

**DATE** 10 August 2012**PROJECT No.** 127646013-004-TM-Rev2**TO** Graham Younge  
Western Desert Resources**CC** Carel van der Westhuizen**FROM** Steven Boxall**EMAIL** sboxall@golder.com.au**WESTERN DESERT RESOURCES - ROPER BAR SURFACE WATER STUDY SUPPLEMENT  
(NRETAS)**

## 1.0 INTRODUCTION

This technical memorandum has been prepared for Western Desert Resources Limited (WDR) to provide supporting information to the Roper Bar Iron Ore Project - Surface Water Study report (document ref: 127646013-002-R-Rev0). The contents of the document are based on the recent site visit by Golder Associates (Golder) personnel and feedback and comments relating to the river re-alignment EIS document.

This technical memorandum provides additional analysis and information relating to the following surface water components of the Roper Bar Iron Ore project:

- Further background information on the modelled scenarios and their impacts on the surface water system
- The potential reduction in downstream flows as a consequence of the flooding of Area F Pit 3
- Assessment of the relative scale of impacted Towns River catchments and sub-catchments
- Inclusion of the estimated 100 year ARI flood inundation areas on flood maps
- A qualitative assessment of soil erosion and flood protection risks and requirements
- Updated design drawings including the location of the upstream pit inflow structure and modifications to the design of the inflow and outflow structures at the eastern end of the pit (at Wades Crossing).

## 2.0 RE-ALIGNMENT SCENARIOS (OPTIONS A, B AND C)

The following descriptions provide an overview of the main components of the three considered design options for flood control as well as the key surface water impacts and their influence on design flood flows and flood extents.

### 2.1 Option A

This option proposed full flood protection for all of the proposed pits. Flows from the upper tributary of the Towns River (UTTR) are to be fully diverted through a designed re-alignment to the northern side of the proposed Area F Pits. Flows are directed through a major creek re-alignment (including some artificial meander sinuosity) joining the existing channel downstream of the mining development. This is the original option noted as conceptual in Golder's preliminary hydrological report (17666004-001-R-Rev0).

Key points:

- If all runoff is to be directed through the proposed creek re-alignment, a bund is required that should be constructed to approximately 29 m AHD. As the flood plain area is relatively flat, this would require the bund to be up to 2 km in length.



- Velocities within the channel are estimated to be as high as 5 m/s. These velocities would require substantial erosion protection (i.e. gabions) within the diversion channel.
- Due to local high points along the route of the creek re-alignment, the constructed channel invert depth may be as deep as 10 m below existing ground level.
- The afflux currently extends off the southern extent of the model boundary and is approximately 4.5 m above base case levels.
- Areal flooding extents are significantly altered upstream of the proposed alignment.

Considering the required flood control engineering and predicted changes in afflux, at the request of WDR this option has not been considered further.

## 2.2 Option B

This option is based on re-alignment design defined in Option A (above), but proposes that flows be directed from UTTR to both the north and south of the proposed mine site adjacent to the flood protection bund and other infrastructure. Option B was considered with the objective of reducing the flow velocities and afflux created by Option A. The splitting of the diverted flows would be based on a control structure allowing flows to be directed along the alternative route when flow depth reaches a defined level at the divergence location.

Key points:

- This is a complex modelling exercise requiring iterative modelling of the split diversion. A two-dimensional model is likely required to accurately assess this option. Apart from the complexity, this type of modelling requires significant data input.
- This option is likely to require the most flood protection infrastructure (on all sides of the pits) and will substantially alter the natural environment.
- Detailed design and modelling of the specifications for an upstream control structure to provide the required level of control for diverting flow on either side of the site will be required.
- Issues associated with changed velocities and afflux are likely to be translated to the eastern end of the proposed pits.

Option B was assessed at a conceptual level only and, at the request of WDR, was not considered further.

## 2.3 Option C

Option C proposes to mine the Area F Pit 3 during the dry season and allow the pit to flood during any major flood events in this period and during subsequent wet seasons. This option represents the lowest impact option in terms of construction of flood protection measures and also a lower requirement for creek re-alignment/diversion. However, Option C does incorporate the additional impacts on flow quantity and quality downstream as a result of flooding the pit after it has been mined fully during the dry season. The impacts on downstream water quality have not been investigated as part of the Surface Water Study report.

Key points:

- The pit would fill up rapidly should a 20 year ARI design flood event occur. This would occur over a period of only several hours.
- Design of a re-alignment channel would also likely be required under this option to allow the pit to free drain. This channel could be the eastern end of the currently proposed re-alignment of option A.
- The flood map of this option is likely to be most similar to the base case pre-development case in respect to afflux and areal flood extents.
- The reduced impact on the river alignment and the geometry of the channels and surrounding floodplain means there are no significant increases in modelled flow velocities, flood extents and afflux upstream of the proposed mine development.

### 3.0 SEASONAL ASSESSMENT OF POTENTIAL IMPACTS ON DOWNSTREAM FLOW VOLUMES

A simple seasonal water balance model has been developed to provide an assessment of the potential impacts of the flooding of Area F Pit 3 on downstream flows. For the purpose of this assessment all data (rainfall and streamflow) have been collated and summarised based on water years running from July to June in order to fully capture the wet season in the seasonal analysis.

#### 3.1 Estimation of Flows and Seasonal Statistics

There are no stream gauging stations on the Towns River with a continuous record of daily streamflow. Therefore, seasonal daily flow data used for this analysis are based on measured flows for a nearby catchment, the McArthur River at Baileys Grave (G9070142), which have been scaled based on the relative catchment areas. The flow record for Baileys Grave extends from November 1965 to date although there are significant gaps throughout the record. A continuous period of measured flows from July 2004 to May 2012 has been assessed and this period provides a range of flow conditions including a very dry year (i.e. 2004-05), a very wet year (i.e. 2010-11) and an average year (2006-07).

Based on the 49 year rainfall record for the Mallapunyah raingauge, located approximately 33 km from Cape Crawford in the McArthur River catchment, the following rainfall statistics have been derived for the full record and the selected three water years which support the choice of the above years as representing dry, average and wet years.

**Table 1: Rainfall Statistics for Selected Water Years (July-June) at the Mallapunyah Raingauge (Based on 49 Years of Record)**

| Statistic | Total Rainfall (mm) | Water Year |
|-----------|---------------------|------------|
| Median    | 693                 | -          |
| Maximum   | 1729                | 2000-01    |
| Minimum   | 211                 | 1989-90    |

**Table 2: Statistics for Selected Years of Rainfall at the Mallapunyah Raingauge**

| Water Year | Total Rainfall (mm) | Rank (1 = highest, 49 = lowest) | Percentile                         |
|------------|---------------------|---------------------------------|------------------------------------|
| 2004-05    | 444                 | 45                              | < 10 <sup>th</sup> Percentile      |
| 2006-07    | 705                 | 24                              | Approx 50 <sup>th</sup> Percentile |
| 2010-11    | 1611                | 2                               | > 95 <sup>th</sup> Percentile      |

These rainfall statistics are very similar to those for the Ngukurr raingauge located in the Towns River catchment.

The total catchment area of the McArthur River at Baileys Grave gauging station is approximately 3 885 km<sup>2</sup> while the total catchment area of the Towns River upstream of Area F Pit 3 is approximately 345 km<sup>2</sup>. Therefore, the average daily flows for the gauging station have been scaled based on the proportional areas implying the assessed flow in the Towns River is equivalent to around 9% of the measured flows at the Baileys Grave gauging station. A summary of annual flows for the water years between 2004 and 2012 are provided in Table 3 below.

**Table 3: Summary of Estimated Annual Flows (July-June) for 2004-05 to 2011-12 at Area F Pit 3**

| <b>Water Year</b> | <b>Total Annual Flow (ML)</b> |
|-------------------|-------------------------------|
| 2004-05           | 3 431                         |
| 2005-06           | 58 897                        |
| 2006-07           | 11 017                        |
| 2007-08           | 6 483                         |
| 2008-09           | 75 959                        |
| 2009-10           | 38 424                        |
| 2010-11           | 116 510                       |
| 2011-12           | 34 203                        |

### 3.2 Pit Filling Water Balance Analysis

The seasonal pit water balance analysis provides an assessment of the interception and hence reduction in downstream flow due to seasonal filling of Area F Pit 3. It also provides an indication of likely requirements for the augmentation of downstream flows (through pumping) during very dry seasonal flows.

For the water balance analysis the following assumptions have been applied:

- The total pit lake volume, after the closure of Area F Pit 3 and the flood protection levee is pushed back into the pit, is assumed to be 3 365 ML (3 365 000 m<sup>3</sup>). The pit volume is approximately 4 185 ML (4 185 000 m<sup>3</sup>) and the volume of the levee is approximately 820 ML (820 000 m<sup>3</sup>)
- The total catchment upstream of the pit is 345 km<sup>2</sup>.
- Direct rainfall onto the pit lake is based on measured daily rainfall at the Ngukurr climate station for the period of analysis.
- Direct open water evaporation losses from the lake are based on a monthly profile derived from mean daily evaporation (mm) for years 1964 to 2012 at the Ngukurr climate station.
- The operation of the pit lake water balance assumes there is no natural flow directly downstream of the pit unless the pit lake volume is full.
- During the dry season, when there are no/minimal flows, the pit lake level will naturally fall as a consequence of evaporative losses.
- The water balance allows for a pumping volume to be incorporated, if required, to maintain some level of flow downstream when flows are fully intercepted by the pit filling process.
- There is no accounting for potential losses from the pit lake to the underlying groundwater system.
- There is no accounting for water taken from the lake for operational use at the mine.

The results of this analysis are presented on a monthly basis (July to June) to provide an assessment of the impacts on both the initial (first) month of flows as well as total flow over the entire wet season and also through subsequent years.



### 3.2.1 Initial Pit Filling Season Water Balance

The following provides a summary of the volumetric impact on flows directly downstream of the pit during a 'dry' (2004-05), 'average' (2006-07) and 'wet' year (2010-11) assuming these are the prevailing condition for the initial filling season. For this analysis it is assumed pit filling will only occur during or after October and the pit water storage level is presented as meters below ground level (mbgl). The monthly storage and impact on downstream flows for the three assessment years ('dry', 'average' and 'wet') are presented in Table 4, Table 5 and Table 6, respectively.

These results show that during 'average' and 'wet' years the filling of the Area F Pit 3 will occur rapidly and the resulting volumetric impact on total wet season flow directly downstream of the pit is negligible, particularly after the pit is fully flooded.

