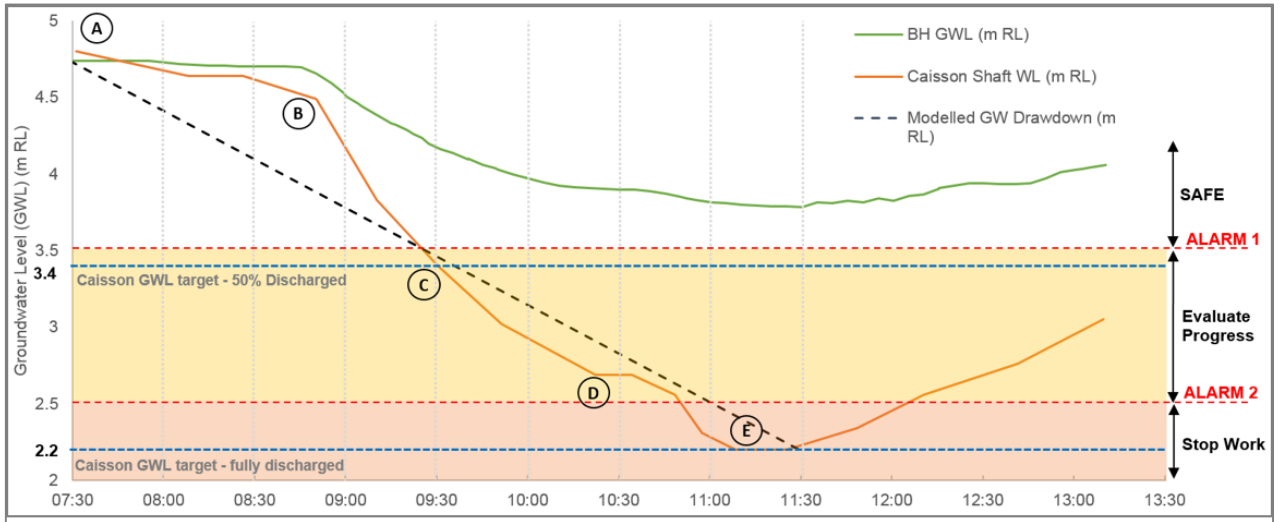

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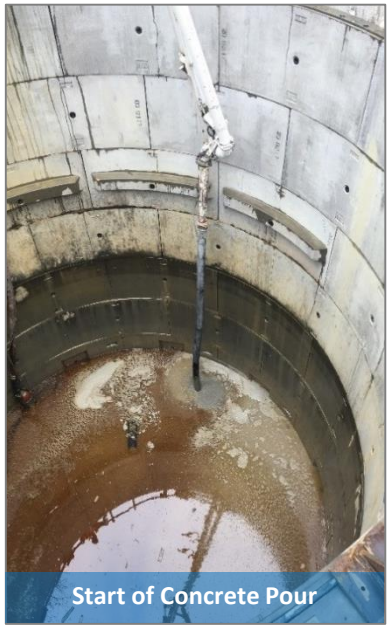
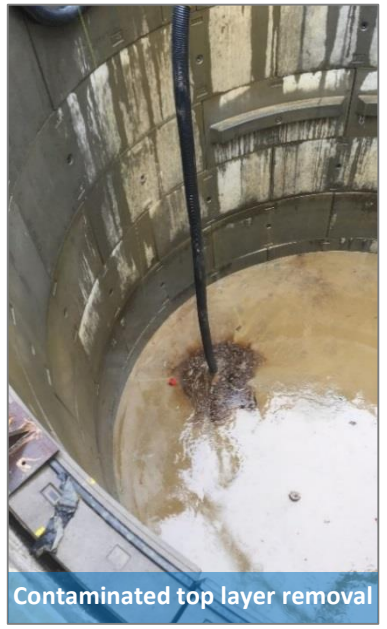
A-E -Groundwater Drawdown


