BHP

OB32 - Aeration Ponds

Preliminary Design Summary

Document no. Rev A: CI-REP-00010

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Level 17 141 Walker Street
North Sydney NSW 2060
Australia

T: +61 2 8923 6866
Worley Limited
ABN 17 096 090 158

worley.com

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PROJECT 311012-00724 - CI-REP-00010: OB32 - Aeration Ponds - Preliminary Design Summary

Rev	Description	Originator	Reviewer	Worley Approver	Revision Date	Customer Approver	Approval Date
Rev A	Issued for Review	C Thomas	Daniel Wood 09.12.2024 D Wood	C Mercado	08/12/2024	Aaron Chhua	

TBC-TBC

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1. Overview

1.1 Document Objective

The objective of this report is to document the work to date on the OB32 Aeration ponds including outlining the various concepts and their Pros and Cons.

1.2 Background

As part of ongoing developments related to the Orebody 32 mine (OB32) Worley designed a pipeline to deliver the output from dewatering the mine to Ophthalmia Dam. This pipeline also has an option for discharging directly to Homestead Creek should certain conditions at the dam require it.

As part of this alternative discharge point, BHP are considering the need for the dewatering water to be degassed before discharge into Homestead Creek to reduce the risk of calcification of the creek bed. This report summarizes the work to date and the outline parameters used in the preliminary design of the ponds.

2. Process Design Basis

2.1 Water Chemistry

The OB32 dewatering water has high calcium carbonate alkalinity that is maintained in solution by high concentrations of dissolved carbon dioxide which in turn is a result of the high pressure (depth) of the natural groundwater. When the groundwater is brought to the surface and is exposed to atmospheric pressure, the carbon dioxide comes out of solution and some calcium carbonate forms a precipitate / scale. The initial carbon dioxide degassing is quite rapid, and this can be seen in water samples taken at the bore headworks where the water will be cloudy from all the fine carbon dioxide bubbles. This is also evident in a rapid increase in pH of the water sample for the first few minutes after the sample has been taken.

Once the initial rapid degassing has occurred, the remaining degassing required to drive a static volume of water to a point of equilibrium where no more calcium carbonate will come out of solution, is relatively slow. There are three critical factors that influence the last stage of degassing:

- Carbon dioxide solubility is proportional to water pressure as can be seen in Figure 2-1. As an example, along a line of constant 30°C water temperature, a difference in water depth from 2 m (0.02 MPa) to 4 m (0.04 MPa) more than doubles carbon dioxide solubility (0.009 mol% to 0.02 mol%);
- As water temperature decreases, carbon dioxide solubility increases as can also be seen in Figure 2-1 with the various temperature curves; and
- Water turbulence promotes degassing as it locally reduces water pressure and exposes a greater water surface to atmospheric conditions.

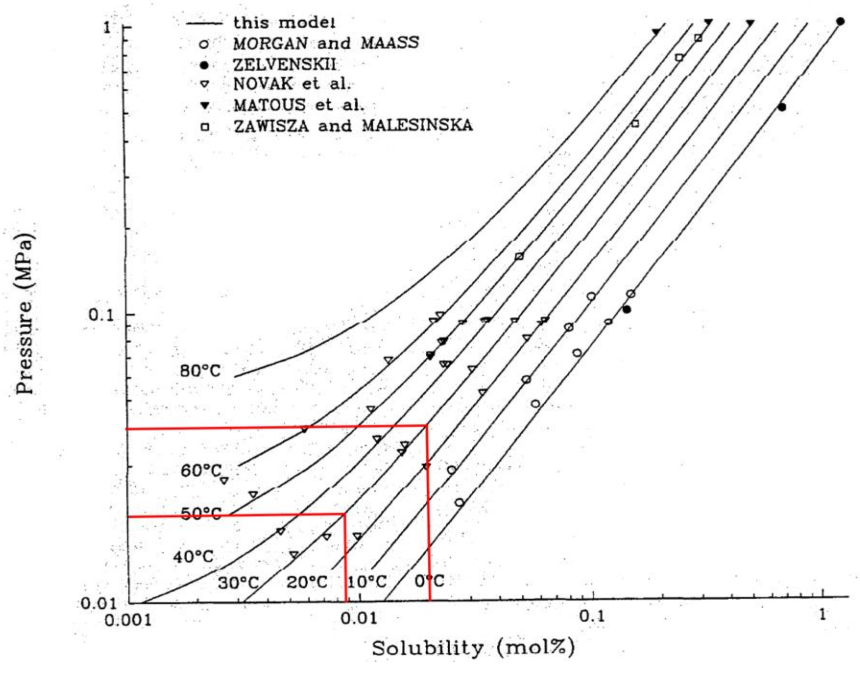


Figure 2-1 - Solubility of carbon dioxide in water [ref: J. Phys. Chem, Vol 20, 1991]

2.2 Hydraulic Design

It should be noted that the points referenced above are based on laboratory scale tests using low salinity drinking quality water. The chemistry of the OB32 surplus water is considerably more complex than drinking quality water and there will be other aspects of this water that will influence carbon dioxide degassing and the subsequent calcium carbonate precipitation. Field work is currently underway at Central Pilbara Hub (CPH) assessing degassing methodologies for South Flank surplus water so that it can be discharged to Marillana Creek. The initial results of this work which is being undertaken by the BHP Team and a specialist geochemist consultant Earth Systems can be reviewed in the Earth Systems Report 'MAC and South Flank Carbonate Precipitation from Groundwater – Source, Control and Management', Sep 2022.

To determine the relevance of the CPH field work to the OB32 aeration pond project, the chemistry of the South Flank water and OB32 water was compared. A summary of the findings is included in Appendix C. Generally, the water chemistries are similar with OB32 water having a higher alkalinity which in turn would indicate a greater propensity for precipitation and scaling. At this stage, the CPH field work is considered suitable to guiding the OB32SW aeration pond design.

The purpose of the aeration ponds is to provide the optimum conditions to remove enough carbon dioxide so as the water entering Homestead Creek is in equilibrium. Based on the water chemistry, the aeration ponds should:

- Be as shallow as possible to minimise water pressure and limit the potential for water cooling and stratification at depth;
- Generate some water turbulence within the pond system to provide some active degassing; and
- Provide adequate residence time to allow passive degassing from the water surface.

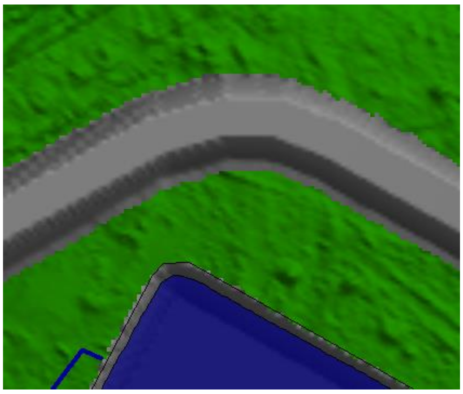
These requirements lead to the following preliminary design basis:

- An average pond water depth of 2 m on the basis of the CPH investigation showing that the 1 m deep RAV infiltration ponds run to equilibrium through passive degassing while the 3 m deep turkeys nests are starting to stratify. The 2 m depth is a reasonable balance between the known performance at CPH and minimising the footprint of the OB32 aeration ponds;
- Divide the ponds into multiple cells with turbulent generating structures connecting each; and
- Provide a residence time at 60 ML/d of at least four days. This is a conservative basis for this stage of the project compared to the findings at CPH where a residence time of two to three days was found to be adequate. This is a value that can be refined through further design stages.

3. Prelim Design Parameters

The following are the key design parameters agreed with BHP to base the pond concepts and designs on subject to formal engineering.

1. Number of Ponds
   a. Two parallel pond systems each rated at 30 ML/d for 4 days. This allows one set of ponds to be taken offline for cleaning / maintenance while still providing 50% system capacity.
   b. Nominally two rows of six individual ponds (total 12 ponds).
2. Pond parameters
   a. Pond base dimensions 200 m x 50 m.
   b. Pond depth 2 m (base of pond to water level). The pond volume results in a four day retention time.
   c. Batter angles for the sides of the ponds 1:2.5.
   d. Freeboard 500 mm.
3. Spillway
   a. Inter pond spillway gradient 1:10 on the downstream side of the spillway.
   b. Spillway width 2 m.
   c. Crest water depth approx. 200 mm.
   d. Spillway needs to be stone pitched or similar to prevent erosion and also create flow turbulence to promote aeration.
4. Outfall
   a. Width 5 m.
   b. Depth 0.5 m.
   c. Constant gradient from outfall point to creek.
   d. Stone pitching to be placed in outfall to increase aeration and slow velocity.
5. Bund
   a. Height 3 m above existing ground to direct floodwater from Homestead Creek away from the ponds.
   b. Crest width 10 m wide.
   c. Batter 1:2.
6. Min Dimensions to key infrastructure
   a. Min distance 45 m from the toe of the railway embankment to the top of the pond batter.
   b. 20 m spacing between pond rowa to allow for maintenance.
   c. 35 m between ponds and bund for the majority of the pond length to allow maintenance
      i. Min distance 20m if needed as is the case in the North Corner



7. Fencing is to be considered, due to the location of the ponds to the town of Newman (3 – 4km) and potential for cattle to access the site. It is also approximately 1km from the nearest public road.
    a. A fence to keep people out around valves and pipework.
    b. Stock fence around ponds

4. Concepts

There were 3 areas considered for the pond concepts related to this project:

- Northern Location
- Middle location
- Southern Location

4.1 Middle Location

4.1.1 Middle Initial Plan

The middle location was the initial location suggested for the ponds as it was adjacent to the pipeline and initially seemed to be an appropriate location and was a good point for discharging into Homestead Creek (Figure 4-1).

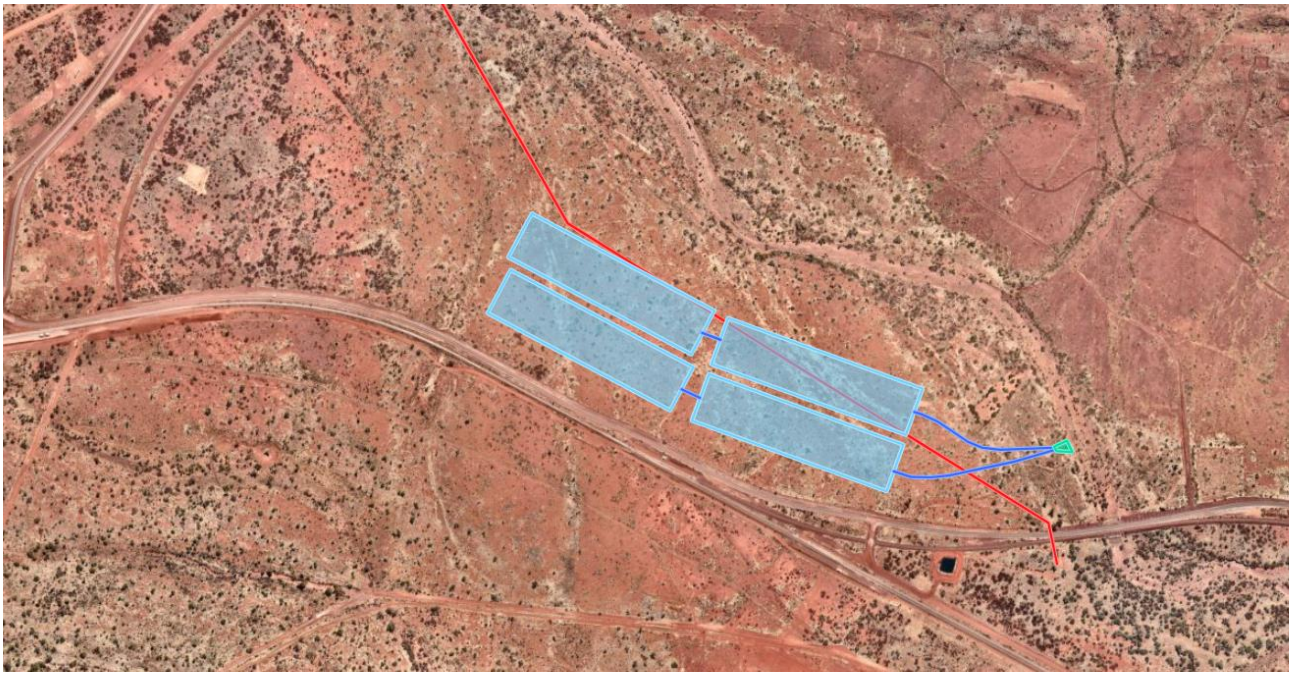


Figure 4-1 -Initial Location

This option required the site laid section of the pipeline to be adjusted to avoid the ponds.

However, at the kickoff meeting it was noted that there was a fiber optic cable also in this area.

4.1.2 Middle Adjusted Plan

With the knowledge of the fiber optic cable, the initial concept was adjusted to be off to the side of the existing pipeline and moved north to avoid the fiber optic cable with the ponds also stretched to keep as much of the pond within the boundary as possible (Figure 4-2).

Figure 4-2 – Revised Initial Location.

4.1.3 Middle Option Discounted

Site was then put into Global Mapper to allow a better assessment of the topography and undertake some preliminary 3D modelling. This work highlighted a couple of gullies that existed that would need to be filled in to allow the construction of the ponds. However as there would potentially be areas that could potentially fail later with all the water from the ponds flowing directly at the rail line, it was decided that these areas should be avoided. This decision led to the consideration of other areas for development.

Refer to Figure 4-3

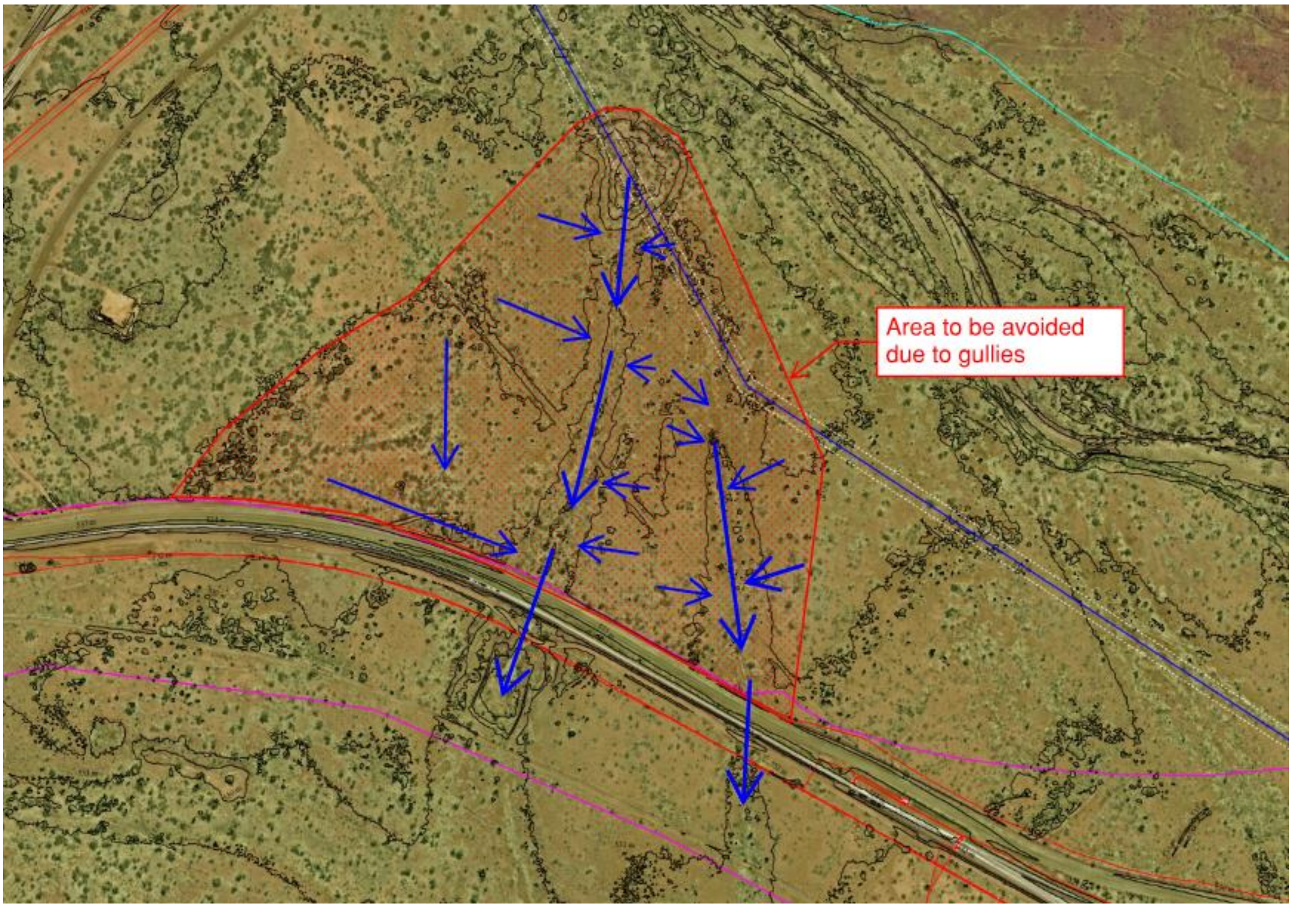


Figure 4-3 - Gully Area

4.2 Northern option

With the understanding of the impact of the gully system on the area, we were left with a northern area to consider for development but with the acceptance that it would need a consenting update to increase the development footprint.