The findings for these three assessment years are summarised below:

- During a 'dry' year there would potentially be no flow realised directly downstream of the site and based on the estimated flows for the 2004-05 wet season the pit may only reach approximately 90% of capacity by the end of the year.
- During an 'average' year the flooding of the pit would fully intercept the early season flows, i.e. up to mid-January of 2007. A significant month of flow, such as February 2007, is sufficient to fully flood the pit, although much of the month's flow (approximately 30%) will be intercepted during the filling process. An 'average' year should be sufficient to completely fill the pit by the middle of the wet season.
- During a 'wet' year the pit will fill rapidly during the first significant period of flow. Based on the estimated flows for 2010-11, the filling of the pit lake would have reduced the January downstream flows by only approximately 20% during the month with little or no impact on downstream flows during the remainder of the 'wet' season.

**Table 4: Monthly Impact on Downstream Flows during a 'Dry' Initial Pit Lake Filling Season (2004-05)**

| Month                          | Jul  | Aug  | Sep  | Oct   | Nov  | Dec   | Jan   | Feb  | Mar  | Apr  | May  | Jun  |
|--------------------------------|------|------|------|-------|------|-------|-------|------|------|------|------|------|
| Upstream Flow (ML)             | 133  | 85   | 63   | 47    | 33   | 1 316 | 1 453 | 203  | 57   | 28   | 8    | 4    |
| % Pit Storage                  | 0%   | 0%   | 0%   | 1%    | 2%   | 42%   | 85%   | 90%  | 92%  | 92%  | 91%  | 91%  |
| Storage Level (m bgl)          | -28  | -28  | -28  | -27.5 | -27  | -11   | -2.5  | -1.5 | -1.5 | -1.5 | -1.5 | -1.5 |
| Downstream Flow (ML)           | 0    | 0    | 0    | 0     | 0    | 0     | 0     | 0    | 0    | 0    | 0    | 0    |
| % Reduction in Downstream Flow | 100% | 100% | 100% | 100%  | 100% | 100%  | 100%  | 100% | 100% | 100% | 100% | 100% |

**Table 5: Monthly Impact on Flows during an 'Average' Initial Pit Lake Filling Season (2006-07)**

| Month                          | Jul  | Aug  | Sep  | Oct  | Nov   | Dec   | Jan   | Feb   | Mar  | Apr  | May  | Jun  |
|--------------------------------|------|------|------|------|-------|-------|-------|-------|------|------|------|------|
| Upstream Flow (ML)             | 315  | 179  | 98   | 72   | 39    | 0     | 912   | 8 670 | 418  | 150  | 91   | 72   |
| % Pit Storage                  | 0%   | 0%   | 0%   | 2%   | 3%    | 3%    | 30%   | 100%  | 100% | 100% | 100% | 100% |
| Storage Level (m bgl)          | -28  | -28  | -28  | -27  | -26.5 | -26.5 | -13.5 | 0     | 0    | 0    | 0    | 0    |
| Downstream Flow (ML)           | 0    | 0    | 0    | 0    | 0     | 0     | 0     | 6341  | 424  | 122  | 68   | 45   |
| % Reduction in Downstream Flow | 100% | 100% | 100% | 100% | 100%  | 100%  | 100%  | 27%   | 0%   | 19%  | 26%  | 38%  |

**Table 6: Monthly Impact on Flows during a 'Wet' Initial Pit Lake Filling Season (2010-11)**

| Month                          | Jul  | Aug  | Sep  | Oct   | Nov  | Dec  | Jan    | Feb    | Mar    | Apr    | May   | Jun   |
|--------------------------------|------|------|------|-------|------|------|--------|--------|--------|--------|-------|-------|
| Upstream Flow (ML)             | 123  | 74   | 49   | 42    | 151  | 905  | 10 690 | 12 444 | 57 353 | 30 889 | 2 227 | 1 564 |
| % Pit Storage                  | 0%   | 0%   | 0%   | 1%    | 6%   | 33%  | 100%   | 100%   | 100%   | 100%   | 100%  | 100%  |
| Storage Level (m bgl)          | -28  | -28  | -28  | -27.5 | -25  | -13  | 0      | 0      | 0      | 0      | 0     | 0     |
| Downstream Flow (ML)           | 0    | 0    | 0    | 0     | 0    | 0    | 8 486  | 12 450 | 57 404 | 30 874 | 2 197 | 1 536 |
| % Reduction in Downstream Flow | 100% | 100% | 100% | 100%  | 100% | 100% | 21%    | 0%     | 0%     | 0%     | 1%    | 2%    |

### **3.2.2 Managed Initial Pit Filling Season Water Balance**

Based on this analysis, during the initial pit filling season it may be necessary to pump some water from the pit to augment flows in the downstream reach of the Towns River, as discussed below in Section 4.0. This would mitigate the impact of pit filling on downstream flows, particularly during a drier than average season. Table 7 presents the 'dry' year scenario with downstream flows augmented by water pumped from the filling lake assuming a maximum pumping rate of 200 L/s (approximately 520 ML/month) is applied during the peak flow months of December and January. This managed pit filling option still allows the pit lake to partially fill (up to approximately 50% of capacity) during a drier than average season, but means there is at least some augmenting of flows in the reach directly downstream of the pit.

The managed filling option with augmentation of flows downstream should be considered until the pit lake is full.

**Table 7: Monthly Impact on Flows during a Managed 'Dry' Initial Pit Lake Filling Season (2004-05)**

| Month                          | Jul  | Aug  | Sep  | Oct   | Nov  | Dec   | Jan   | Feb | Mar  | Apr | May  | Jun  |
|--------------------------------|------|------|------|-------|------|-------|-------|-----|------|-----|------|------|
| Upstream Flow (ML)             | 133  | 85   | 63   | 47    | 33   | 1 316 | 1 453 | 203 | 57   | 28  | 8    | 4    |
| % Pit Storage                  | 0%   | 0%   | 0%   | 1%    | 2%   | 26%   | 54%   | 56% | 57%  | 56% | 54%  | 53%  |
| Storage Level (m bgl)          | -28  | -28  | -28  | -27.5 | -27  | -15   | -8.5  | -8  | -7.5 | -8  | -8.5 | -8.5 |
| Augmented Downstream Flow (ML) | 0    | 0    | 0    | 0     | 0    | 520   | 520   | 100 | 50   | 50  | 50   | 0    |
| % Reduction in Downstream Flow | 100% | 100% | 100% | 100%  | 100% | 61%   | 64%   | 51% | 12%  | 0%  | 0%   | 100% |

### 3.2.3 Subsequent Season Pit Filling Water Balance

A series of scenarios are presented to show the impact on downstream flow for the 2<sup>nd</sup> year after the pit has been open to flooding. Year 1 represents the initial pit filling season and Year 2 represents the subsequent filling season. These three scenarios (defined below) are based on combinations of years to represent a worst case, i.e. two very dry years in succession, as well as the more likely scenarios including average years of streamflow.

**Scenario 1** - Two consecutive 'dry' years (Year 1: 2004-05, Year 2: 2004-05)

**Scenario 2** - 'Dry' year followed by an 'average' year (Year 1: 2004-05, Year 2: 2006-07)

**Scenario 3** - Two consecutive 'average' years (Year 1: 2006-07, Year 2: 2006-07)

The results of the three pit lake water balance scenarios are presented in the tables provided in Attachment B. The key findings for these water balance analyses are summarised below:

- Should two consecutive 'dry' years be experienced during the flooding of the pit lake then pumping from the pit to augment downstream flow (as described in Section 3.2.2) may be required beyond the initial filling season. The simulations show that the pit lake would be completely filled before the end of a second drier than average wet season.
- After a 'dry' initial year, with pumping to augment flows downstream during the filling season, the remaining storage deficit will rapidly fill during a subsequent 'average' year with negligible impact on downstream flows after the first major runoff in the 2<sup>nd</sup> 'wet' season.
- The scenario of two consecutive 'average' streamflow years shows that after the initial flooding of the pit during the first wet season the volumetric impact on downstream flows during the second season are very much reduced. This analysis shows that the option of pumping to augment downstream flows can reduce the impacts of pit filling, particularly during the initial flow responses of the first wet season.

### 3.2.4 Ongoing Pit Filling Seasonal Water Balance

A further water balance scenario (Scenario 4) has been carried out to provide an assessment of the ongoing seasonal pit lake water balance when the Area F Pit 3 Lake is full at the beginning of the simulation period.

**Scenario 4** - A dry year with a sustained dry season after the pit is full (Year 1: 2004-05, Year 2: 2005-06)

This scenario provides an estimate of the potential maximum level of natural drawdown of the pit lake level, and subsequent impacts on downstream flows, during a very dry period. For this assessment the two year period 2004-05 to 2005-06 has been used for the analysis as this represents a 'dry' wet season followed by a sustained dry season with very little or no streamflow through to November 2005. The results of the pit lake water balance for Scenario 4 are presented in the table provided in Attachment B. The key findings are:

- Simulation of the pit lake water balance after it is completely full indicates natural evaporative losses during a dry season are unlikely to reduce the pit storage volume to less than 90-95% of total storage (equivalent to a reduction of up to 400 ML).
- The natural reduction in water level during the dry season, as a result of open water evaporation, may reduce water levels by approximately 1-1.5 m below the full level of the pit lake
- During a very dry year, this level of pit water storage deficit will be quickly filled during the following wet season.

### 3.2.5 Summary of Pit Filling Water Balance Analysis

The following key findings provide an overall summary of the scenario analysis of the filling of Area F Pit 3:

- During a very dry year, and also during an average wet season, there may be impacts on streamflow downstream of the pit lake due to interception of flows during filling
- The option of managed pit lake filling using pumped augmentation can be used to mitigate the impact of the pit lake interception on downstream flows, particularly during a drier than average wet season

- After the pit lake has filled, the ongoing impacts on downstream flows is much reduced and the pit lake will reach a full level early the following wet season, even during drier than average years
- During the dry season, as the pit storage level naturally falls there will be no flow downstream of the pit, although these reaches of the Towns River regularly have no flows relatively early in the dry season.

It is therefore recommended that pumps should be made available to manage and mitigate the impacts on downstream flows during the initial filling of the pit lake. The pumped augmentation options may also be required during the subsequent year, particularly if the pit lake is not completely filled during the first wet season. The ongoing water storage level and impacts on downstream flow should be monitored throughout the life of the mine.

#### 4.0 SCALE OF IMPACTS ON THE WIDER TOWNS RIVER CATCHMENT

The following information provides a high level assessment of the potential scale of the impact on the wider Towns River catchment as a consequence of the flooding of Area F Pit 3. The analysis involves the delineation of the whole of the Towns River catchment and its major sub-catchments, down to a reference point taken to be the Towns River road crossing at Savannah Way, approximately 20 km downstream of the mine development site.