Start of Concrete Pour


Contaminated top layer removal


Concrete base plug completed


Groundwater recharged 24 hours later

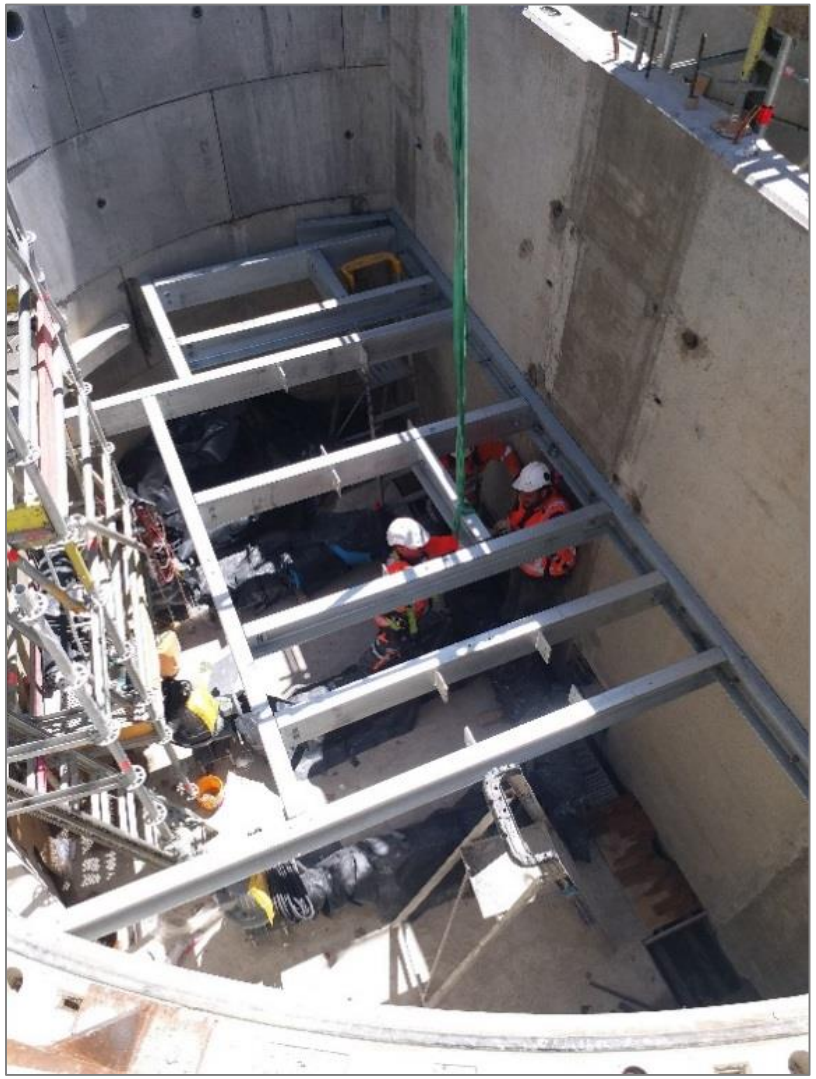
Internal Floor and Walls

- First time workers enter the Caisson
- Wall connections
- Reinforced floor slab

Internal dividing walls

- Separation for wet and dry well
- Pre-cast wall panels
- Connection design for cast in-situ
- 100t mobile crane for lift

Structural Floor and Mechanical fit out



- Mezzanine floor supported off precast corbel
- Pumps and pipework installation
- Electrical control board installation

Precast Concrete Roof Slab Placement

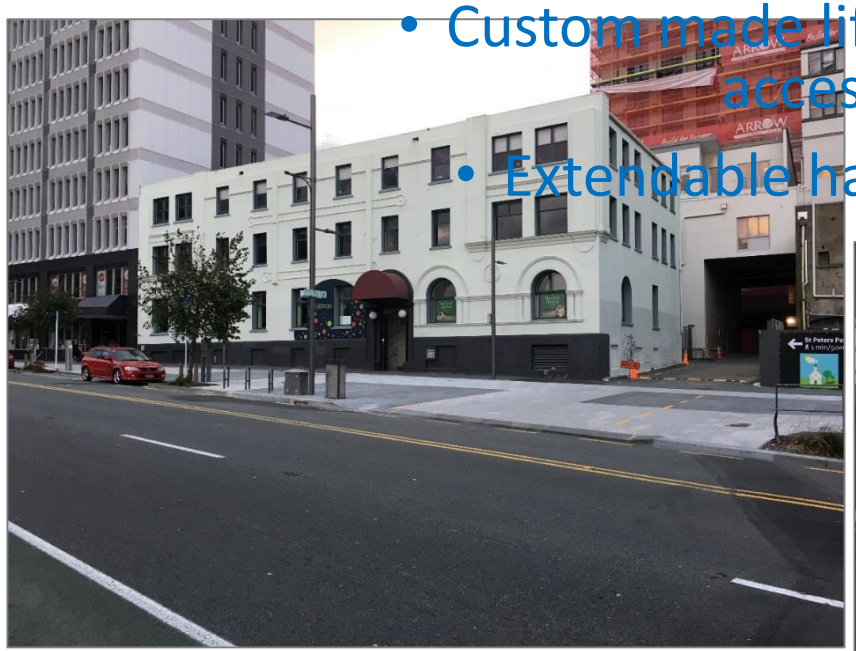
- 400mm thick slab
- 100t mobile crane
- 18.5t load
- 2 week programme saving

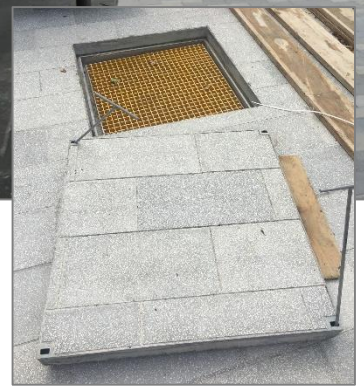
Reinstatement

Completed internal fit out of dry well

Reinstatement – hidden out of sight

- Custom made lift assist access cover
- Extendable handrails





- Paver infill access covers

What did we find

- What we were looking for
  - Quicker construction
  - Safer working environment
  - Reduced noise
  - Smaller footprint
  - Minimised disruption

- Contaminated ground / water biggest challenge
  - Correct methodology
  - Real time data

- Collaboration is key to safe and successful delivery
  - Pre-construction design stage
  - Geo / Str Eng input critical

- Unique in NZ (as far as we know)
  - Innovative integral internal wall design
  - Inside a precast segmental water retaining structure

Thank you – Questions?

GHD

Wellington Water

Absolutely Positively Wellington City Council
Me Heke Ki Pōneke

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water NEW ZEALAND CONFERENCE & EXPO
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INNOVATIVE SEGMENTAL CAISSON **CONSTRUCTION** FOR A NEW **PUMP STATION** IN WELLINGTON'S CBD