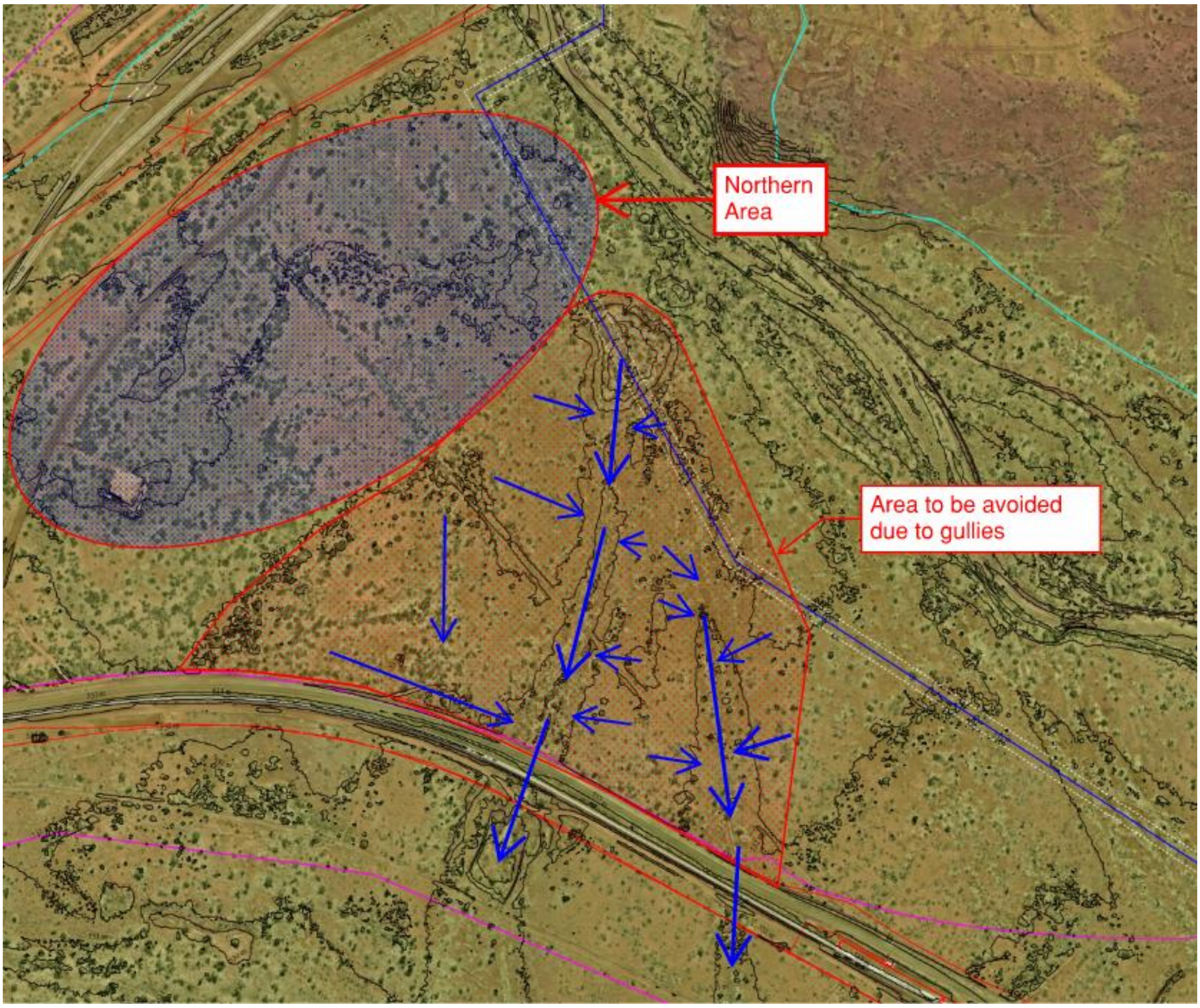


Figure 4-4 – Northern Area

This area was considered given the relatively flat topography but with the acknowledgement that a cascading pond system as the preferred method was unlikely to be achievable and that forced aeration would potentially be required.

The Concept for the northern area went though a couple of minor iterations with the preferred layout being as shown in Figure 4-5

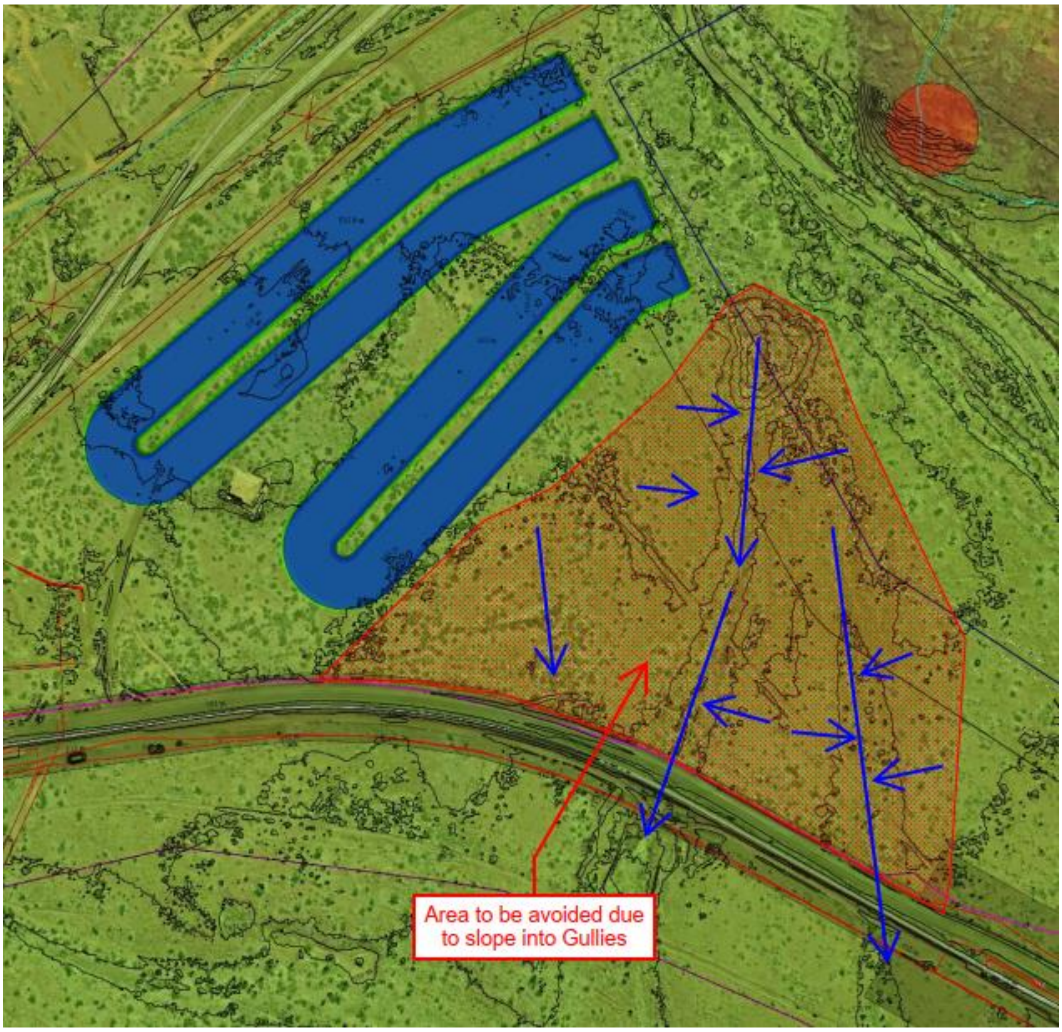


Figure 4-5 - Northern Option

As a potential mitigation for the forced aeration, it was agreed that initially bunds would be installed at agreed spacings to cause mixing of the water with a 50mm difference in elevation between the two sides of the bunds to encourage water to flow (refer to Figure 4-6). It was agreed that once the ponds were installed should additional aeration be required then mechanical aeration could be installed.

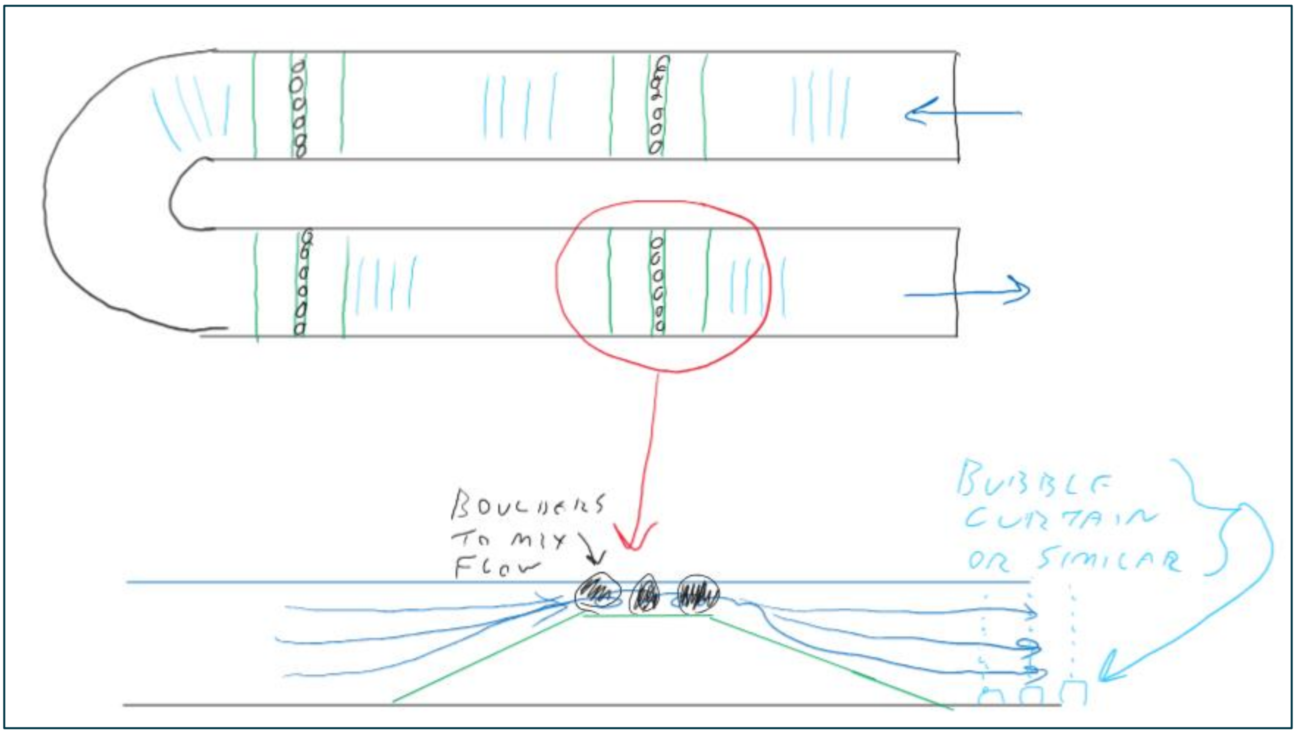


Figure 4-6 - Mixing Bunds

This option was shared with BHP and agreed that it was a workable solution if not ideal due to the need to mechanical aeration and the outlet crossing the pipeline which would lead to additional engineering (Figure 4-7).

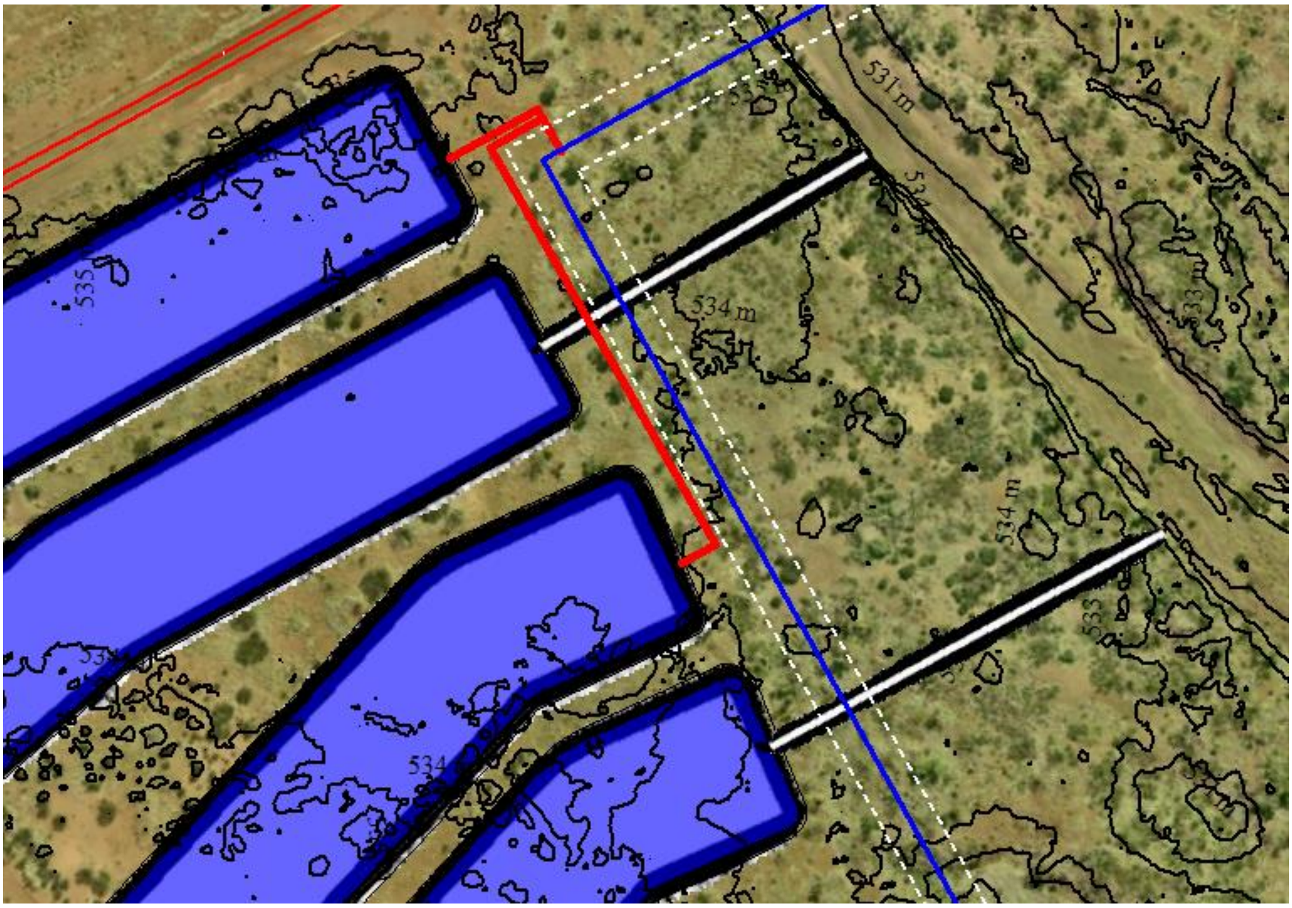


Figure 4-7 - Northern Inlet (red) and outlet (white)

4.3 Southern option

While undertaking the work related to the initial and Norther locations it was noted in global mapper hat there was an area to the south of the Homestead Creek discharge that fitted the parameters initially envisaged in the project (Figure 4-8) with the added advantages of:

- The area was downstream of the rail crossing
- In the event of the ponds overflowing water would not flow in the direction of the rail line
- The offtake for the new ponds would be just upstream of the pipeline discharge point and therefore could be isolated from the pipeline for installation of the Tie-in. (Figure 4-9)
- There is a current area of concern related to overland flow where the topography directs flow to run along the side of the rail line (Figure 4-10). However, the new design will direct the majority of this flow + any overflow of the ponds way form the rail line as it will intersect the outlet channel before reaching the rail line.