The Towns River at Savannah Way represents the convergence of the three major tributaries of the Towns River. These include the Yumanji Creek (Little Towns River), to the north of the Towns River catchment, the Magaranyi River, to the south and the continuation of the Towns River draining the central areas of the overall Towns River catchment. These catchments are presented in Figure 1 and their respective areas are summarised in Table 8. Figure 1 also highlights the potentially impacted catchment area directly upstream of the mine development.

**Table 8: Summary of Sub-Catchment Areas (Upstream of Towns River Crossing at Savannah Way)**

| Sub-Catchment                      | Area                        |
|------------------------------------|-----------------------------|
| Towns River                        | 470 km <sup>2</sup>         |
| Magaranyi River                    | 2 105 km <sup>2</sup>       |
| Yumanji Creek (Little Towns River) | 1 344 km <sup>2</sup>       |
| <b>Total Area</b>                  | <b>3 919 km<sup>2</sup></b> |

The Towns River sub-catchment is the smallest of the three sub-catchments joining the main Towns River at Savannah Way and the catchment area directly upstream of the Roper Bar mine development (approximately 345 km<sup>2</sup>) represents only around 10% of the total Towns River catchment upstream of Savannah Way.

Based solely on contributing catchment areas it can be inferred that impacts on flows in the Towns River sub-catchment as a consequence of the mine development, and in particular the flooding of the Area F Pit 3 as summarised in Section 3.2, will have much lower volumetric impact on total flow downstream of the tributary inflows of the Yumanji Creek and Magaranyi River.

#### 5.0 100 YEAR ARI FLOOD EVENT

A flood map showing the areal extent of flooding, including the 100 year ARI event for the Option C case, is shown in Figure 2. This map includes all known mine infrastructure and WRDs.

The modifications to the Towns River channel through the proposed mine site as a consequence of the Option C river re-alignment are presented in more detail in Figure 3. The modification to the river channel through the proposed mine area will result in a reduction in the length of the channel of approximately 120 m, which is equivalent to a 2% reduction over the length of the modified reach.

#### 6.0 SOIL EROSION AND FLOOD PROTECTION ISSUES

The Towns River channel in the areas surrounding the proposed mine development sites has historically been very mobile, with large numbers of meanders and ox bow lake formations indicating the channel is subjected to some level of lateral migration across the floodplain over time. These formations and their lateral movement may not vary significantly over a single wet season, and are likely to be generally limited to

an extension of meander bends through enhanced erosion. Results from the hydraulic modelling indicate that facing class rock protection at least 0.5 m thick should be provided on the outer curves of the largest meanders. This level of protection should also be provided at the pit inlets and outlets in the re-aligned channel where the flow into and out of the existing meanders occurs.

WDRL clearly understands that the re-aligned channel may be subject to erosion and/or lateral movement during the period of mining and accepts responsibility to address any erosion and sediment control issues. They will be required to provide structural protection where necessary and carry out regular monitoring and maintenance of the re-alignment, including the existing oxbows, for the duration of the mine operation with the view to fully establishing the re-alignment prior to closure.

## **7.0 UPDATED DESIGN DRAWINGS**

Updated design drawings for Option C - Preliminary are provided in Attachment C. These designs outline the general arrangement, longitudinal profile and typical cross-sections and also include an indicative inlet for flows into Area F Pit 3.

## **8.0 CLOSING REMARKS**

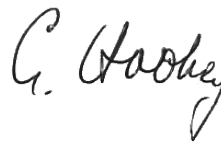
The analyses and assessments presented are based on the current understanding of the mine development and the most accurate available information. The results, maps, drawings and recommendations presented in this technical memorandum should provide some guidance as to the likely impacts of the mining proposal and assist with addressing comments received on the EIS document.

### **GOLDER ASSOCIATES PTY LTD**



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Hydrologist

SB/GRH/slj



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Associate, Group Manager Water Services

Attachments: A - Maps  
B - Pit Filling Water Balance Scenario Summary Tables  
C - Designs for Option C - Preliminary

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## **ATTACHMENT A**

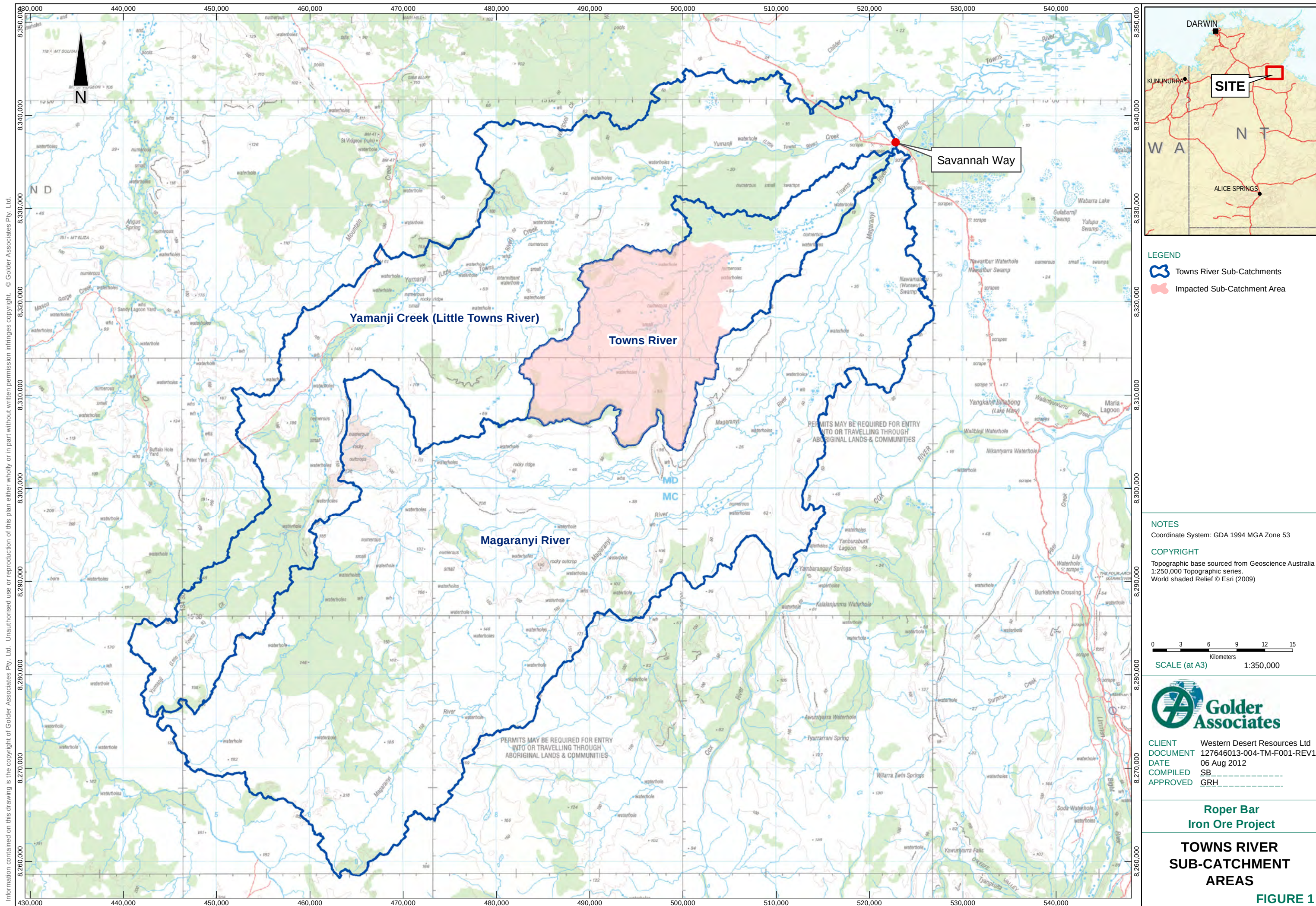
### **Maps**

Figure 1 - Towns River Sub-Catchments

Figure 2 - Flood Map - Post Development Option C

Figure 3 - Towns River Pre- and Post Development Channel Alignment





LEGEND

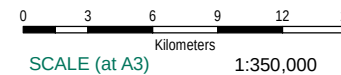
- Towns River Sub-Catchments
- Impacted Sub-Catchment Area

NOTES

Coordinate System: GDA 1994 MGA Zone 53

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Topographic base sourced from Geoscience Australia  
 1:250,000 Topographic series.  
 World shaded Relief © Esri (2009)



CLIENT Western Desert Resources Ltd  
 DOCUMENT 127646013-004-TM-F001-REV1  
 DATE 06 Aug 2012  
 COMPILED SB  
 APPROVED GRH