The main disadvantages of this area were:

- The consent boundary would need to be expanded.
- The area would be more prone to flooding as it was closer to the creek. However, it was out of the 1:10 year flood event. (Figure 4-11)
- The wetted area assessment would need to be expanded as the discharge point would be about 2.5km downstream of the initially planned discharge.
- There was an existing Process water line crossing the site that would need to be relocated as part of the construction works (Figure 4-12).

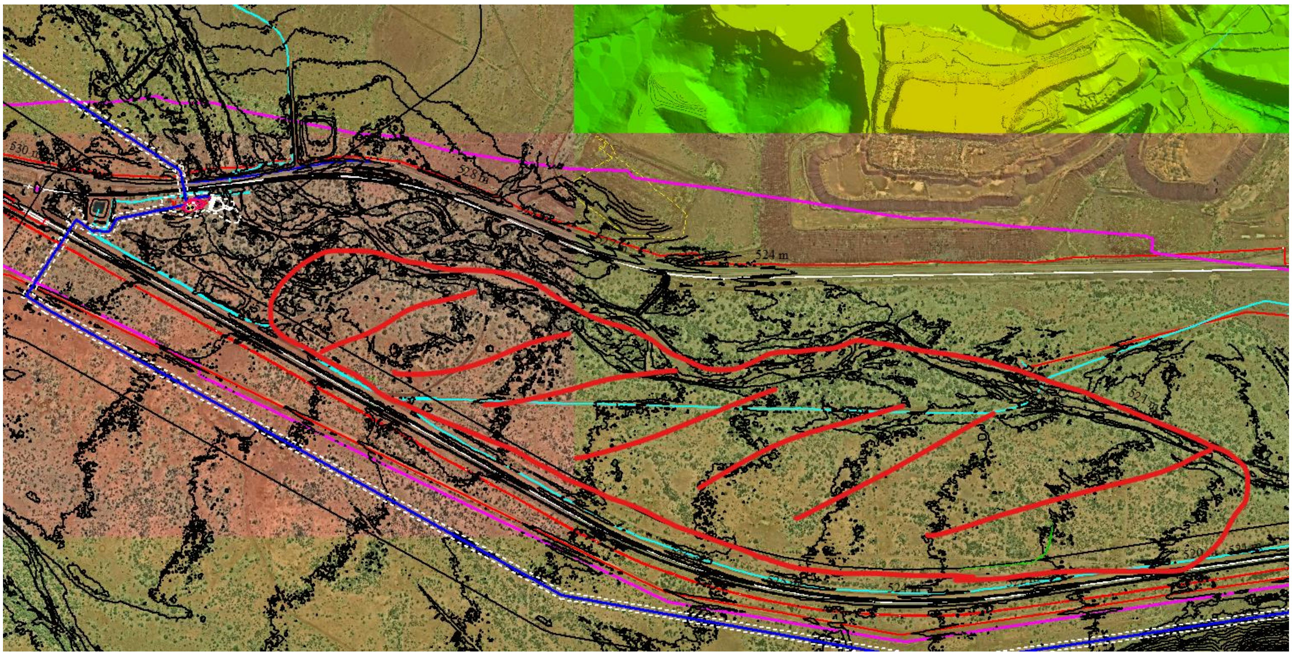


Figure 4-8 - Southern Area

Figure 4-9 - Southern Option - Offtake Location

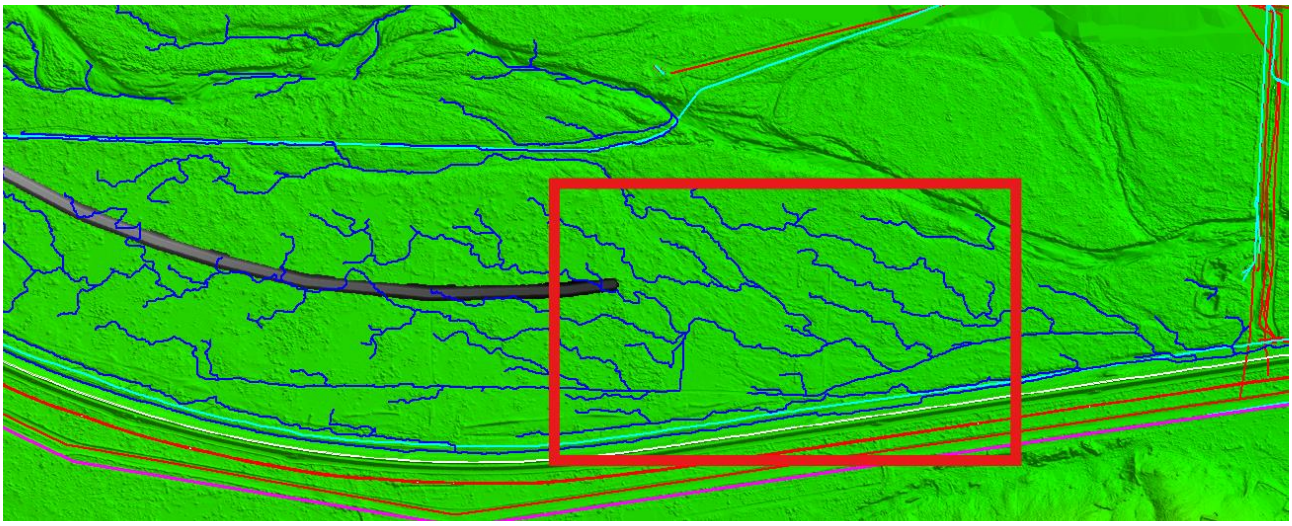


Figure 4-10 - Overland flow - Area of concern existing flow

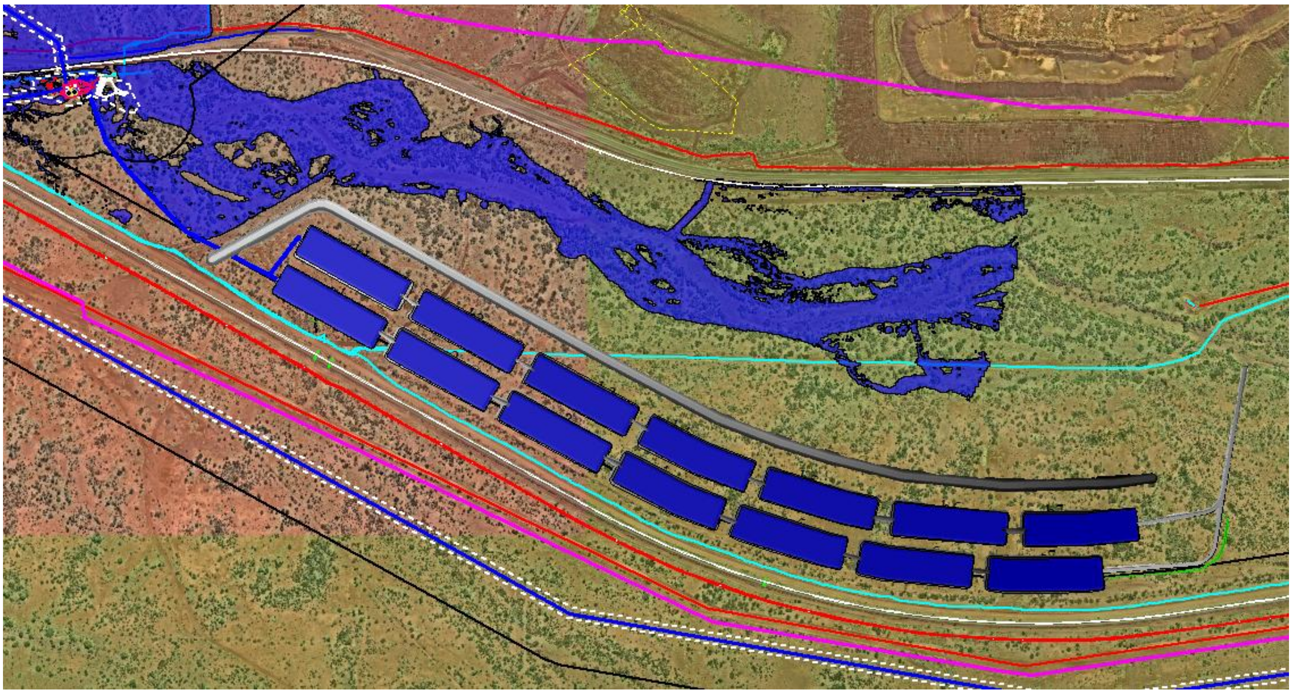


Figure 4-11 - Southern option relative to 1:10 year flood.

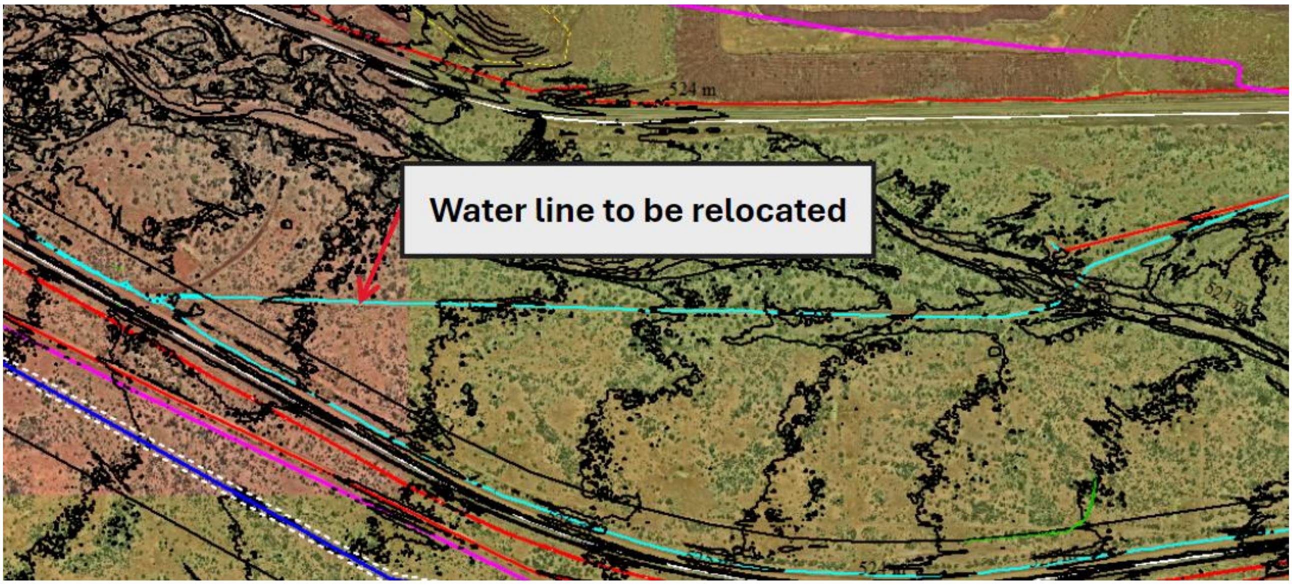


Figure 4-12 - Process water line to be relocated.

5. Selected Concept

BHP took the above information and along with some additional clarifications discussed into discussions with stakeholders to confirm that would be the preferred option. The outcome of these discussions was that the southern option although not ideal addressed the majority of the concerns and provided the most "Fit for Purpose" solution to the situation.

As a result, it has been agreed that the southern option (Figure 5-1) should be progressed to approximately a 60 – 80% (preliminary design) form a civil.

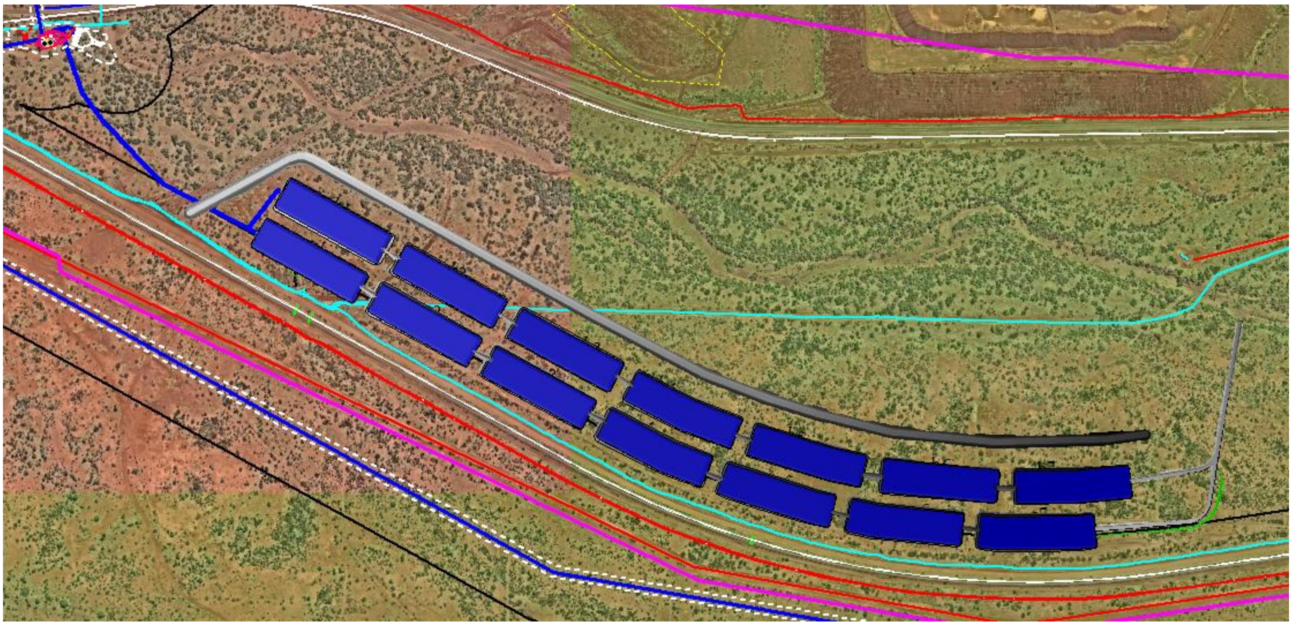


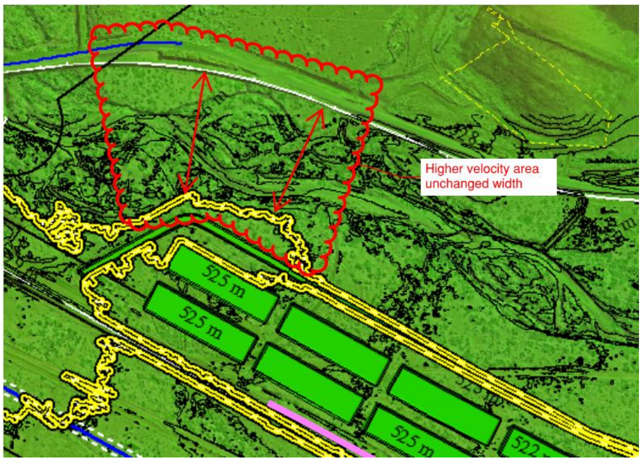
Figure 5-1 - Southern Option – Concept

This agreement means that the design to progress will generate the following leveraging work from other scopes which will need further design should this concept be progressed too Detailed design.

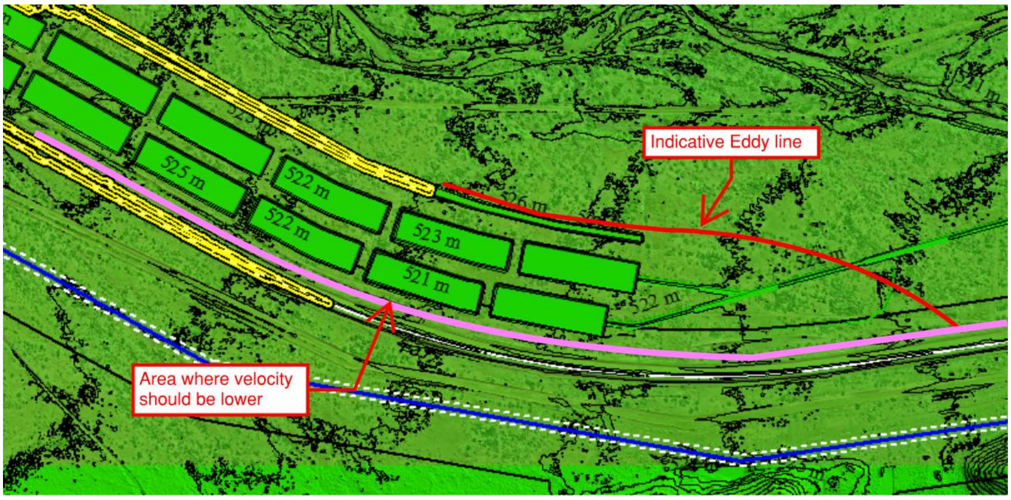
<u>Impact on rail</u>

There was a concern that the selected option may constrain the water flow as it takes up quite a lot of the potential flood plain. However, this is not anticipated to be the case as

- The northern rail line the area where the velocities are higher, in the choke point, the creek width is limited by the natural topography. It should also be noted that the base of the rail embankment in this area is lower then the natural topography in the other side of the creek in this area.



- The southern rail line is afforded more protection as the bund will generate a natural eddy which will provide lower velocity flows as illustrated below.



It should be noted that these initial judgement-based assessments of the impact on the rail lines will be verified in a later stage with modelling should this work be progressed further.

6. Phase Outputs

The key deliverables for the phase were agreed as:

- 2 – 3 Cad generated Design Sketches (DSK) for documentation of the concept
  - Plan
  - Elevation
  - Typical details (based on designs in other projects)
- Summary report (this report) of the work to date
- Quantities
  - Excavated material
  - Water Storage capacities per pond
- Preliminary piping concept for connection into the system just prior to the homestead creek outfall.

6.1 CAD Generated Sketches

Appendix A of this report con contains full sized (A3) copies of the Sketches generated as part of this phase of the project.

- DSK-001_Plan
  - Overall plan
  - Key area plans
  - Longitudinal section through 1 set of ponds
- DSK-002_Sections & Details
  - Typical Section for inlet
  - Typical Sections for spillway
  - Typical section Outlet
  - Typical Cross section across width of the development
- DSK-003_Cut & Fill Map

Appendix B contains renders from the model to allow visualisation of the concept (10 images)

6.2 Quantities

Based on the Model the current anticipated storage capacity for the pond system is

Table 1 – Water Storage volumes

POND I.D	Pond Base	Water RL	Water Volume
A1	524.0	526.0	23,170
A2	523.0	525.0	22,880
A3	522.2	524.2	22,890
A4	521.5	523.5	23,020
A5	520.7	522.7	23,190
A6	520.1	522.1	22,975
B1	523.7	525.7	23,170
B2	523.4	525.4	22,640
B3	522.4	524.4	22,685
B4	521.6	523.6	22,775
B5	520.8	522.8	22,915
B6	520.2	522.2	22,550
Total			274,860

Based on the Modeling the anticipated volume of excavated material is shown in the table below with "–" denoting Cut quantities.

Table 2 – Cut and fill volumes

POND I.D	EXTG RL (LOW POINT)	POND BASE RL	Cut – Fill (Cut = -)
A1	526.5	524.0	-39,545
A2	525.5	523.0	-39,405
A3	524.7	522.2	-37,560
A4	524.0	521.5	-36,180
A5	523.2	520.7	-37,350
A6	522.6	520.1	-35,970
B1	526.2	523.7	-37,580
B2	525.9	523.4	-35,175
B3	524.9	522.4	-36,560
B4	524.1	521.6	-36,375
B5	523.3	520.8	-38,355
B6	522.7	520.2	-34,825
Spillway A1 - A2			-325
Spillway A2 - A3			-270
Spillway A3 - A4			-225
Spillway A4 - A5			-240
Spillway A5 - A6			-215
Spillway B1 - B2			-265
Spillway B2 - B3			-275
Spillway B3 - B4			-250
Spillway B4 - B5			-245
Spillway B5 - B6			-250
Outlet Drain			-7,755
Bund			76,745
Total			-378,450

Due to the large amount of cut in excess of fill, work will need to be undertaken to minimise the amount of material taken off site.

6.3 Preliminary Piping Concept

Based on the work to date on the pipeline and layouts and drawings from the pipeline project, a preliminary piping concept has been created which is shown in the images below.

New piping is modelled in Green with the valves modelled in Red.

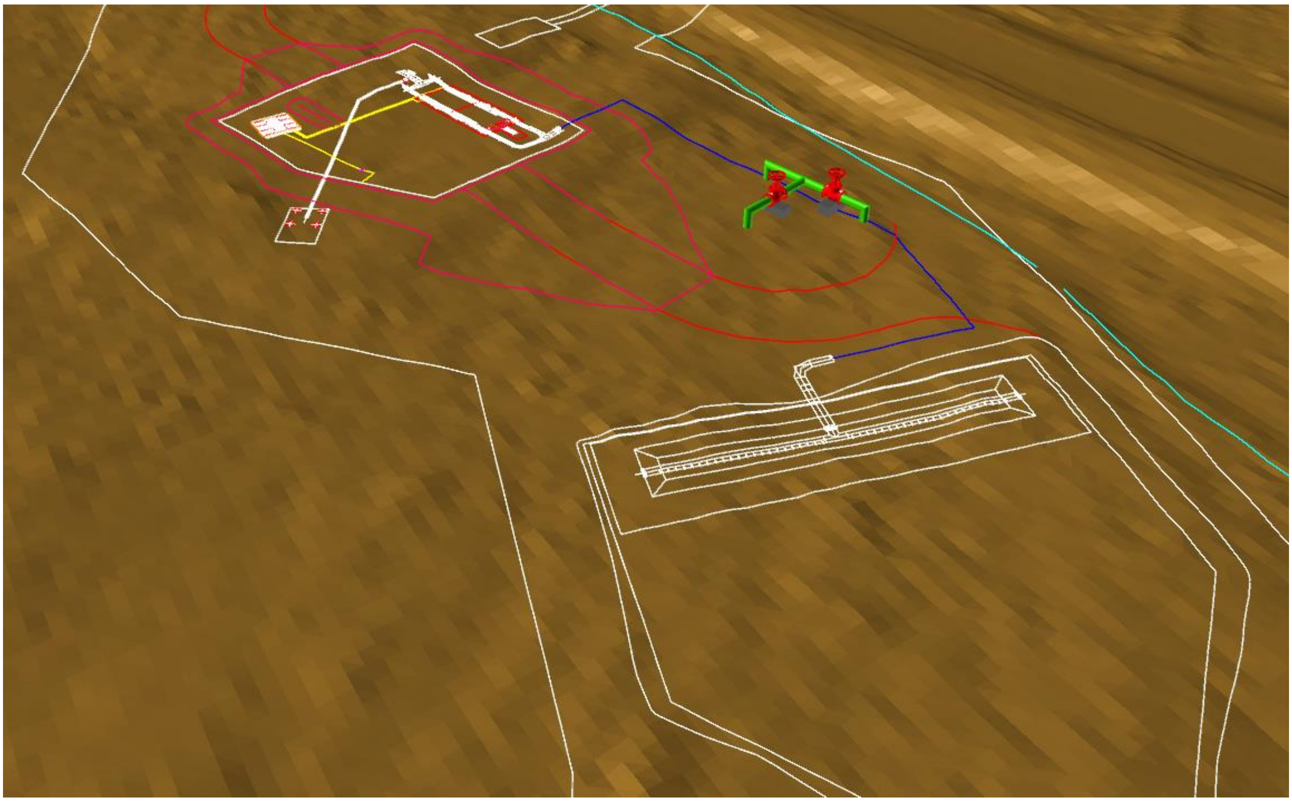


Figure 6-1 – Piping offtake to Aeration Ponds

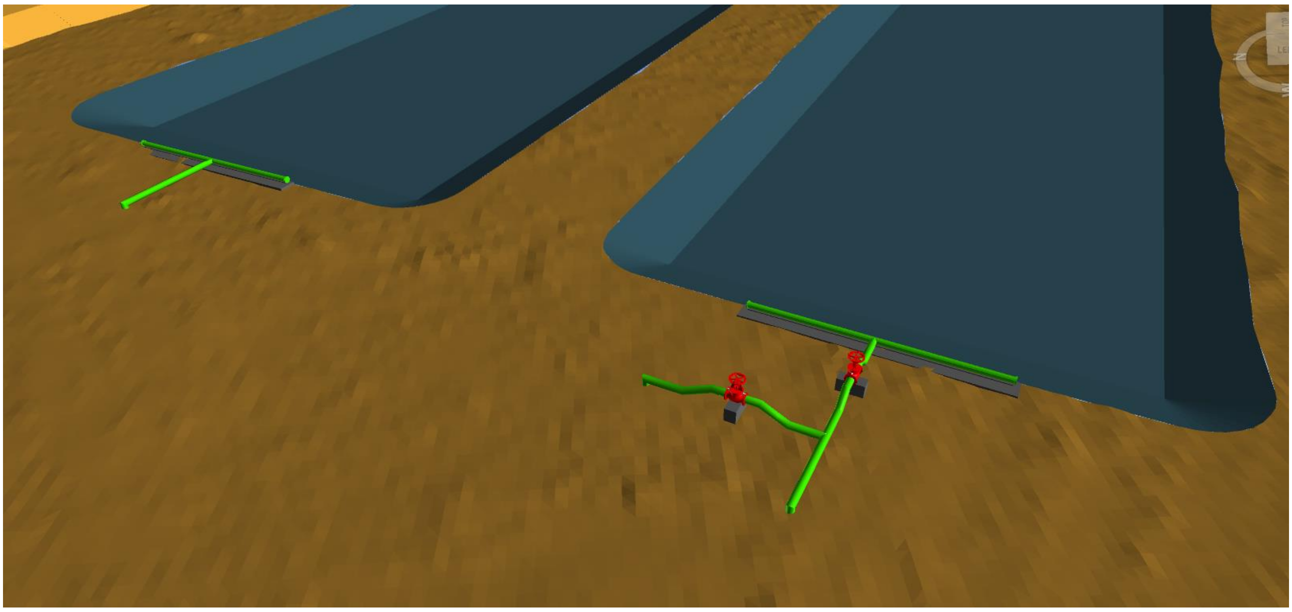


Figure 6-2 – Piping inlet to Ponds

7. Future works

7.1 Areas based on Other Projects

The following are the key areas where items have been borrowed from other similar projects that are in close proximity to this site.

- Inlet structure to be based on the design for the Homestead creek outlet.
    - Designed by Worley
- Acceptable slope angles based on the BHP RAF pond slopes.
    - 1:2.5 for slopes related to water structures (ponds, spillway sides etc.)
    - 1:2.0 for slopes out of the water (bunds etc)

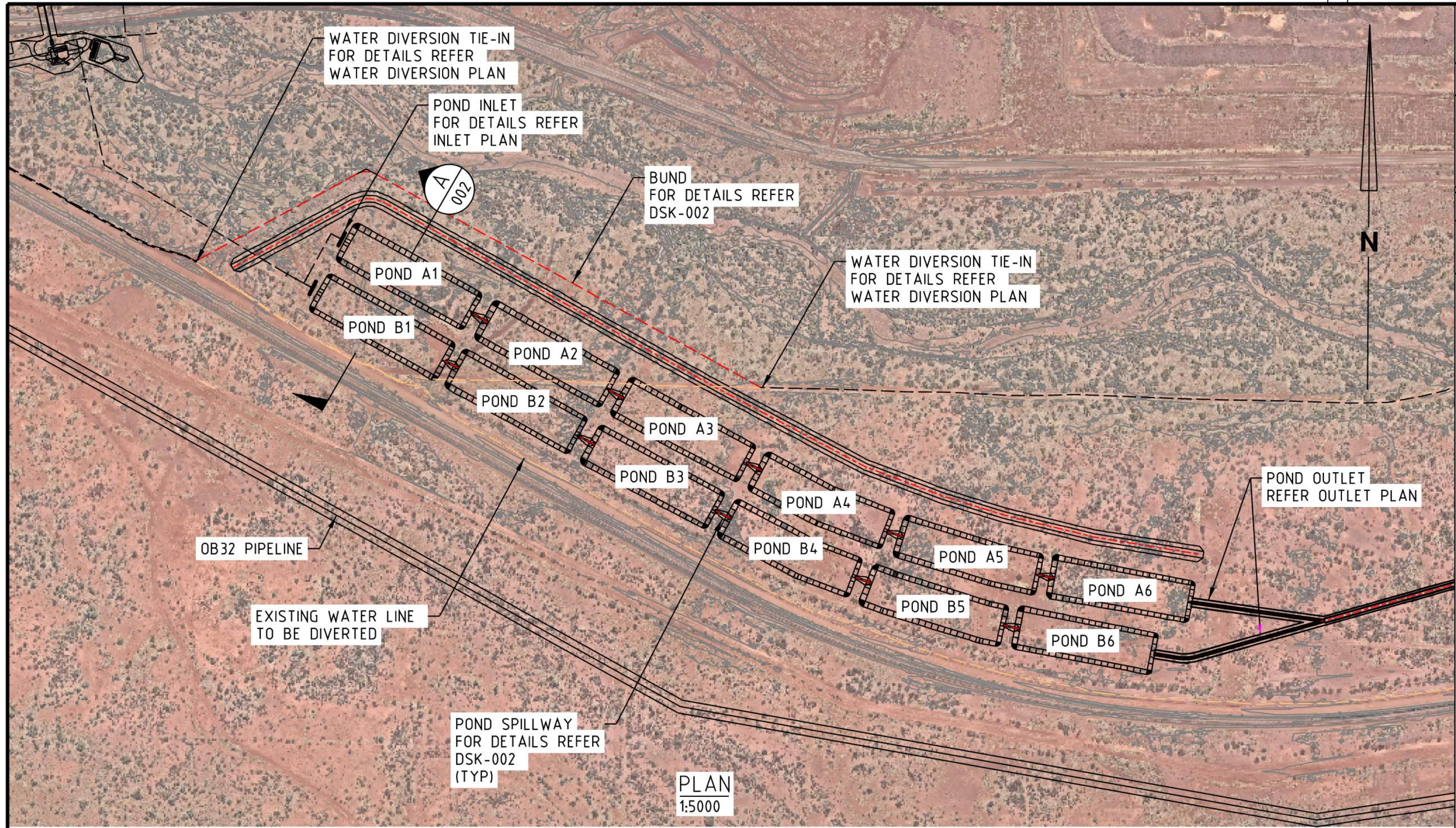
7.2 Further work in future phases

The following are the key areas for further work should this option be progressed to Approved for construction.