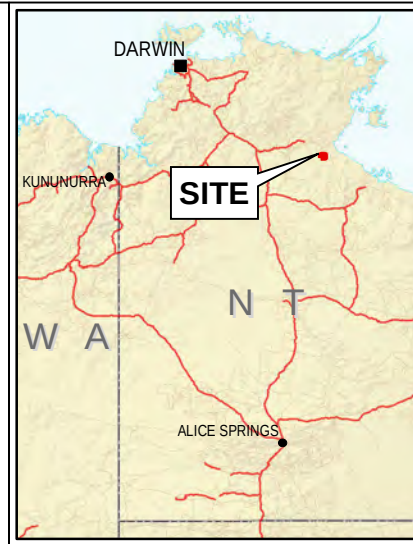
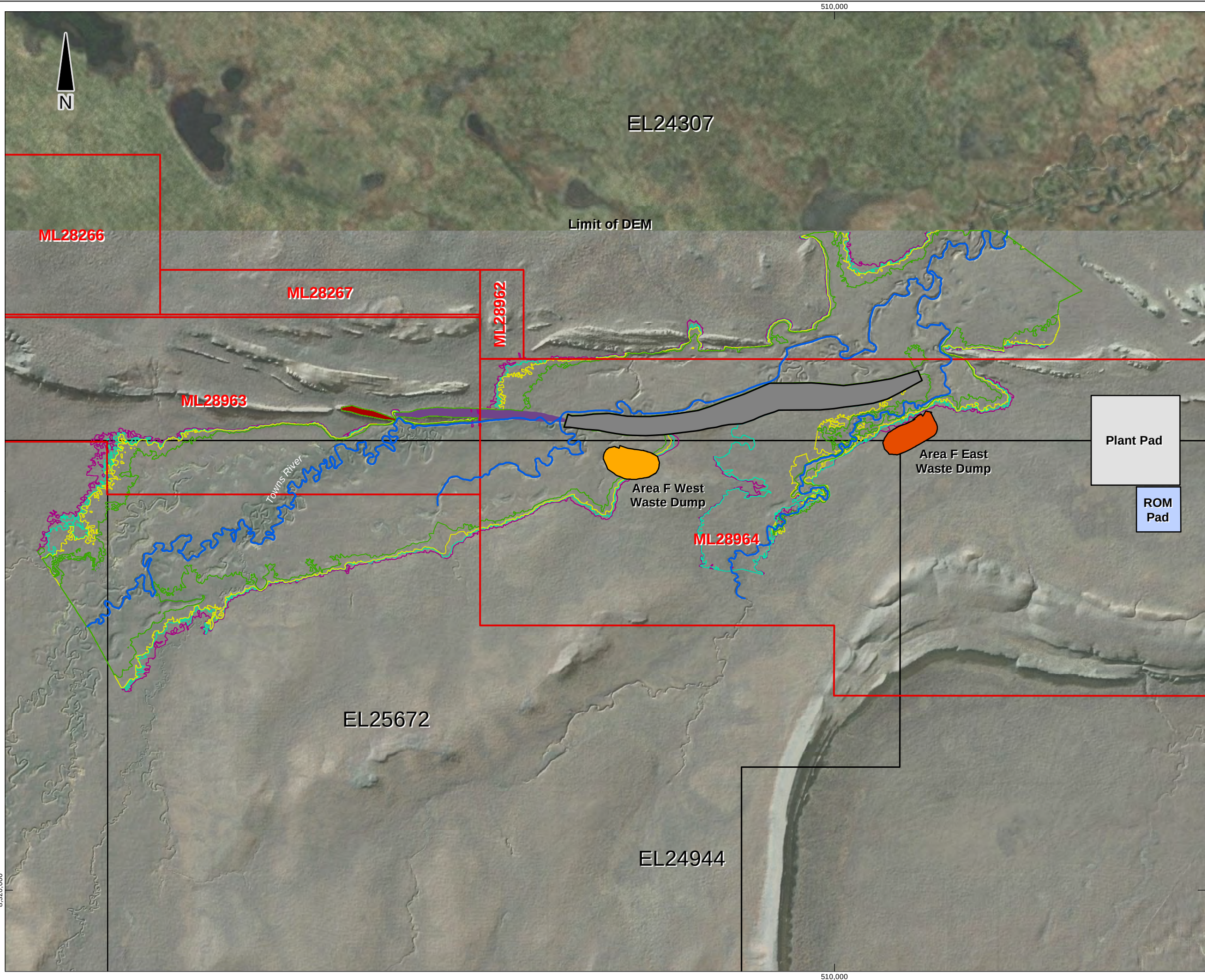
**Roper Bar  
 Iron Ore Project**

**TOWNS RIVER  
 SUB-CATCHMENT  
 AREAS**

**FIGURE 1**



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**LEGEND**

- Mining Lease Boundary (approximate)
- Exploration Lease Boundary
- Modelled Channel

**Flood Modelling**

- 5 Year ARI Flood Extent
- 20 Year ARI Flood Extent
- 50 Year ARI Flood Extent
- 100 Year ARI Flood Extent
- Levee Bank for Area F Pit 1 & Pit 2
- Area F Pit 3
- Area F Pit 4
- Area F West Waste Dump
- Area F East Waste Dump

**NOTES**

Coordinate System: GDA 1994 MGA Zone 53

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Detailed shaded Relief generated from Digital Elevation Model (DEM) supplied by Client.  
World shaded Relief © Esri (2009)  
Aerial Photography sourced from Google Earth Pro  
Mining Lease boundaries digitized from plans sourced online from the Department of Resources - Northern Territory Government.  
Exploration Lease boundaries supplied by Client.

0 0.35 0.7 1.05 1.4 1.75  
Kilometers  
SCALE (at A3) 1:40,000

**Golder Associates**

|          |                              |
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| APPROVED | GRH                          |

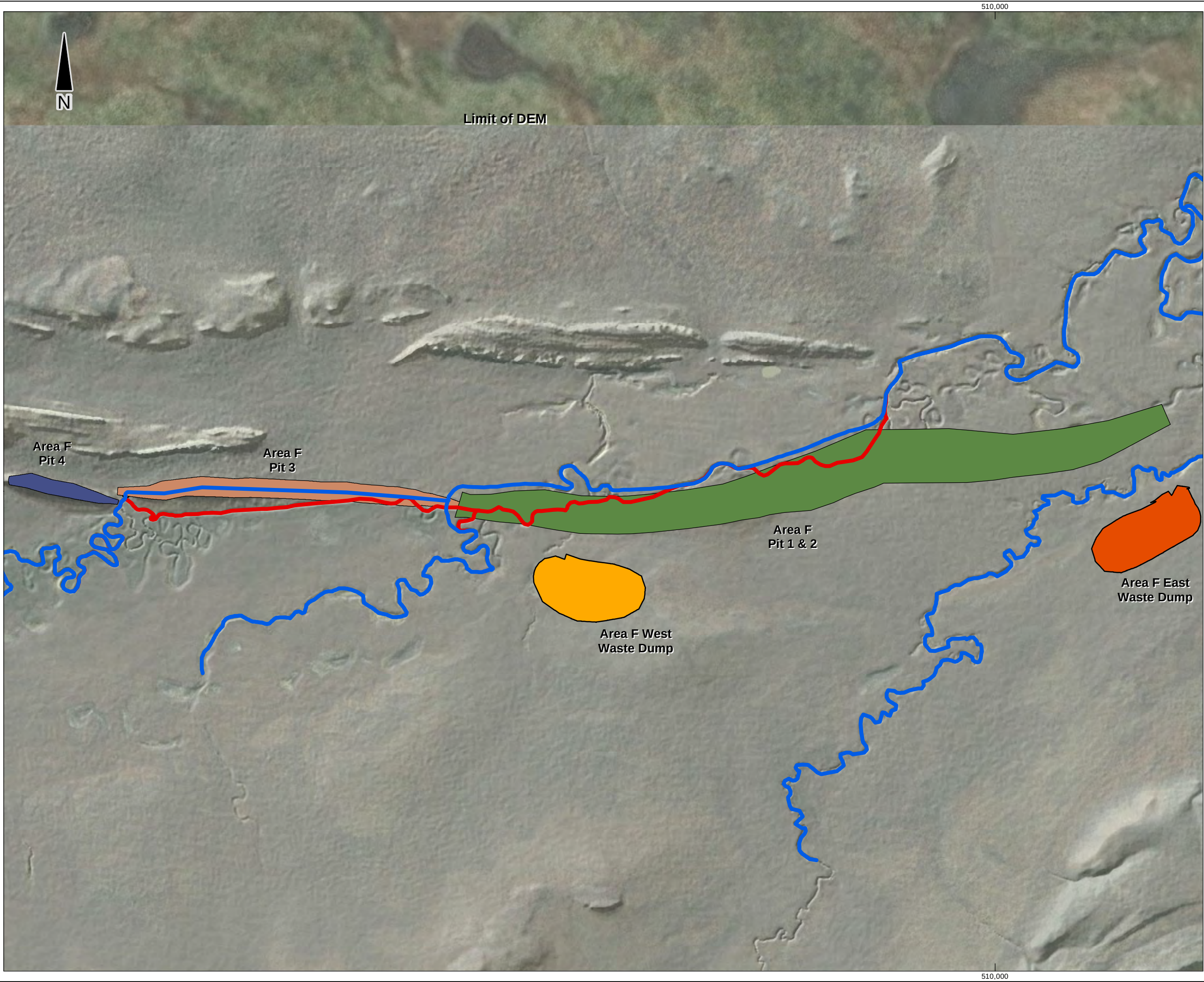
**Roper Bar  
Iron Ore Project**

**FLOOD MAP  
POST-DEVELOPMENT  
OPTION C**

**FIGURE 2**



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- LEGEND**
- Towns River (Post-Development)
  - Towns River (Pre-Development)
  - Levee Boundary for Area F Pit 1 & Pit 2
  - Area F Pit 3
  - Area F Pit 4
  - Area F West Waste Dump
  - Area F East Waste Dump

**NOTES**  
Coordinate System: GDA 1994 MGA Zone 53

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Mining Lease boundaries digitized from plans sourced online from the Department of Resources - Northern Territory Government.  
Exploration Lease boundaries supplied by Client.

0 0.2 0.4 0.6 0.8 1  
Kilometers  
SCALE (at A3) 1:20,000

  
**CLIENT** Western Desert Resources Ltd  
**DOCUMENT** 127646013-004-TM-F003-Rev1  
**DATE** 06 Aug 2012  
**COMPILED** SB  
**APPROVED** GRH

**Roper Bar  
Iron Ore Project**

**TOWNS RIVER PRE- AND  
POST-DEVELOPMENT  
CHANNEL ALIGNMENT**

**FIGURE 3**



**ATTACHMENT B**  
**Pit Filling Water Balance Scenario Summary Tables**

Summary of Pit Storage and Impact on Downstream Flows

Scenario 1 – Two consecutive dry years (Year 1: 2004-05, Year 2: 2004-05)

|                                    | Year 1 - Dry Year (2004-05) |      |      |       |      |       |       |     |      |     |      |      | Year 2 - Dry Year (2004-05) |      |      |      |      |       |       |      |      |      |      |      |
|------------------------------------|-----------------------------|------|------|-------|------|-------|-------|-----|------|-----|------|------|-----------------------------|------|------|------|------|-------|-------|------|------|------|------|------|
|                                    | Jul                         | Aug  | Sep  | Oct   | Nov  | Dec   | Jan   | Feb | Mar  | Apr | May  | Jun  | Jul                         | Aug  | Sep  | Oct  | Nov  | Dec   | Jan   | Feb  | Mar  | Apr  | May  | Jun  |
| Inflow (ML)                        | 133                         | 85   | 63   | 47    | 33   | 1,316 | 1,453 | 203 | 57   | 28  | 8    | 4    | 133                         | 85   | 63   | 47   | 33   | 1,316 | 1,453 | 203  | 57   | 28   | 8    | 4    |
| % Pit Storage                      | 0%                          | 0%   | 0%   | 1%    | 2%   | 26%   | 54%   | 56% | 57%  | 56% | 54%  | 53%  | 56%                         | 58%  | 59%  | 59%  | 59%  | 83%   | 100%  | 100% | 100% | 100% | 99%  | 99%  |
| Storage Level (m BGS) <sup>1</sup> | -28                         | -28  | -28  | -27.5 | -27  | -15   | -8.5  | -8  | -7.5 | -8  | -8.5 | -8.5 | -8                          | -7.5 | -7.5 | -7   | -7   | -3    | 0     | 0    | 0    | -0.5 | -0.5 | -0.5 |
| Pumped Volume (ML)                 | 0                           | 0    | 0    | 0     | 0    | 518   | 518   | 100 | 50   | 50  | 50   | 0    | 0                           | 0    | 0    | 0    | 0    | 518   | 0     | 0    | 0    | 0    | 0    | 0    |
| Downstream Flow(ML)                | 0                           | 0    | 0    | 0     | 0    | 518   | 518   | 100 | 50   | 50  | 50   | 0    | 0                           | 0    | 0    | 0    | 0    | 518   | 886   | 176  | 63   | 0    | 0    | 0    |
| Reduction in downstream flow (%)   | 100%                        | 100% | 100% | 100%  | 100% | 61%   | 64%   | 51% | 12%  | 0%  | 0%   | 100% | 100%                        | 100% | 100% | 100% | 100% | 61%   | 39%   | 14%  | 0%   | 100% | 100% | 100% |