- Mechanical & Structural
    - Design of the inlet structure to verify the assumptions in this phase.
- Geotechnical
    - Slope stability verification.
- Hydrological
    - Wetting front extent
    - Stream velocity checks
        - Impact on rail
        - Armour sizing
    - Riprap sizing
- Civil
    - Design finalisation
    - Construction details
    - Minimising the amount of fill material transported from the area

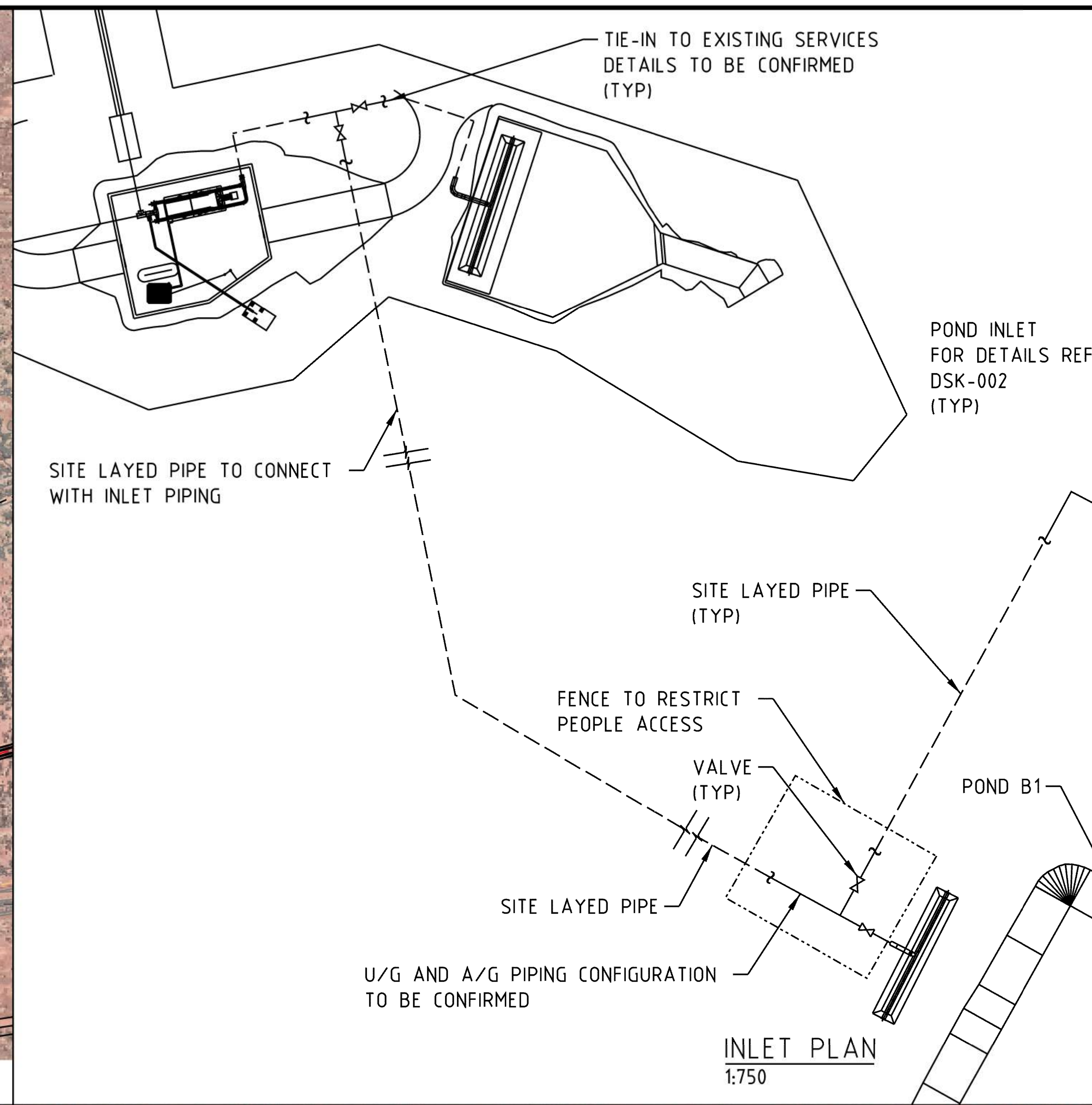
- Cost Estimating
  - Schedule of Quantities
  - Estimating
- Constructability
  - Engagement with contractors
  - Construction optimisation
- General
  - Construction Specifications
  - Drawings updated to Approved for Construction

Appendix A. – CAD Sketches



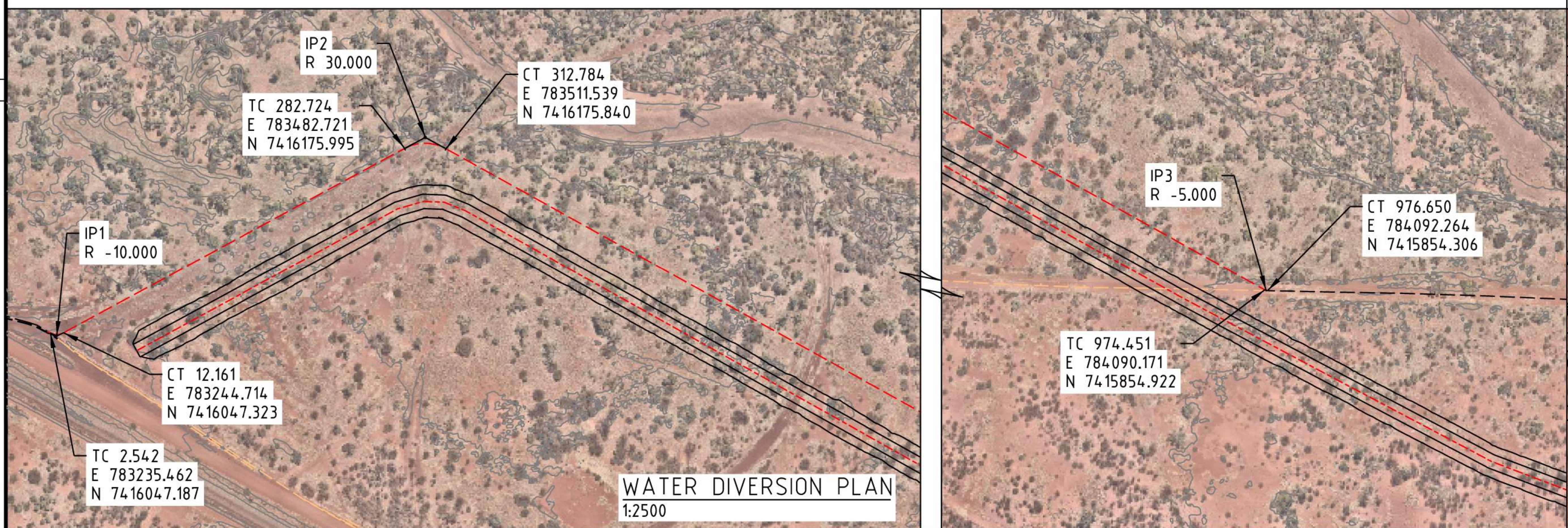
PLAN
1:5000

(STOCK FENCE AROUND PONDS OMITTED FOR CLARITY)

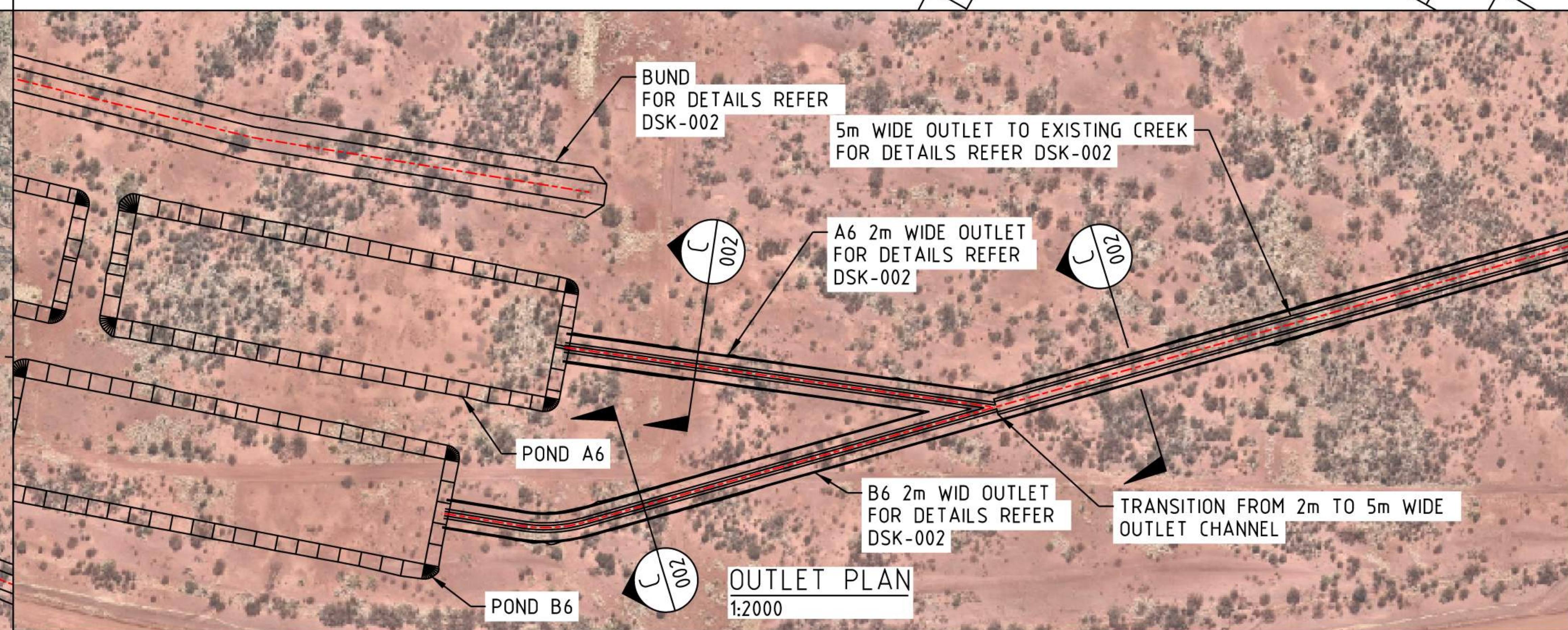


INLET PLAN
1:750

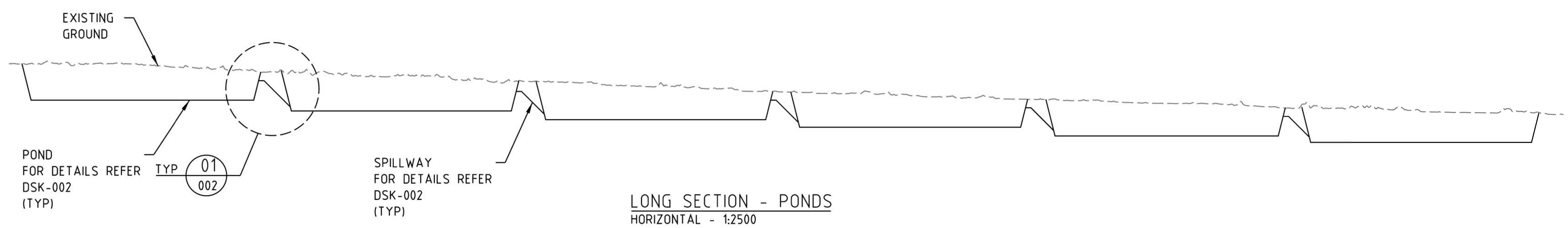
GENERAL NOTES



WATER DIVERSION PLAN
1:2500



OUTLET PLAN
1:2000



LONG SECTION - PONDS
HORIZONTAL - 1:2500
VERTICAL - 1:250

SCALE 1 : 250 (5 0 5 10 15 Metres)
SCALE 1 : 750 (15 0 15 30 45 Metres)
SCALE 1 : 2500 (50 0 50 100 150 Metres)
SCALE 1 : 2000 (40 20 0 40 80 120 Metres)
SCALE 1 : 5000 (100 0 100 200 300 Metres)

REFERENCE DOCUMENTS	DOC NO
POND DEVELOPMENT CUT AND FILL ELEVATIONS	DSK-003
POND DEVELOPMENT DETAILS AND SECTIONS	DSK-002
CONTRACT NUMBER OR PURCHASE ORDER NUMBER	

CONSTRUCTION AS-BUILT (RED INK): COMPANY ...... SIGNATURE ...... NAME ...... PROJECT CODE ...... ☐ DRAWING MARKED UP ☐ NO CHANGE

COMMISSIONING AS-BUILT (BLUE INK): COMPANY ...... SIGNATURE ...... NAME ...... PROJECT CODE ...... ☐ DRAWING MARKED UP ☐ NO CHANGE

NO	DATE	REVISION REVISION COMMENT TO INCLUDE PROJECT CODE FOR ALL REVISIONS	NO	DATE	REVISION REVISION COMMENT TO INCLUDE PROJECT CODE FOR ALL REVISIONS

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COMPANY ......
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DESIGNED BY ......
DRAWN BY ......
CHECKED BY ......
DESIGN & HSEC APPROVED BY ......

BHP

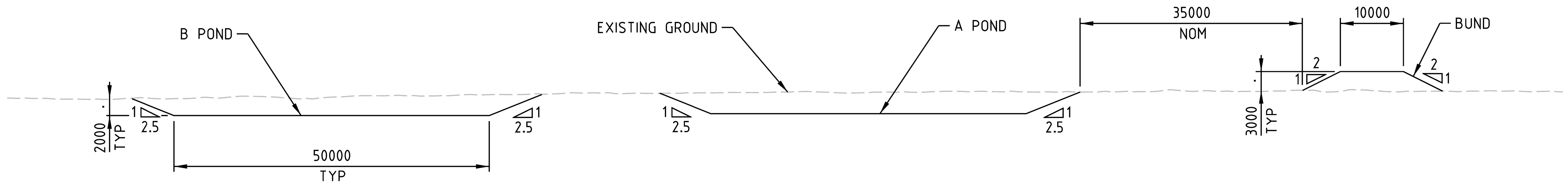
BHP Iron Ore Pty Ltd ABN 46 008 700 981

OREBODY 32
POND DEVELOPMENT
PLAN

SCALE ...... A1 DRG. NO. DSK [redacted] - [redacted] 001

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200

GENERAL NOTES:



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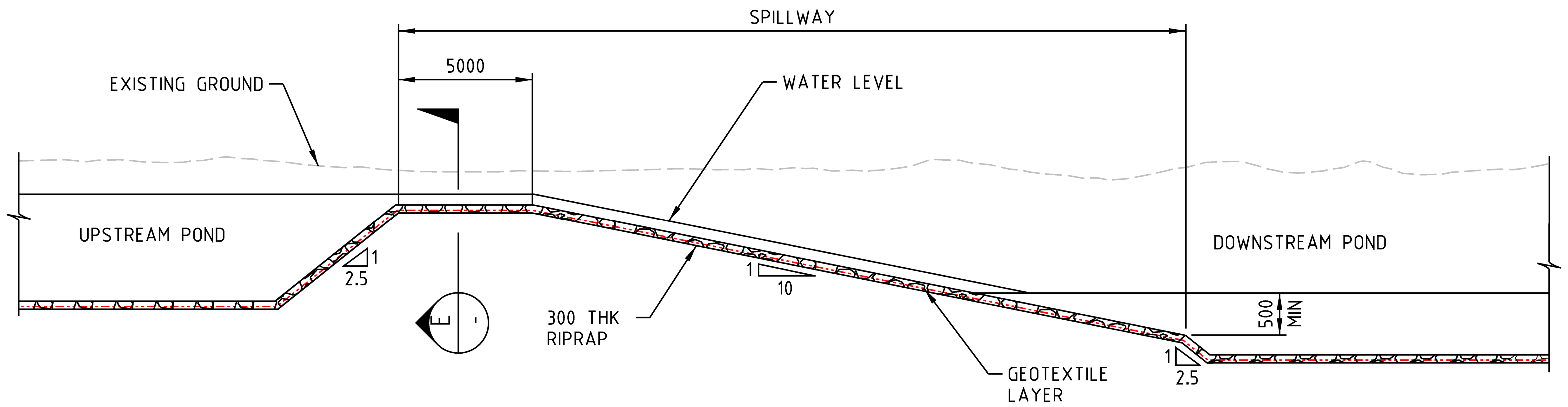

DETAIL (01 / 001) SPILLWAY LONG-SECTION
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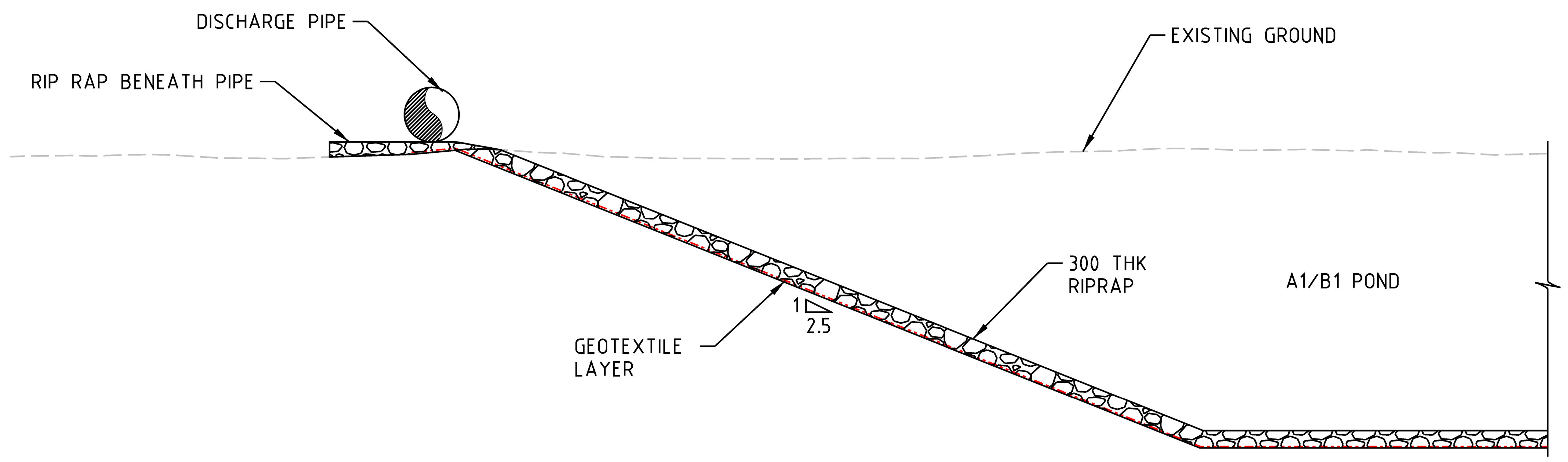
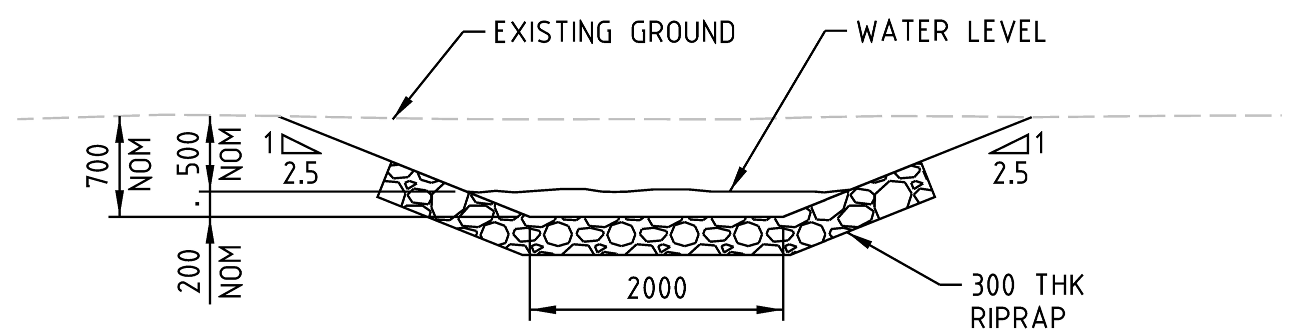