Scenario 2 – Dry year followed by an average year (Year 1: 2004-05, Year 2: 2006-07)

|                                    | Year 1 - Dry Year (2004-05) |      |      |       |      |       |       |     |      |     |      |      | Year 2 - Average Year (2006-07) |      |      |      |      |      |     |       |      |      |      |      |
|------------------------------------|-----------------------------|------|------|-------|------|-------|-------|-----|------|-----|------|------|---------------------------------|------|------|------|------|------|-----|-------|------|------|------|------|
|                                    | Jul                         | Aug  | Sep  | Oct   | Nov  | Dec   | Jan   | Feb | Mar  | Apr | May  | Jun  | Jul                             | Aug  | Sep  | Oct  | Nov  | Dec  | Jan | Feb   | Mar  | Apr  | May  | Jun  |
| Inflow (ML)                        | 133                         | 85   | 63   | 47    | 33   | 1,316 | 1,453 | 203 | 57   | 28  | 8    | 4    | 315                             | 179  | 98   | 72   | 39   | 0    | 912 | 8,670 | 418  | 150  | 91   | 72   |
| % Pit Storage                      | 0%                          | 0%   | 0%   | 1%    | 2%   | 26%   | 54%   | 56% | 57%  | 56% | 54%  | 53%  | 62%                             | 66%  | 68%  | 69%  | 69%  | 69%  | 81% | 100%  | 100% | 100% | 100% | 100% |
| Storage Level (m BGS) <sup>1</sup> | -28                         | -28  | -28  | -27.5 | -27  | -15   | -8.5  | -8  | -7.5 | -8  | -8.5 | -8.5 | -7                              | -6   | -5.5 | -5   | -5   | -5.5 | -3  | 0     | 0    | 0    | 0    | 0    |
| Pumped Volume (ML)                 | 0                           | 0    | 0    | 0     | 0    | 518   | 518   | 100 | 50   | 50  | 50   | 0    | 0                               | 0    | 0    | 0    | 0    | 0    | 518 | 0     | 0    | 0    | 0    | 0    |
| Downstream Flow(ML)                | 0                           | 0    | 0    | 0     | 0    | 518   | 518   | 100 | 50   | 50  | 50   | 0    | 0                               | 0    | 0    | 0    | 0    | 0    | 518 | 8,034 | 424  | 122  | 68   | 45   |
| Reduction in downstream flow (%)   | 100%                        | 100% | 100% | 100%  | 100% | 61%   | 64%   | 51% | 12%  | 0%  | 0%   | 100% | 100%                            | 100% | 100% | 100% | 100% | 100% | 43% | 7%    | 0%   | 19%  | 26%  | 38%  |

Scenario 3 – Two consecutive average years (Year 1: 2006-07, Year 2: 2006-07)

|                                    | Year 1 - Average Year (2006-07) |      |      |      |       |       |       |       |      |      |      |      | Year 2 - Average Year (2006-07) |      |      |      |      |      |      |       |      |      |      |      |
|------------------------------------|---------------------------------|------|------|------|-------|-------|-------|-------|------|------|------|------|---------------------------------|------|------|------|------|------|------|-------|------|------|------|------|
|                                    | Jul                             | Aug  | Sep  | Oct  | Nov   | Dec   | Jan   | Feb   | Mar  | Apr  | May  | Jun  | Jul                             | Aug  | Sep  | Oct  | Nov  | Dec  | Jan  | Feb   | Mar  | Apr  | May  | Jun  |
| Inflow (ML)                        | 315                             | 179  | 98   | 72   | 39    | 0     | 912   | 8,670 | 418  | 150  | 91   | 72   | 315                             | 179  | 98   | 72   | 39   | 0    | 912  | 8,670 | 418  | 150  | 91   | 72   |
| % Pit Storage                      | 0%                              | 0%   | 0%   | 2%   | 3%    | 3%    | 15%   | 100%  | 100% | 100% | 100% | 100% | 100%                            | 100% | 100% | 100% | 100% | 99%  | 100% | 100%  | 100% | 100% | 100% | 100% |
| Storage Level (m BGS) <sup>1</sup> | -28                             | -28  | -28  | -27  | -26.5 | -26.5 | -19.5 | 0     | 0    | 0    | 0    | 0    | 0                               | 0    | 0    | 0    | -0.5 | -0.5 | 0    | 0     | 0    | 0    | 0    | 0    |
| Pumped Volume (ML)                 | 0                               | 0    | 0    | 0    | 0     | 0     | 518   | 0     | 0    | 0    | 0    | 0    | 0                               | 0    | 0    | 0    | 0    | 0    | 0    | 0     | 0    | 0    | 0    | 0    |
| Downstream Flow(ML)                | 0                               | 0    | 0    | 0    | 0     | 0     | 518   | 5,826 | 424  | 122  | 68   | 45   | 288                             | 143  | 58   | 24   | 0    | 0    | 876  | 8,676 | 424  | 122  | 68   | 45   |
| Reduction in downstream flow (%)   | 100%                            | 100% | 100% | 100% | 100%  | 100%  | 43%   | 33%   | 0%   | 19%  | 26%  | 38%  | 9%                              | 20%  | 41%  | 67%  | 100% | 100% | 4%   | 0%    | 0%   | 19%  | 26%  | 38%  |

Scenario 4 – After the pit is full, a dry year with a sustained dry season (Year 1: 2004-05, Year 2: 2005-06)

|                                    | Year 1 - Dry Year (2004-05) |      |      |      |      |       |       |      |      |      |      |      | Year 2 - Dry Start to the Year (2005-06) |      |      |      |      |       |        |       |        |        |       |      |
|------------------------------------|-----------------------------|------|------|------|------|-------|-------|------|------|------|------|------|------------------------------------------|------|------|------|------|-------|--------|-------|--------|--------|-------|------|
|                                    | Jul                         | Aug  | Sep  | Oct  | Nov  | Dec   | Jan   | Feb  | Mar  | Apr  | May  | Jun  | Jul                                      | Aug  | Sep  | Oct  | Nov  | Dec   | Jan    | Feb   | Mar    | Apr    | May   | Jun  |
| Inflow (ML)                        | 133                         | 85   | 63   | 47   | 33   | 1,316 | 1,453 | 203  | 57   | 28   | 8    | 4    | 2                                        | 0    | 0    | 0    | 496  | 1,296 | 17,798 | 2,776 | 17,432 | 17,021 | 1,584 | 491  |
| % Pit Storage                      | 100%                        | 100% | 100% | 100% | 100% | 100%  | 100%  | 100% | 100% | 100% | 99%  | 99%  | 98%                                      | 97%  | 95%  | 94%  | 100% | 100%  | 100%   | 100%  | 100%   | 100%   | 100%  | 100% |
| Storage Level (m BGS) <sup>1</sup> | 0                           | 0    | 0    | -0.5 | -0.5 | 0     | 0     | 0    | 0    | -0.5 | -0.5 | -0.5 | -0.5                                     | -0.5 | -1   | -1   | 0    | 0     | 0      | 0     | 0      | 0      | 0     | 0    |
| Pumped Volume (ML)                 | 0                           | 0    | 0    | 0    | 0    | 0     | 0     | 0    | 0    | 0    | 0    | 0    | 0                                        | 0    | 0    | 0    | 0    | 0     | 0      | 0     | 0      | 0      | 0     | 0    |
| Downstream Flow(ML)                | 0                           | 0    | 0    | 0    | 0    | 1,301 | 1,443 | 176  | 63   | 0    | 0    | 0    | 0                                        | 0    | 0    | 0    | 269  | 1,272 | 17,798 | 2,753 | 17,460 | 17,023 | 1,554 | 463  |
| Reduction in downstream flow (%)   | 100%                        | 100% | 100% | 100% | 100% | 1%    | 1%    | 14%  | 0%   | 100% | 100% | 100% | 100%                                     | 100% | 100% | 100% | 46%  | 2%    | 0%     | 1%    | 0%     | 0%     | 2%    | 6%   |

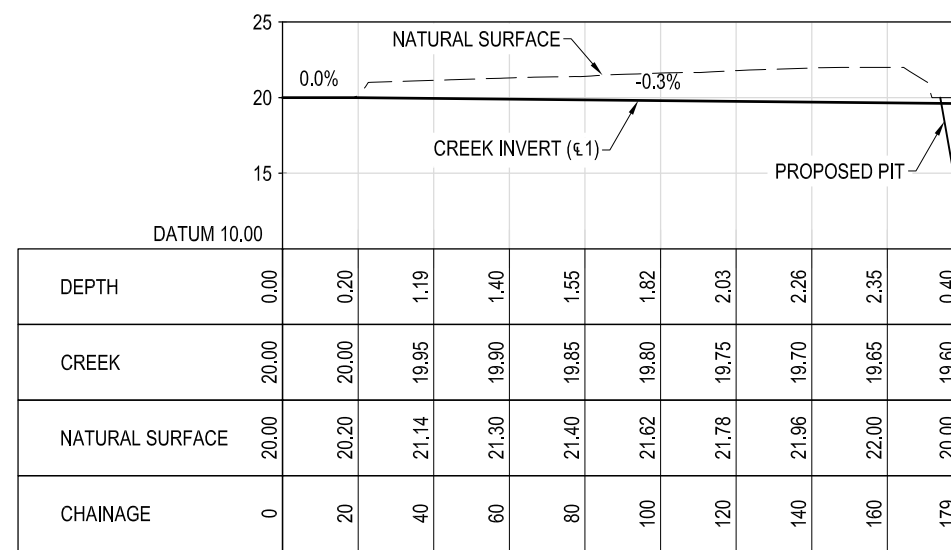
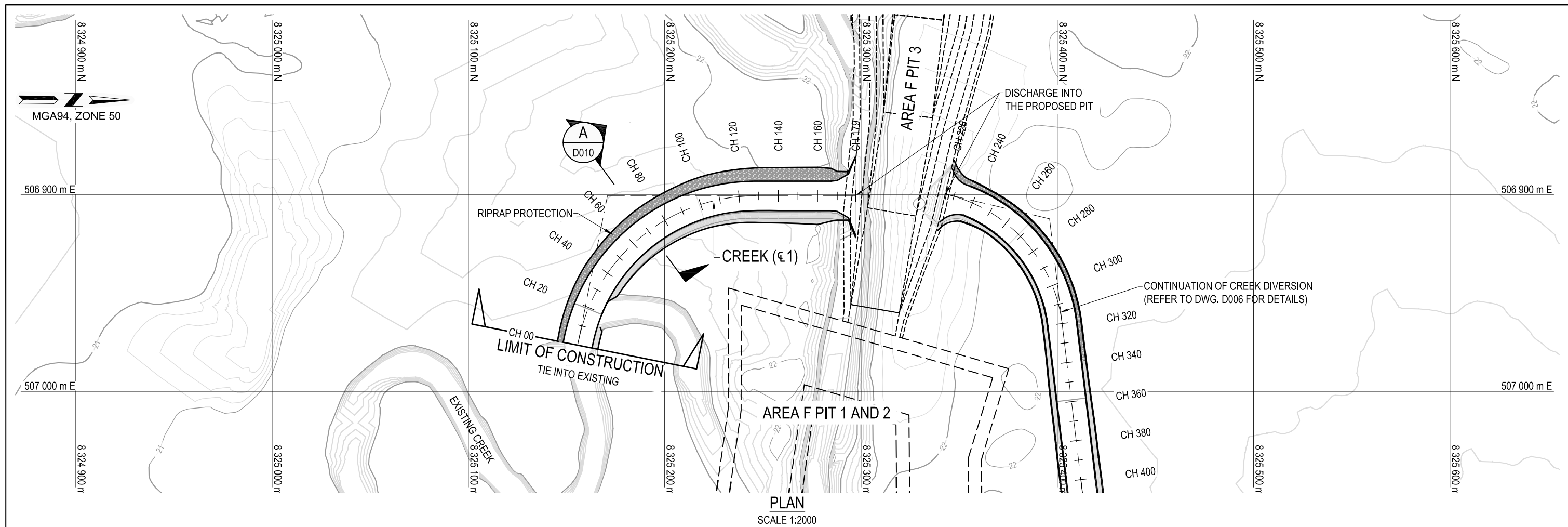
<sup>1</sup> BGS = Below Ground Surface