SECTION (B / 001) INLET TO POND
1:50



SECTION (D / -) SPILLWAY CROSS-SECTION
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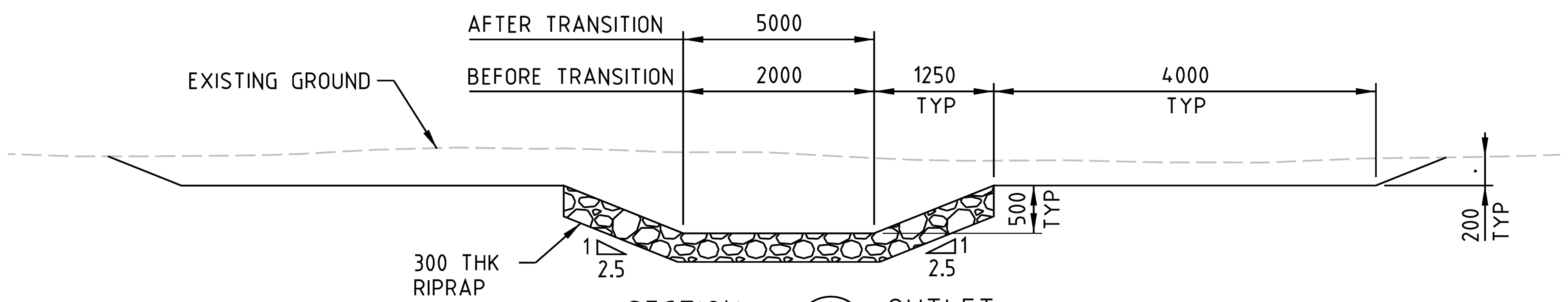


SECTION (C / 001) OUTLET
1:50

SCALE 1 : 50 (1 0 1 2 3 Metres)

SCALE 1 : 150 (3 0 3 6 9 Metres)

SCALE 1 : 500 (10 0 10 20 30 Metres)

REFERENCE DOCUMENTS	DOC NO
POND DEVELOPMENT CUT AND FILL E,EVATIONS	DSK-003
POND DEVELOPMENT PLAN	DSK-001
CONTRACT NUMBER OR PURCHASE ORDER NUMBER	

CONSTRUCTION AS-BUILT (RED INK)
COMPANY
SIGNATURE
NAME
PROJECT CODE
☐ DRAWING MARKED UP
☐ NO CHANGE

COMMISSIONING AS-BUILT (BLUE INK)
COMPANY
SIGNATURE
NAME
PROJECT CODE
☐ DRAWING MARKED UP
☐ NO CHANGE

NO	DATE	REVISION REVISION COMMENT TO INCLUDE PROJECT CODE FOR ALL REVISIONS	NO	DATE	REVISION REVISION COMMENT TO INCLUDE PROJECT CODE FOR ALL REVISIONS

BHPIO TO COMPLETE

DRAWING STATUS REVIEW	SIGNED	DATE	REV
INFORMATION ONLY			
AS BUILT			
CONSTRUCTION MAY PROCEED			
CONSTRUCTION MAY PROCEED EXCEPT AS NOTED			
REVISE AND RESUBMIT			

BHPIO/REVIEWER TO COMPLETE
COMPANY
SIGNED
THIS DRAWING HAS BEEN REVIEWED FOR GENERAL COMPLIANCE TO SCOPE AND COMPANY STANDARDS

DESIGNER/CONTRACTOR TO COMPLETE
COMPANY
DESIGNED BY
DRAWN BY
CHECKED BY
DESIGN & HSEC APPROVED BY

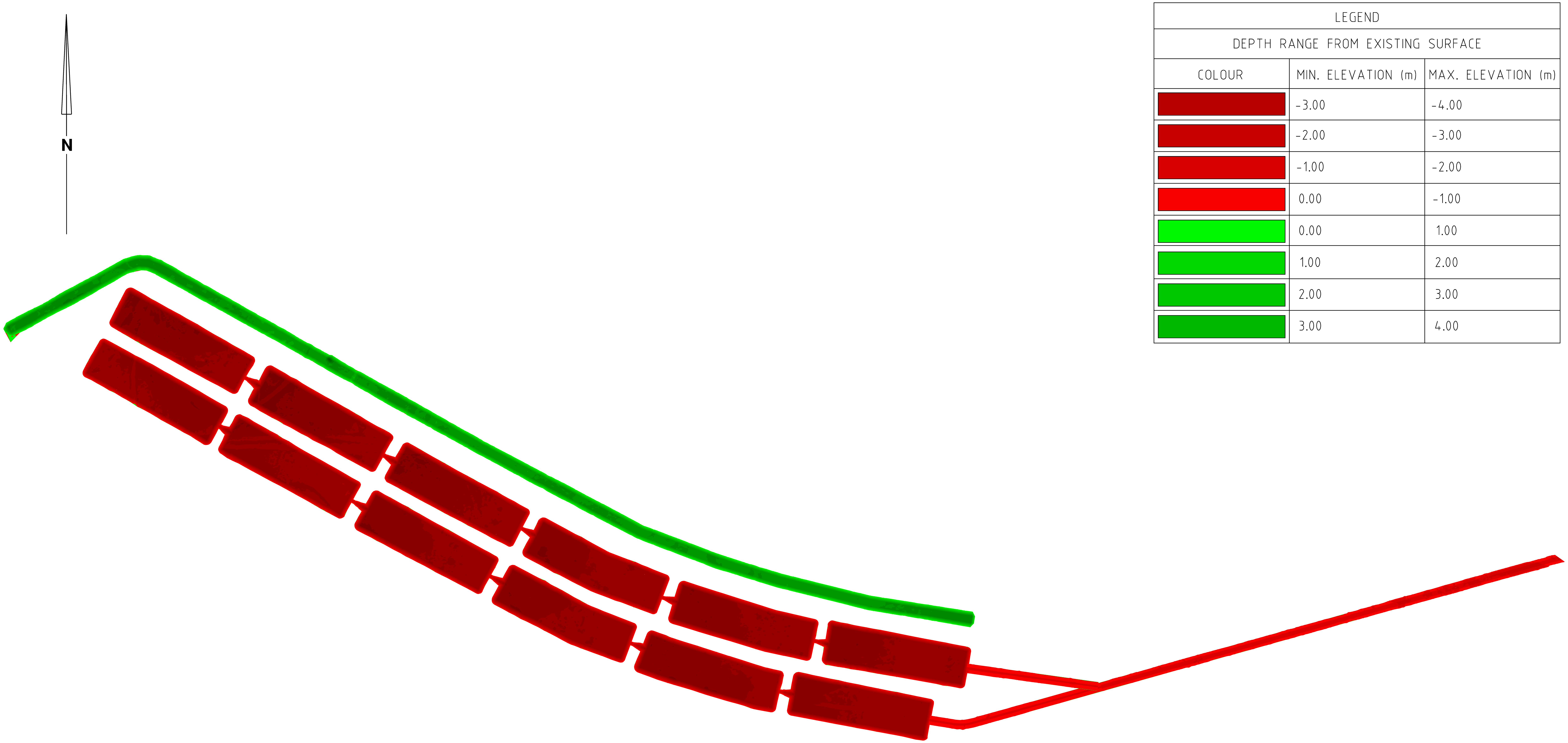
BHP

BHP Iron Ore Pty Ltd A.B.N. 46 008 700 981

OREBODY 32
POND DEVELOPMENT
SECTIONS AND DETAILS

SCALE | A1 | DRG. NO. DSK [redacted] - [redacted] 002

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200



PLAN
1:3000

LEGEND		
DEPTH RANGE FROM EXISTING SURFACE		
COLOUR	MIN. ELEVATION (m)	MAX. ELEVATION (m)
	-3.00	-4.00
	-2.00	-3.00
	-1.00	-2.00
	0.00	-1.00
	0.00	1.00
	1.00	2.00
	2.00	3.00
	3.00	4.00

REFERENCE DOCUMENTS	DOC NO
POND DEVELOPMENT DETAILS AND SECTIONS	DSK-002
POND DEVELOPMENT PLAN	DSK-001
CONTRACT NUMBER OR PURCHASE ORDER NUMBER	

CONSTRUCTION AS-BUILT (RED INK)	COMMISSIONING AS-BUILT (BLUE INK)
COMPANY	COMPANY ....
SIGNATURE	SIGNATURE ....
NAME	NAME ....
PROJECT CODE	PROJECT CODE ....
☐ DRAWING MARKED UP	☐ DRAWING MARKED UP
☐ NO CHANGE	☐ NO CHANGE

NO	DATE	REVISION REVISION COMMENT TO INCLUDE PROJECT CODE FOR ALL REVISIONS	NO	DATE	REVISION REVISION COMMENT TO INCLUDE PROJECT CODE FOR ALL REVISIONS

BHPIO TO COMPLETE

DRAWING STATUS REVIEW	SIGNED	DATE	REV
INFORMATION ONLY			
AS BUILT			
CONSTRUCTION MAY PROCEED			
CONSTRUCTION MAY PROCEED EXCEPT AS NOTED			
REVISE AND RESUBMIT			

BHPIO/REVIEWER TO COMPLETE

COMPANY ....

SIGNED ....

THIS DRAWING HAS BEEN REVIEWED FOR GENERAL COMPLIANCE TO SCOPE AND COMPANY STANDARDS

DESIGNER/CONTRACTOR TO COMPLETE

COMPANY ....
DESIGNED BY ....
DRAWN BY ....
CHECKED BY ....
DESIGN & HSEC APPROVED BY ....

BHP

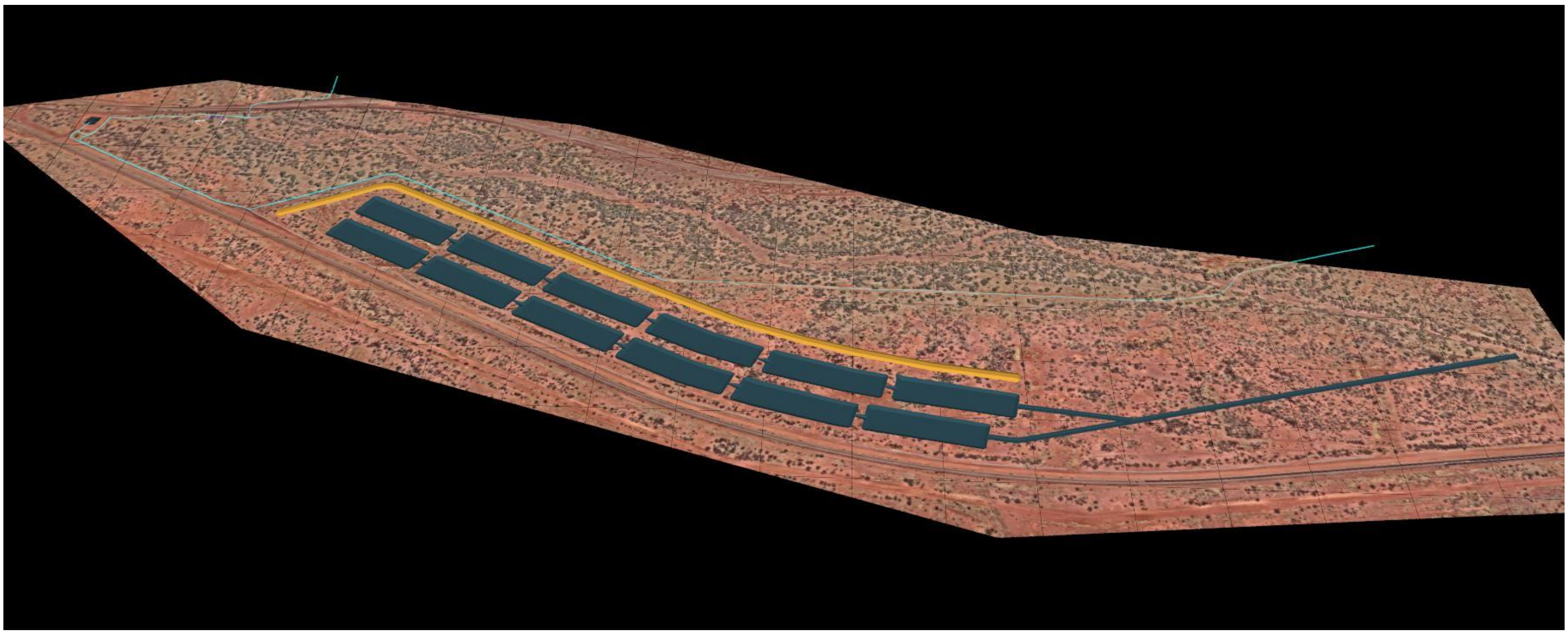
BHP Iron Ore Pty Ltd A.B.N. 46 008 700 981

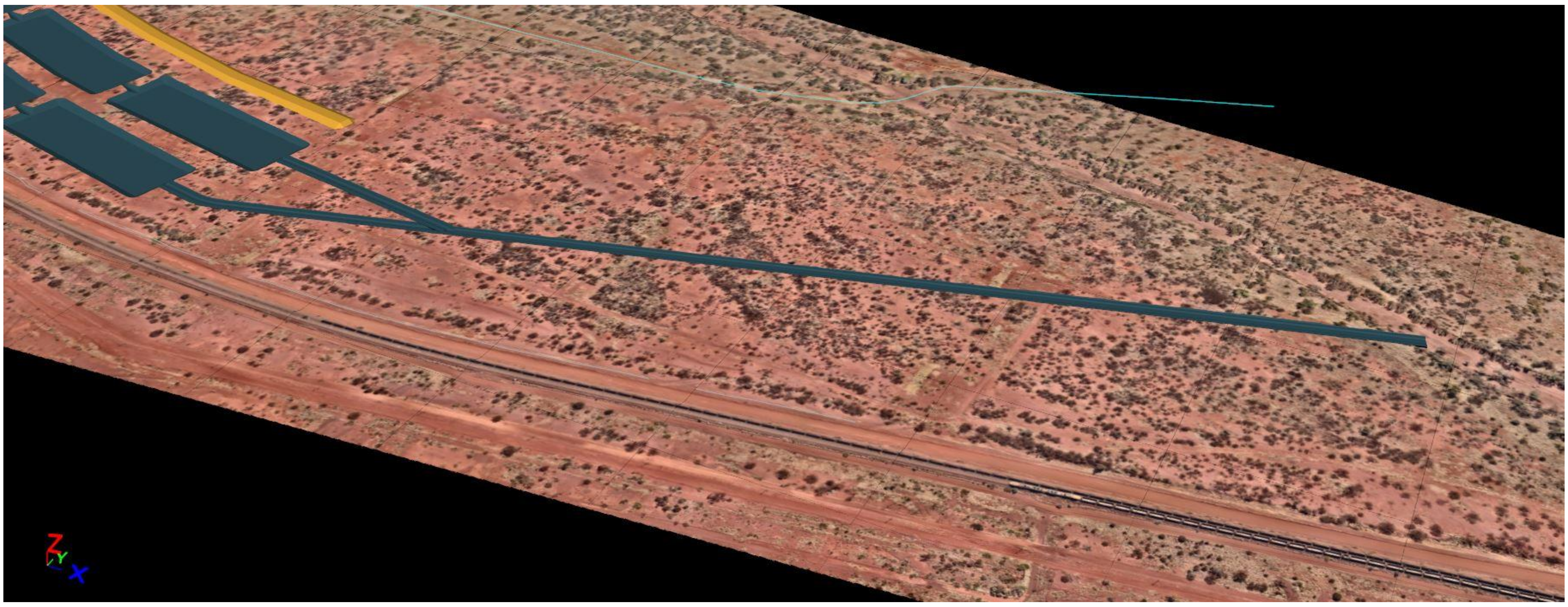
OREBODY 32
POND DEVELOPMENT
CUT AND FILL ELEVATIONS