## **ATTACHMENT C**

**Designs for Option C - Preliminary**



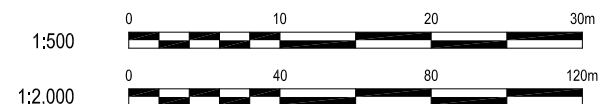




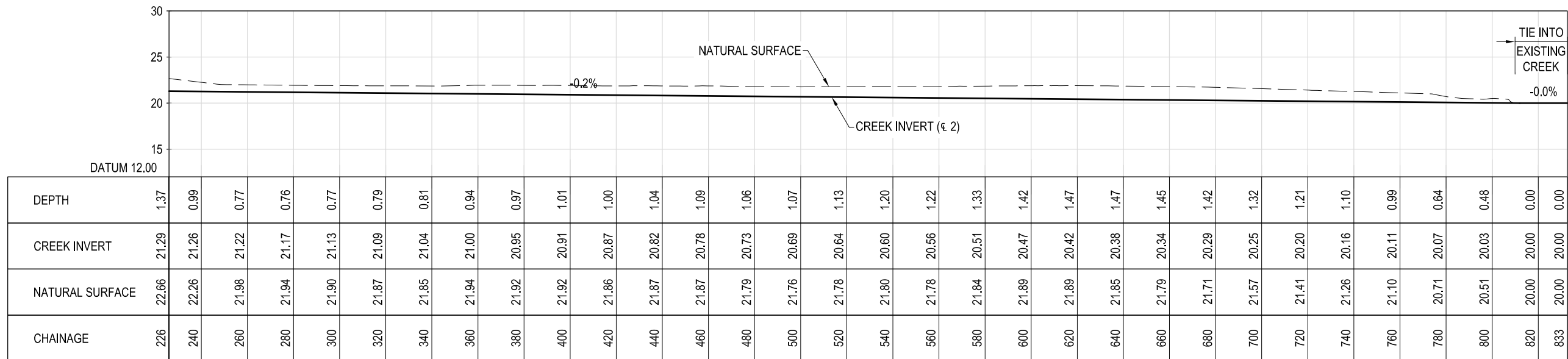
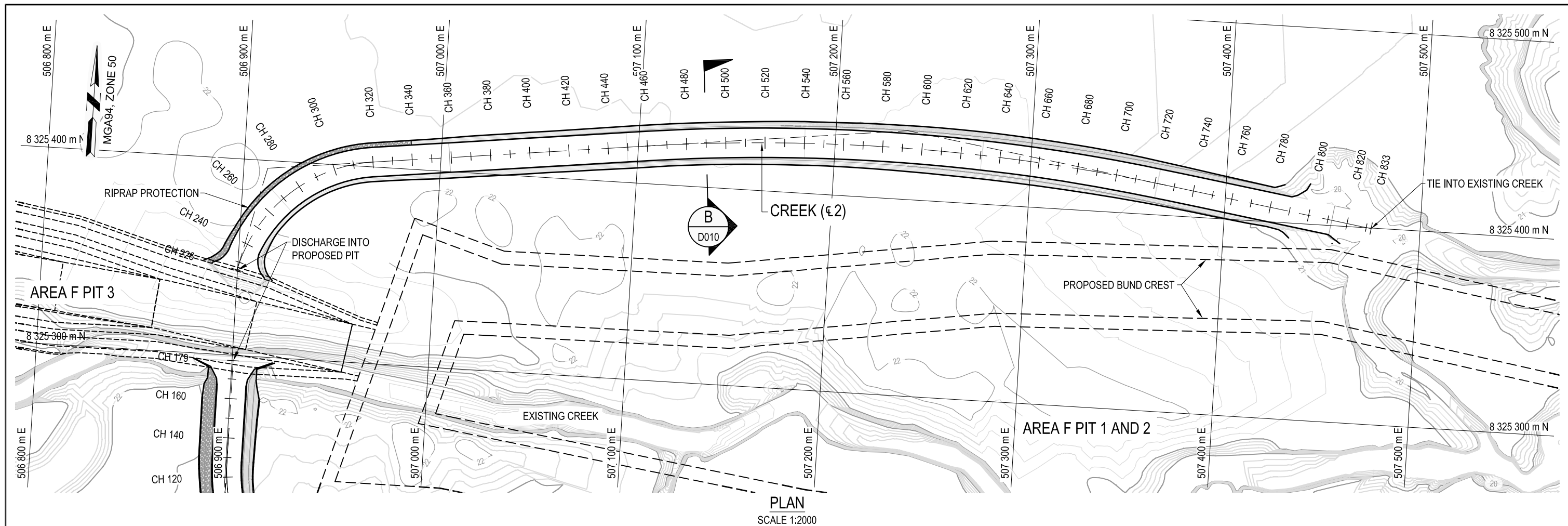
LONGITUDINAL SECTION CH0 - CH179

HOR. SCALE 1:2000  
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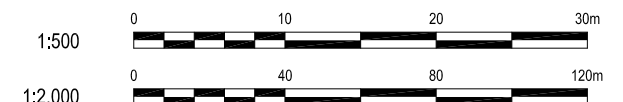
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|                             |             |  |  |  |  |  | A PRELIMINARY ISSUE FOR CLIENT COMMENT                                                                                            |             |        |              |            |      |                             |                                                                                                                                                                                                                                                                                                                   |                   |                  |                         |                                                                |               |                    |               |  |
| REVISION                    | DESCRIPTION |  |  |  |  |  | DRAWN                                                                                                                             | DRAWN CHECK | DESIGN | DESIGN CHECK | AUTHORISED | DATE | LEAD PROJECT DRAFTER<br>ESK | PROJECT MANAGER<br>MG                                                                                                                                                                                                                                                                                             | SCALE<br>AS SHOWN | SHEET SIZE<br>A3 | PROJECT No<br>127646013 | DOC No<br>004                                                  | DOC TYPE<br>M | DRAWING No<br>D002 | REVISION<br>1 |  |



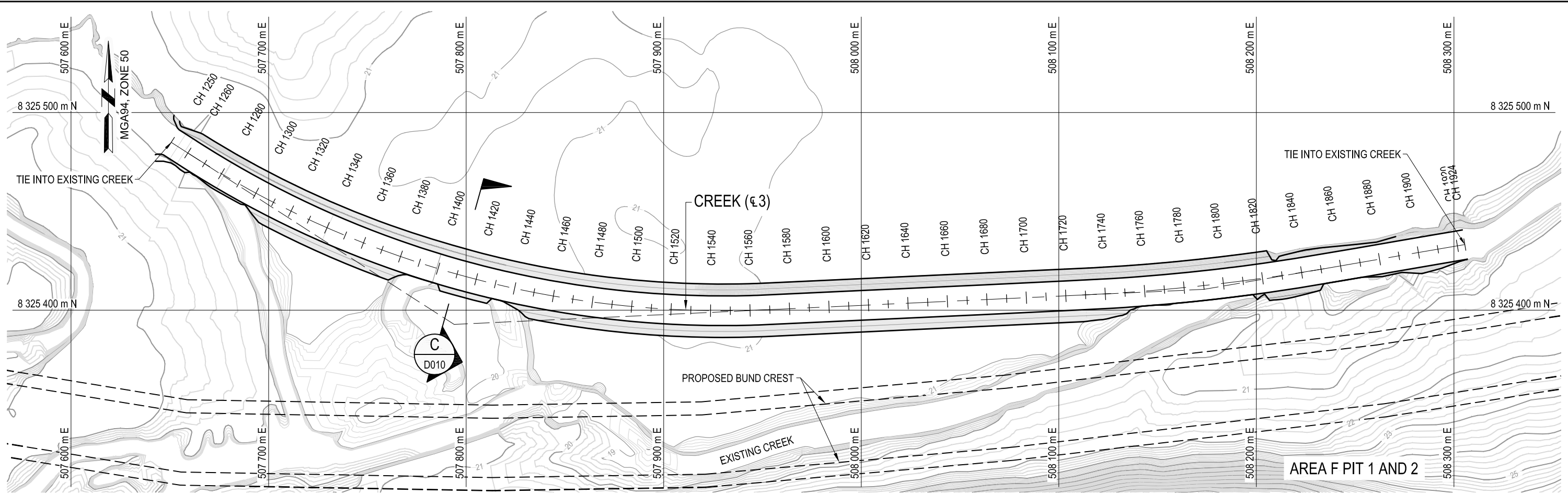
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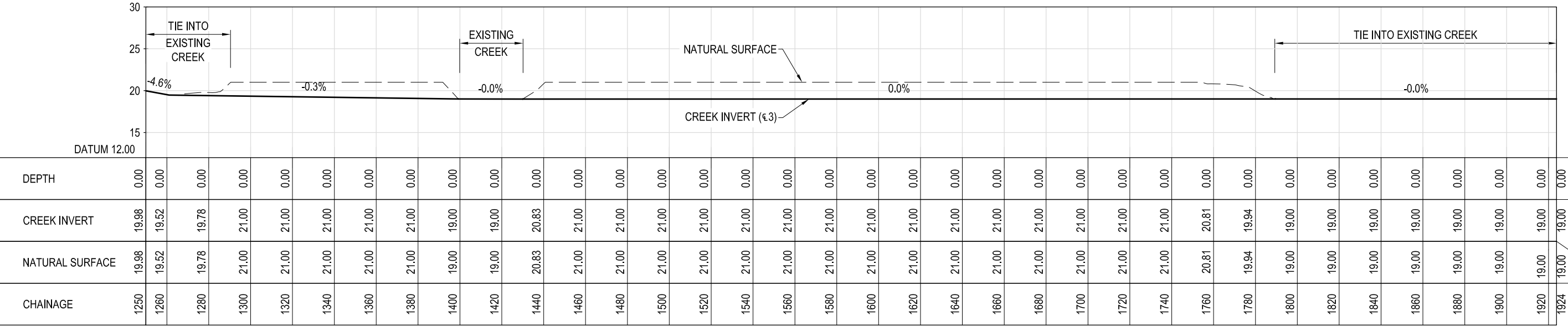