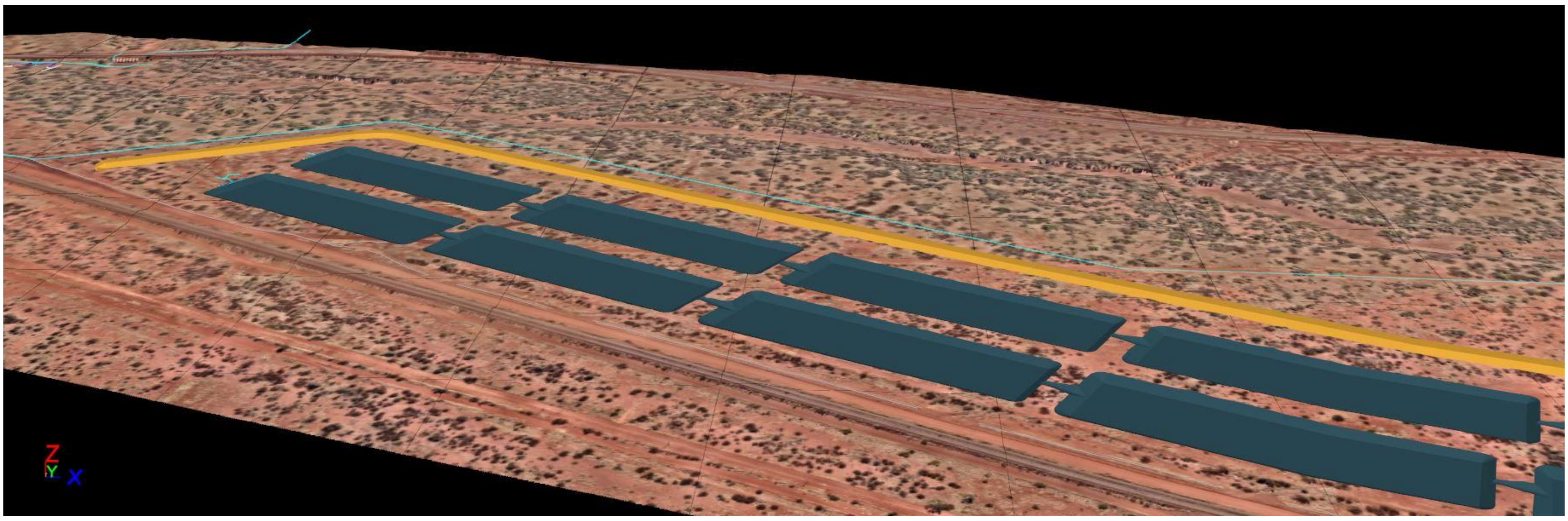
SCALE .... **A1** **DRG. NO.** DSK [redacted] - [redacted]003

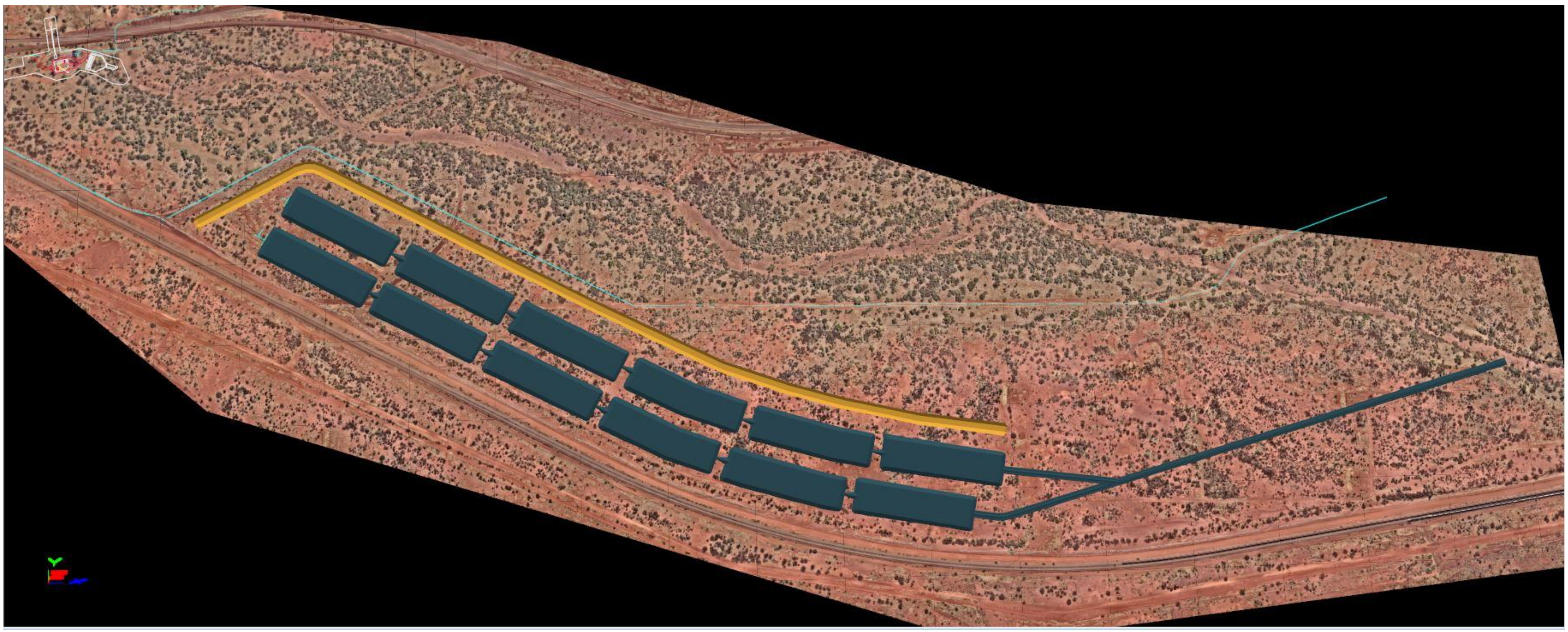
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200