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|                                        |  |  |  |  |  |  |  | DRAWN<br>DRAWN CHECK<br>DESIGN<br>DESIGN CHECK<br>AUTHORISED<br>DATE                                                   |  |  |  | PROJECT MANAGER<br>MG                                                                                                   |  |  |  | DOC No<br>004                                                  |  |  |  |
| A PRELIMINARY ISSUE FOR CLIENT COMMENT |  |  |  |  |  |  |  | SCALE<br>AS SHOWN                                                                                                      |  |  |  | SHEET SIZE<br>A3                                                                                                        |  |  |  | DOC TYPE<br>M                                                  |  |  |  |
| REVISION                               |  |  |  |  |  |  |  | DRAWING No<br>D003                                                                                                     |  |  |  | REVISION<br>1                                                                                                           |  |  |  |                                                                |  |  |  |



PLAN

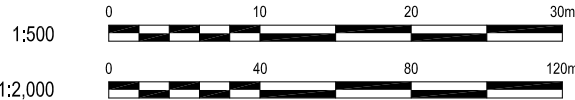
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LONGITUDINAL SECTION CH1250 - CH1924

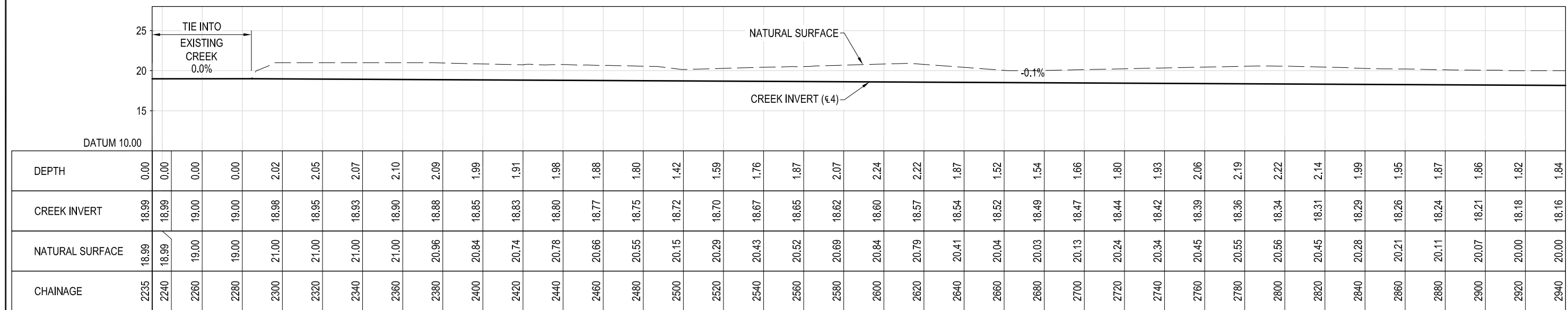
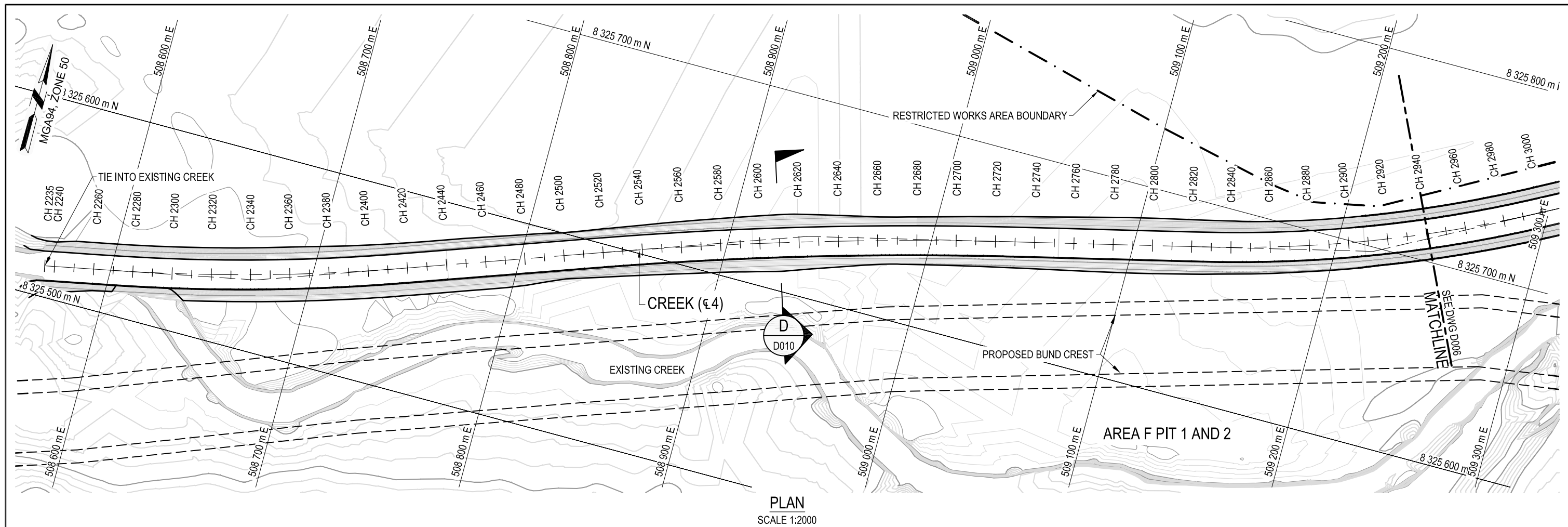
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| <div>WORK IN PROGRESS</div> |  |                                      |  |  |  |  |  | <div>INFORMATION CONTAINED ON THIS DRAWING IS THE COPYRIGHT OF GOLDER ASSOCIATES PTY. LTD.</div>                                  |  |             |  |        |  |              |  | <div><div><div><div></div><div>Golder Associates</div></div><div>1 HAVELOCK STREET<br/>WEST PERTH, WA 6005<br/>AUSTRALIA<br/>PH (08) 9213 7600<br/>FAX (08) 9213 7611<br/>WEB: www.golder.com</div></div></div> |  |      |  | <div>CLIENT<br/>Western Desert Resources Ltd</div> |  |  |  |                                                                             |  |  |  |                              |  |  |  |                                     |  |  |  |                           |  |  |  |                           |  |  |  |                                |  |  |  |                           |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|                             |  |                                      |  |  |  |  |  | <div>UNAUTHORISED USE OR REPRODUCTION OF THIS PLAN EITHER WHOLLY OR IN PART WITHOUT WRITTEN PERMISSION INFRINGES COPYRIGHT.</div> |  |             |  |        |  |              |  | <div>PROJECT<br/>Roper Bar Project - Ephemeral Creek Re-Alignment</div>                                                                                                                                         |  |      |  |                                                    |  |  |  | <div>DRAWING TITLE<br/>PLAN AND LONGITUDINAL SECTION<br/>SHEET 3 OF 5</div> |  |  |  |                              |  |  |  |                                     |  |  |  |                           |  |  |  |                           |  |  |  |                                |  |  |  |                           |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| A                           |  | PRELIMINARY ISSUE FOR CLIENT COMMENT |  |  |  |  |  | DRAWN                                                                                                                             |  | DRAWN CHECK |  | DESIGN |  | DESIGN CHECK |  | AUTHORISED                                                                                                                                                                                                      |  | DATE |  |                                                    |  |  |  |                                                                             |  |  |  |                              |  |  |  |                                     |  |  |  |                           |  |  |  |                           |  |  |  |                                |  |  |  |                           |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |