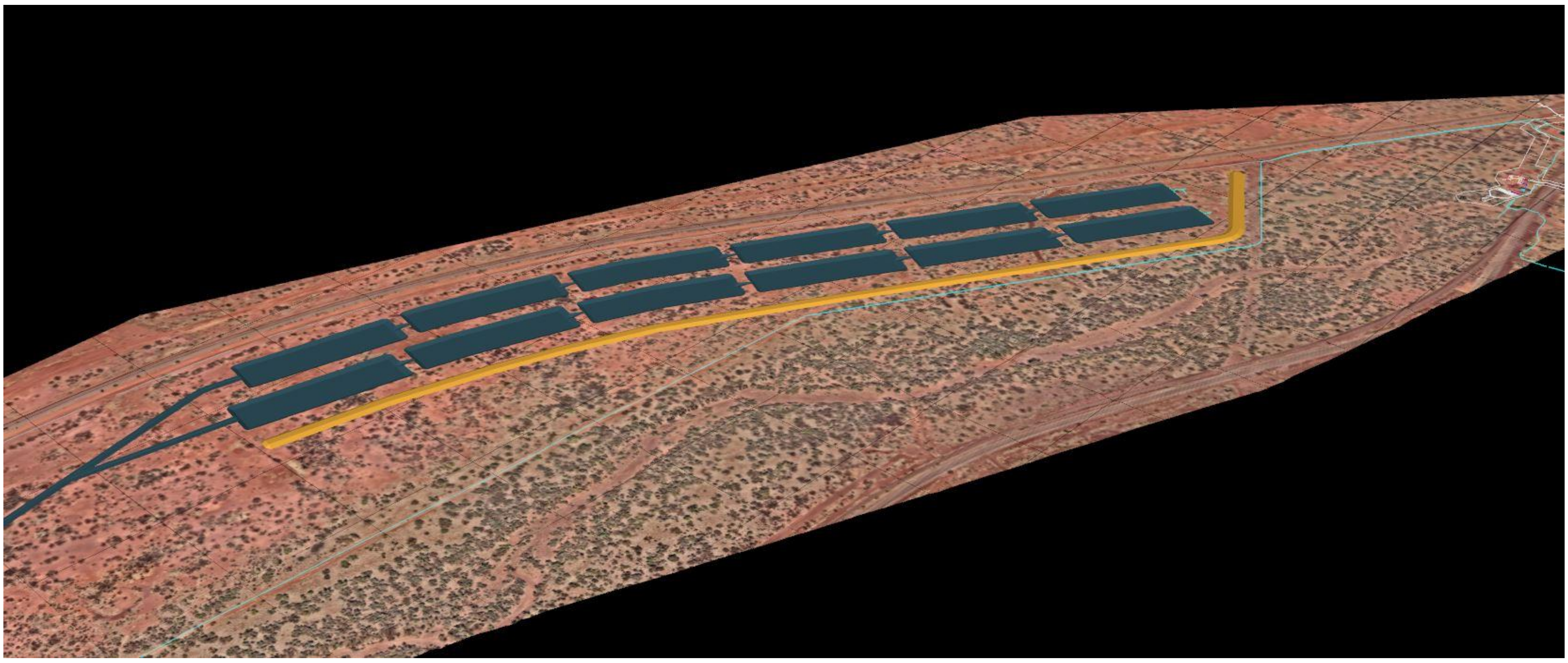
Appendix B. – 3D Renders

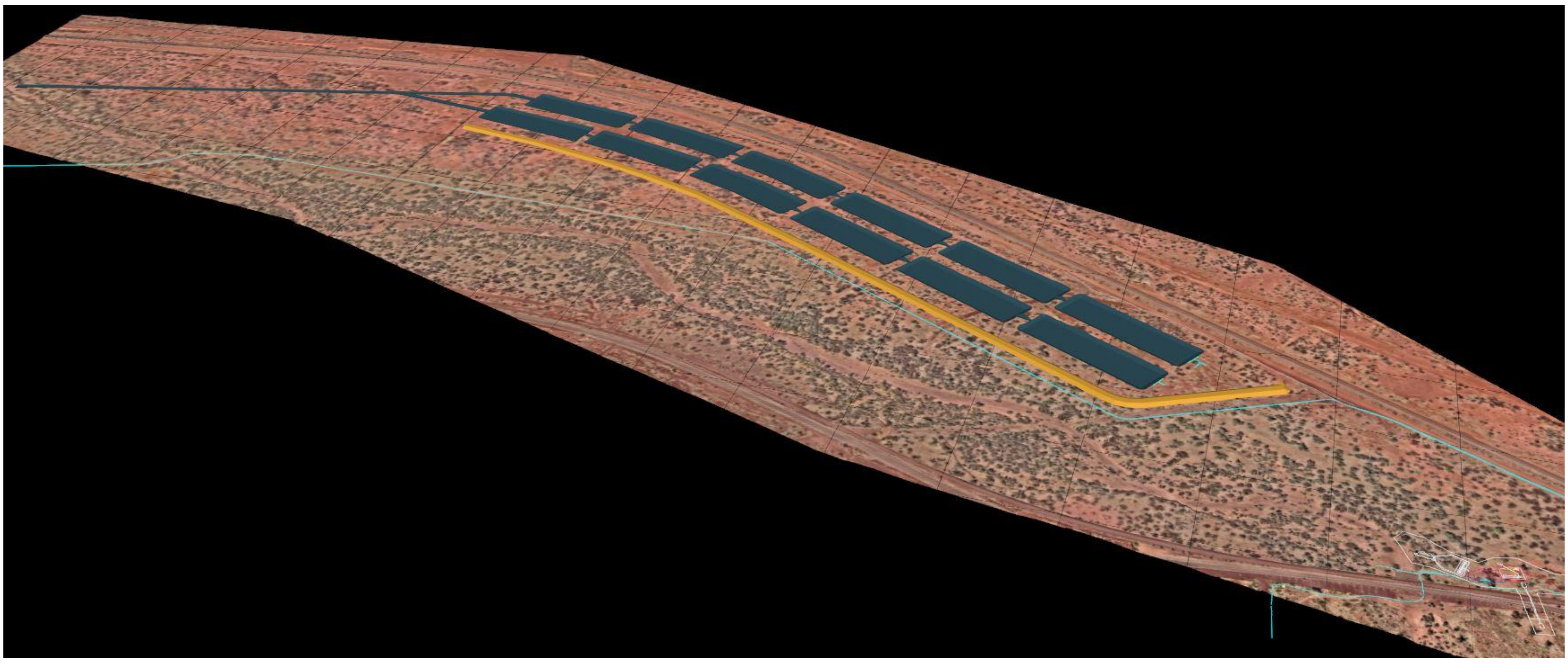


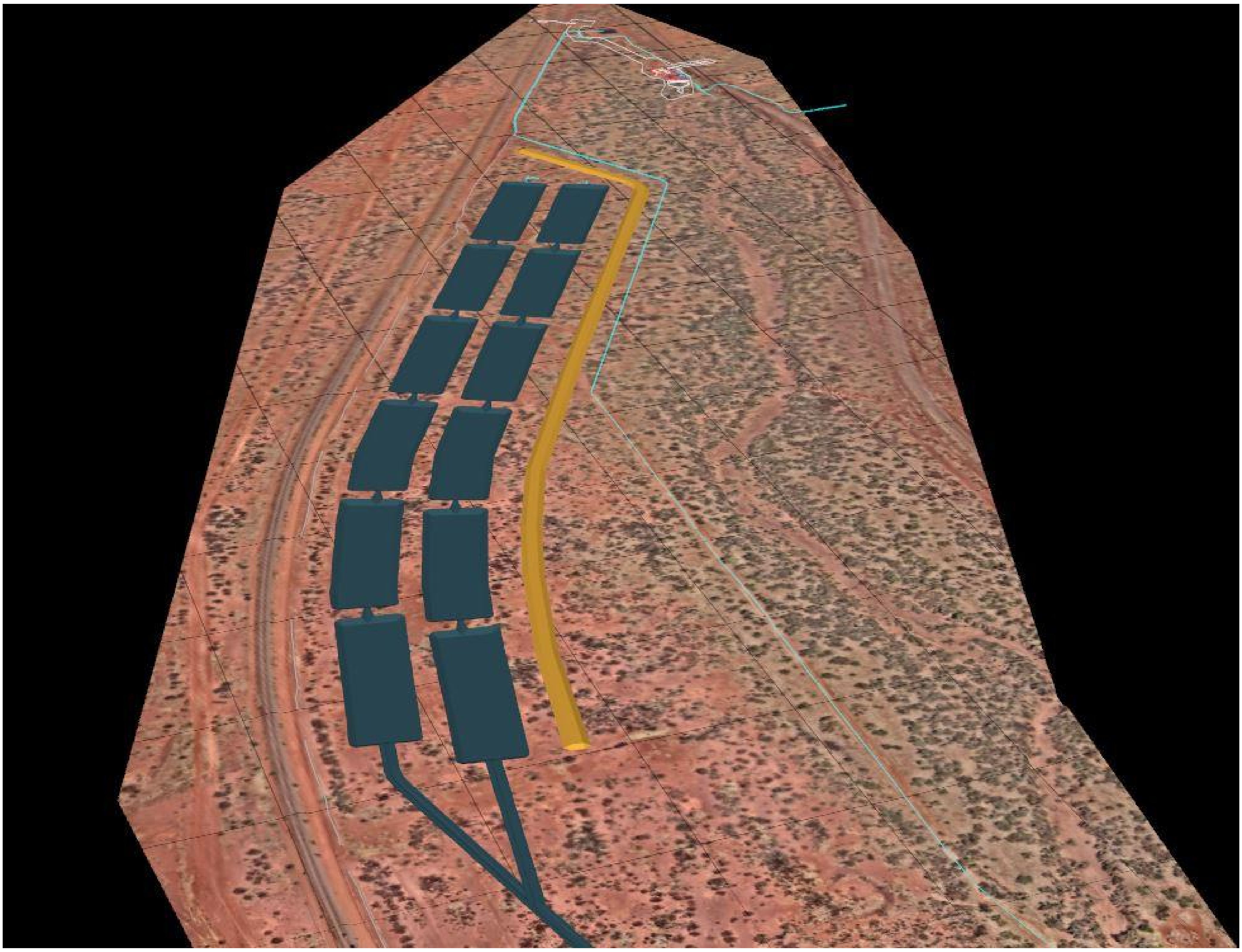

Z
Y
X

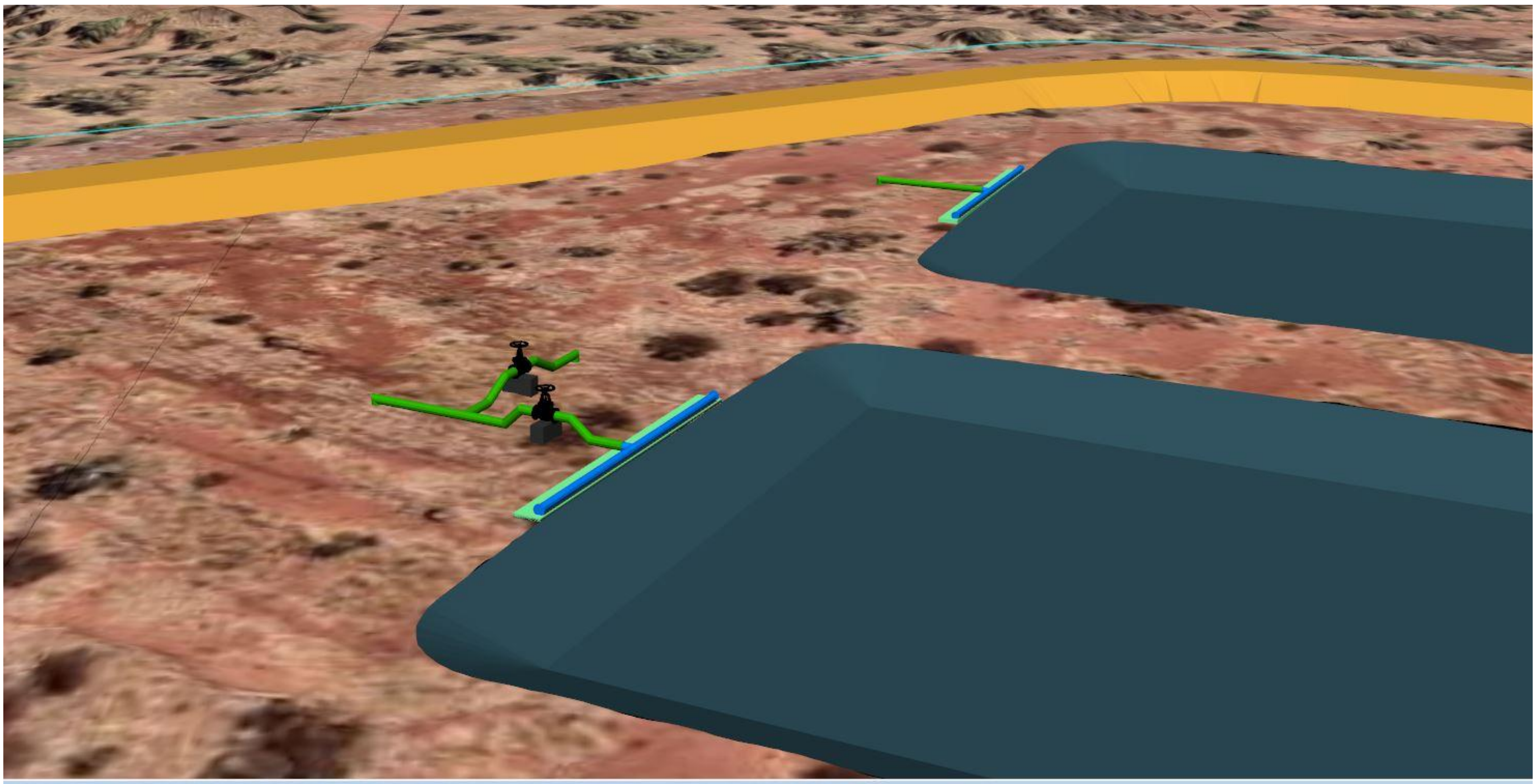

Z
Y
X

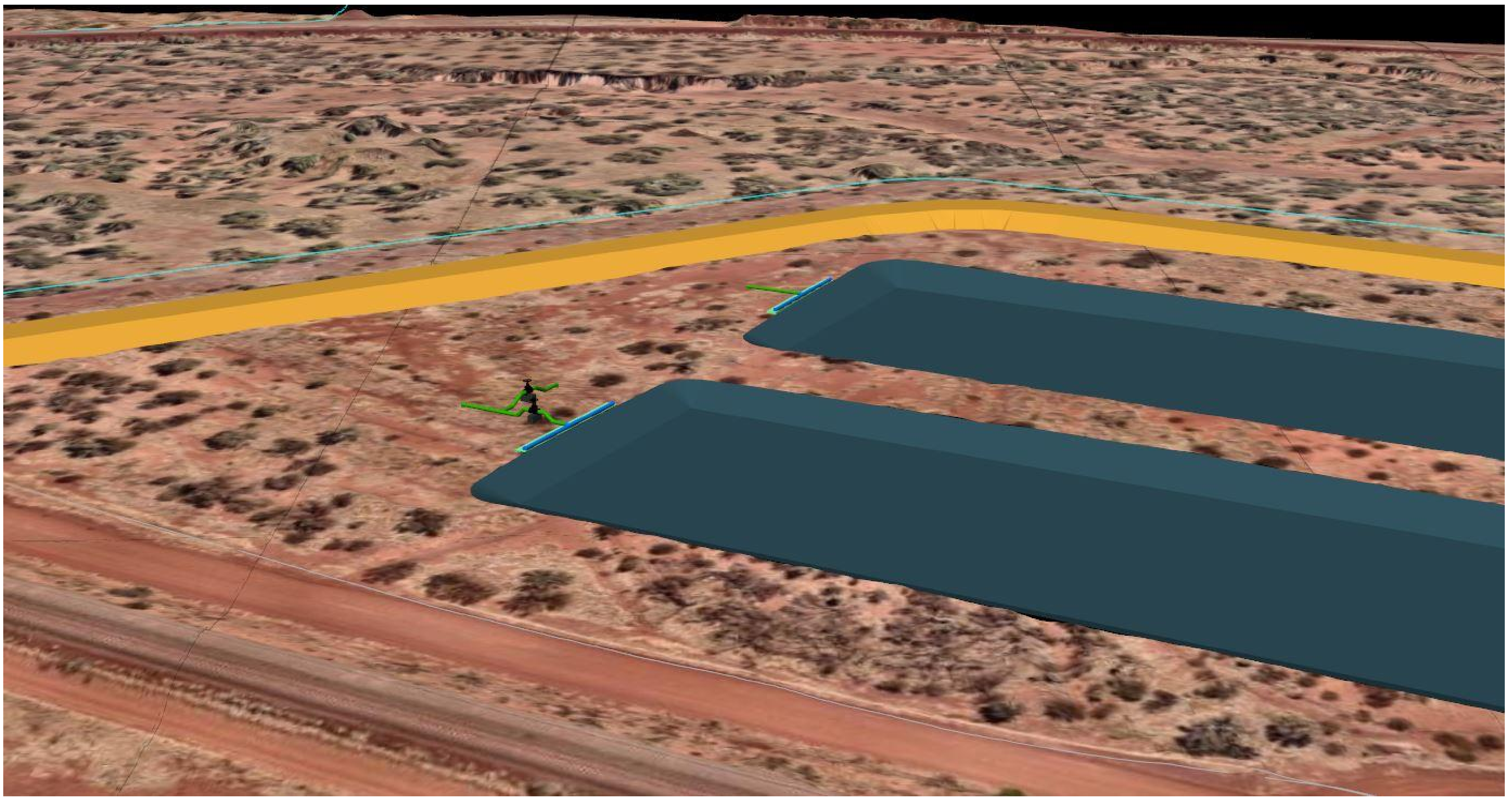


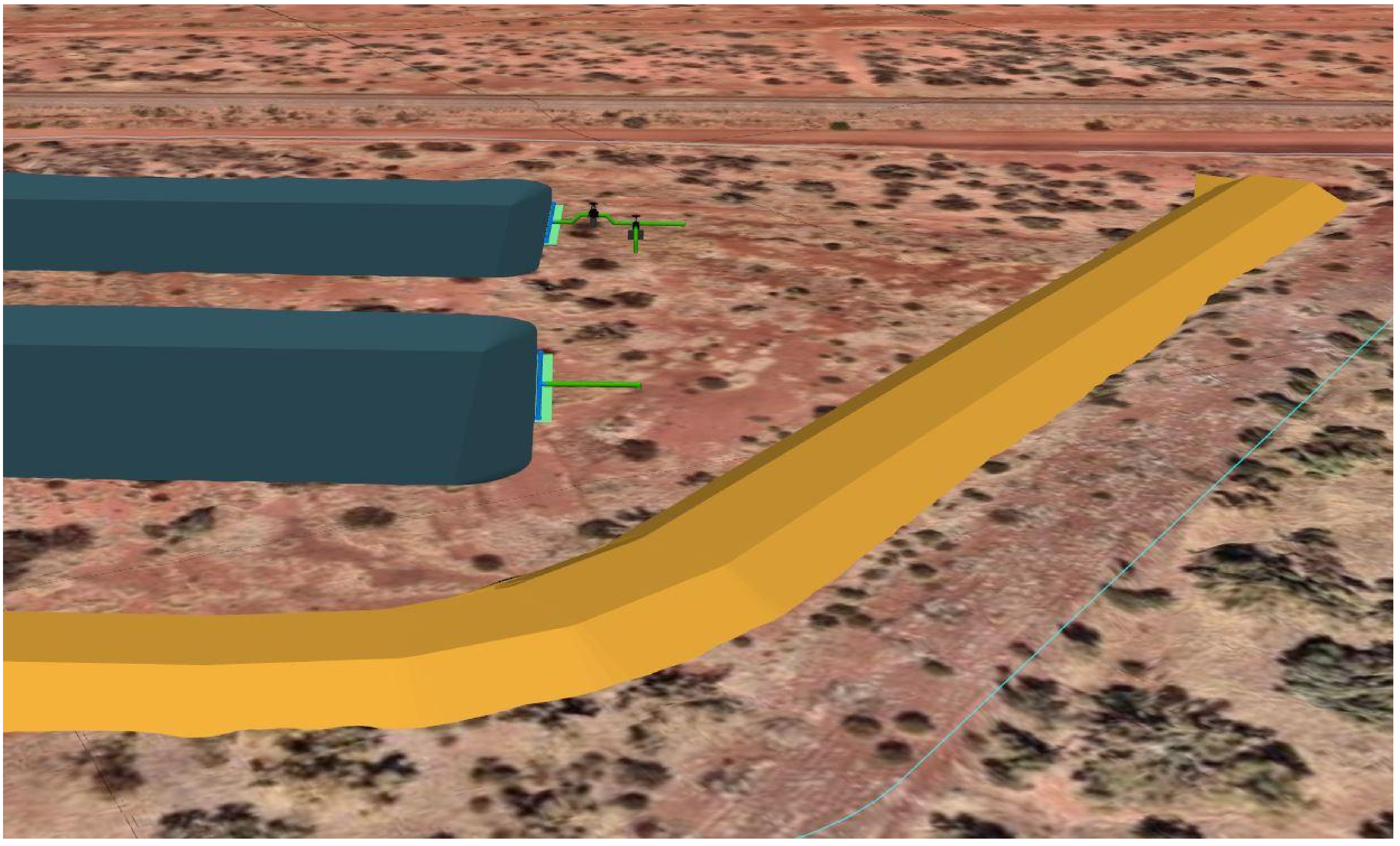












Appendix C. – South Flank Water Quality Comparison

OB32 Aeration Ponds, Water Quality

Table 1.1: Averaged water quality analysis for OB32 compared to values from Earth Systems Report

Parameter	Unit	OB32 Average Value	CPH (Earth Systems)	
			Mining Area C	South Flank
pH		7.2	7.8 – 8.1	8.0 – 8.2
Conductivity	uS/cm	1325	540 – 660	539 – 615
Calcium	mg/L	77	37 – 50	44 – 49
Magnesium	mg/L	73	23 – 30	23 – 29
Sodium	mg/L	86	27 – 35	21 – 31
Potassium	mg/L	6.2	6 – 9	8 – 14
Total Alkalinity CaCO3	mg/L	445	187 – 220	230 – 245
Chloride	mg/L	136	38 – 52	24 – 29
Sulphate	mg/L	77	33 – 42	17 – 36
Iron (Total)	mg/L	0.02		
Manganese	mg/L	0.1		
TOC	mg/L	0.3		
Nitrate	mg/L	0.69		
Turbidity	NTU	1		
Silica	mg/L	36		
Boron	mg/L	0.25		
Ammonia	mg/L	0.01		
Zinc	mg/L	0.012		
Lead	mg/L	0.003		

Table 1.1 compares averaged OB32 water quality to typical CPH water quality as presented in the Earth Systems report (Refer to table 5-2 in report). Comparison of available OB32 data shows higher levels of total dissolved solids such as calcium, magnesium, chloride and sulphate as well as higher total alkalinity. Given the higher levels, OB32 would be somewhat more prone to scaling with increasing pH and temperature.

In terms of other analytes, manganese is slightly high. At concentrations exceeding 0.1 mg/L, manganese can stain and give rise other issues. All other analytes are comparable.

Review of OB32 Hydrobiology Report - Comments on Methodology and Findings

BENCH TOP TESTS

Given the restraints of the lab tests being off-site, both batches served as good indicators that the 100% OB32 water is prone to calcium carbonate scaling. However, with the constant agitation of the sample in the mixing beaker, it is possible that the results are skewed as they may not be representative of the flow conditions OB32 water may face downstream of the bores. pH data is also absent from this method but is an important contributing factor, the sample may have had a longer period to de-gas CO_2, raising the pH. Some iterations of higher temperature may have also been beneficial, although this would of likely resulted in a shorter period of time before Figures 3-1 and 3-2 within the Hydrobiology report reach a plateau through accelerated calcium carbonate nucleation and crystal growth.

It is important to note that without any agitation (Bottles that were left undisturbed) the 100% OB32 bore samples showed a 15 mg/L change in Ca, when compared to the agitated samples that had a ~75 mg/L change in Ca. Change is referring to the precipitation of calcium carbonate in the solution.

GEOCHEMICAL MODELLING

The chemical equilibrium speciation modelling for the saturation indices (S.I.) of both the 15.5°C and 40°C models indicated that OB32 was oversaturated with respect to the carbonate phases dolomite, calcite, and aragonite at both temperatures.

Both model inputs for 100% OB32 for the two different temperatures are similar to the averaged water quality results in Table 1-1, these inputs are shown below.

temp	15.5
pH	7.74
pe	4
redox	pe
units	ppm
density	1
Alkalinity	428.5
Ca	79.5
K	6.5
Mg	80
Na	86
S(6)	77
water	1 # kg

temp	40
pH	7.74
pe	4
redox	pe
units	ppm
density	1
Alkalinity	428.5
Ca	79.5
K	6.5
Mg	80
Na	86
S(6)	77
water	1 # kg

PHREEQC software was used for geochemical modelling. It produced results that were more conservative than that of the constantly agitated bench top test. Hydrobiology did note that the greater mass of precipitation from the bench top test may have been due to the magnetic stirrer. The modelling does not account for the presence of suspended calcite solids in suspension (formed in-situ) as additional nucleation sites. With this likely being the case the theoretical model fits well to the trend of the bench top testing, and provides a good indication of theoretical species saturation indices at the given pH, temperature, hardness and alkalinity.

FINAL COMMENTS

Results from both the bench top test and theoretical geochemical modelling show that OB32 water is prone to carbonate scaling to which the severity of is governed by flow conditions, pH and temperature. Figure 3-6 within the Hydrobiology report gives a good indication of the 100% OB32 scaling potential.