WORK IN PROGRESS

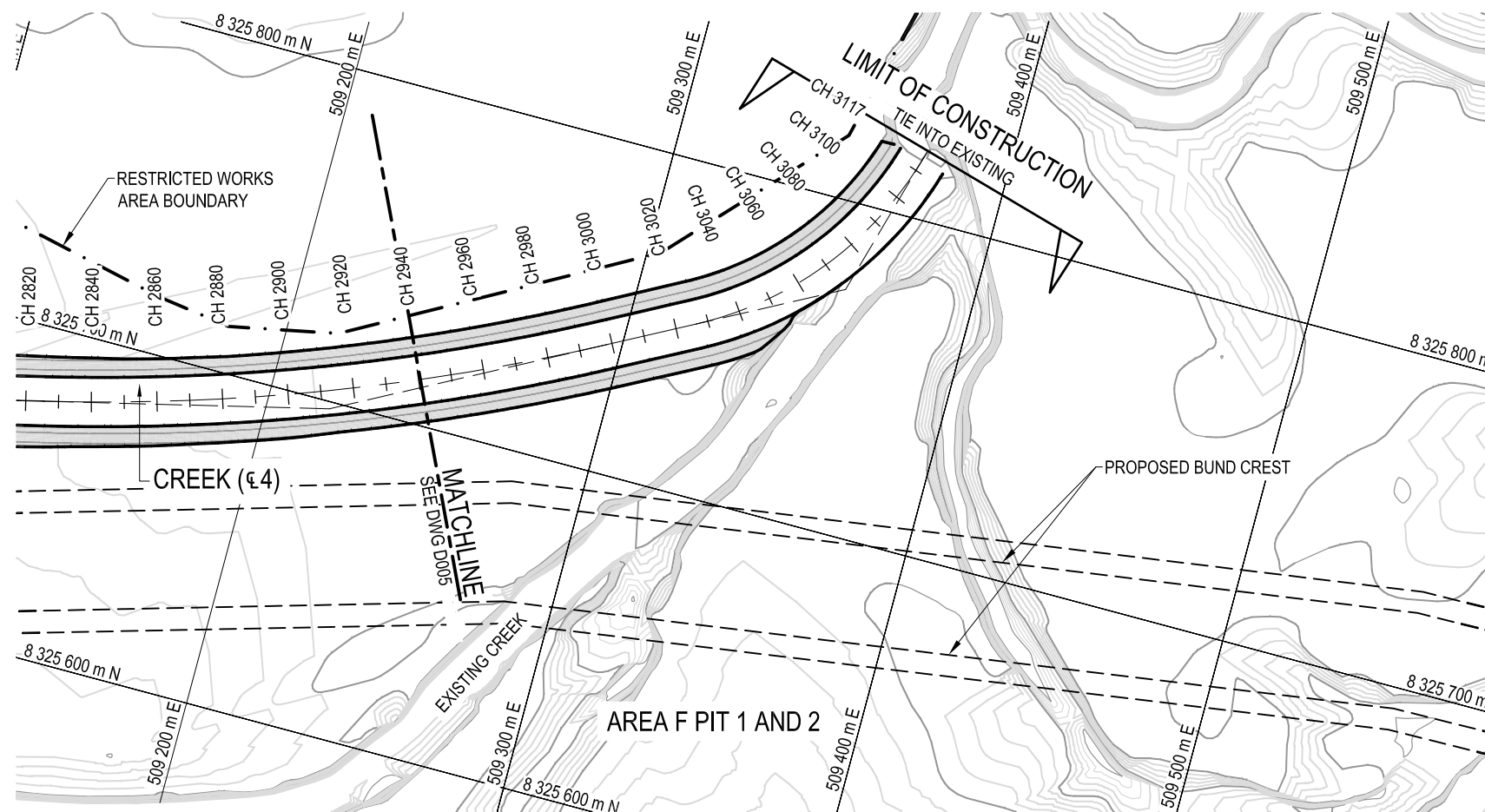
LONGITUDINAL SECTION CH2235 - CH2940  
HOR. SCALE 1:2000  
VERT. SCALE 1:500

ISSUED FOR  
**DRAFT**  
NOT FOR CONSTRUCTION

0 10 20 30m  
0 40 80 120m

1:500  
1:2,000

|                                                                                                                        |  |                                                                                                                         |  |                                                             |  |
|------------------------------------------------------------------------------------------------------------------------|--|-------------------------------------------------------------------------------------------------------------------------|--|-------------------------------------------------------------|--|
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| SCALE<br>AS SHOWN                                                                                                      |  | SHEET SIZE<br>A3                                                                                                        |  | PROJECT No<br>127646013                                     |  |
| DRAWN                                                                                                                  |  | DRAWN CHECK                                                                                                             |  | DESIGN                                                      |  |
| DESIGN CHECK                                                                                                           |  | AUTHORISED                                                                                                              |  | DATE                                                        |  |



SCALE 1:2000



**ISSUED FOR**

**DRAFT**

**NOT FOR CONSTRUCTION**

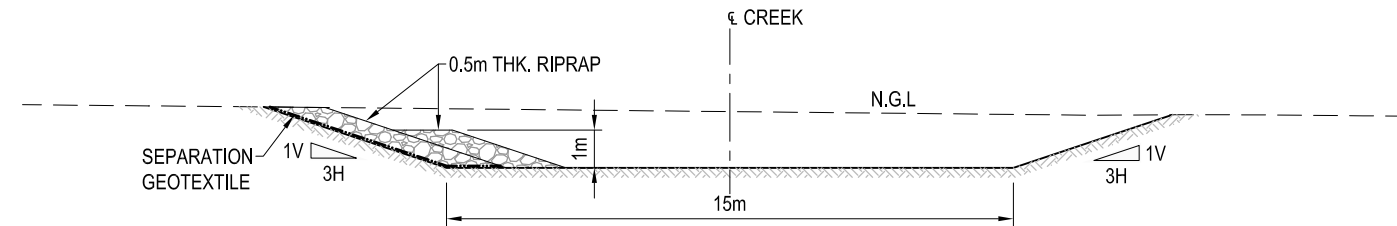
1:400

0 8 16 24m

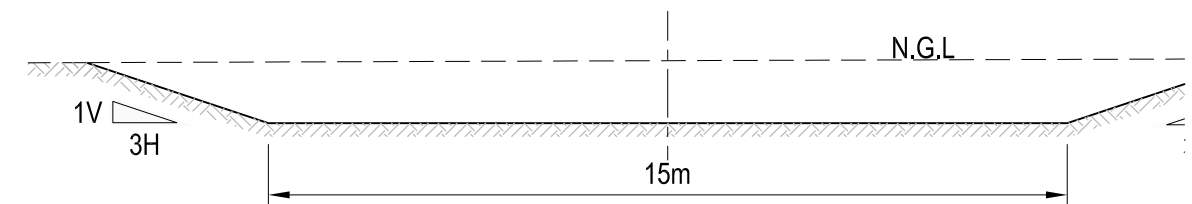
1:2,000

0 40 80 120m

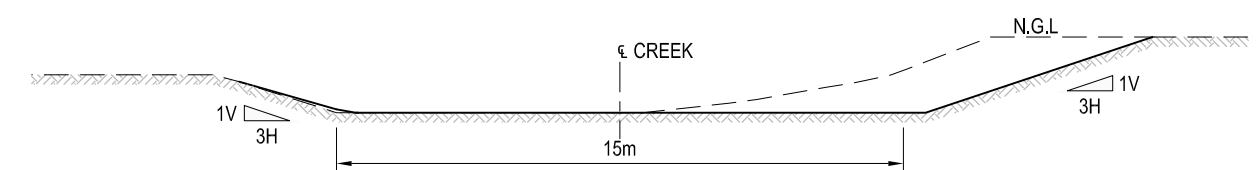
Plot Date: 6 August 2012 Time:12:53:29 PM By: Werder-Bigham, Rogan Path: J:\Hydro\2012\127646013 Western Desert Roper Bar NTCAD\DRAWINGS - File Name: 127646013-004-M-D006-REV1.dwg  
Xref: GAP LOGO-A3.dwg; 127646013-XREF-area f west v3.dwg; 127646013-XREF-DESIGN REV2 nwb.dwg; 127646013-XREF-LEVEE BANK REV1.dwg; 127646013-XREF-LEVEE BANK.dwg;



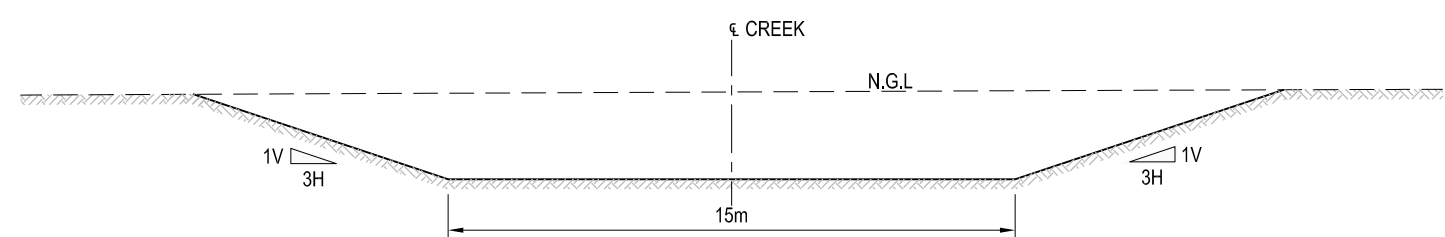
SECTION A TYPICAL SECTION AT CH70  
HOR SCALE 1:200  
VER SCALE 1:200



SECTION B TYPICAL SECTION AT CH530  
HOR SCALE 1:200  
VER SCALE 1:200



SECTION C TYPICAL SECTION AT CH1430  
HOR SCALE 1:200  
VER SCALE 1:200



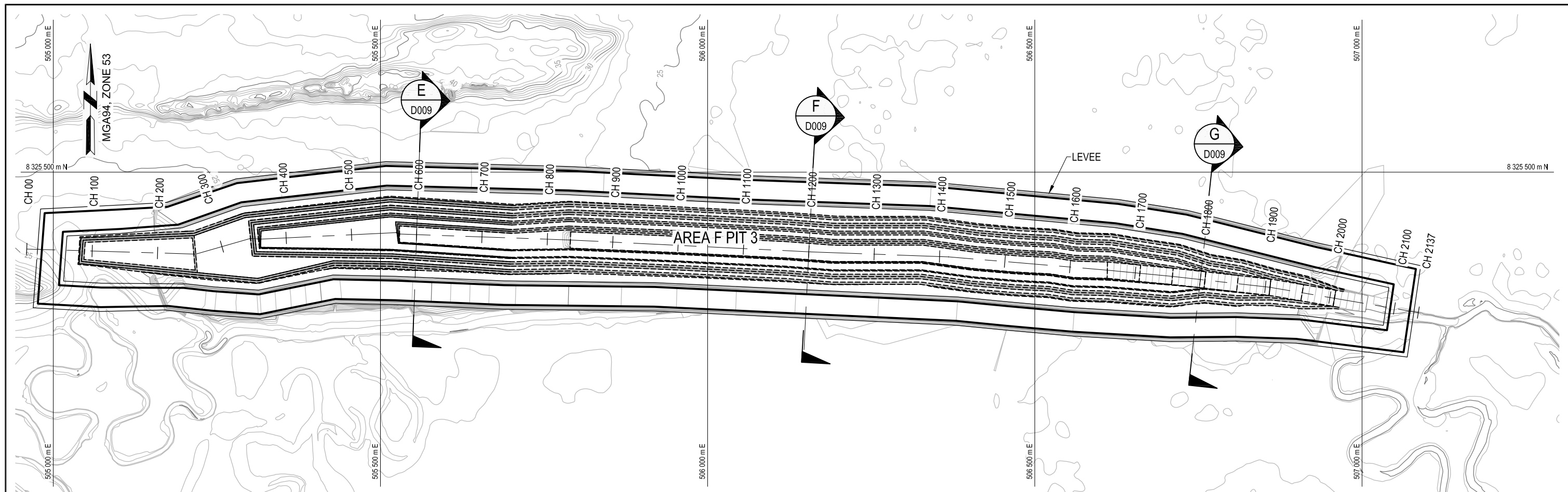
SECTION D TYPICAL SECTION AT CH2610  
HOR SCALE 1:200  
VER SCALE 1:200

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NOT FOR CONSTRUCTION

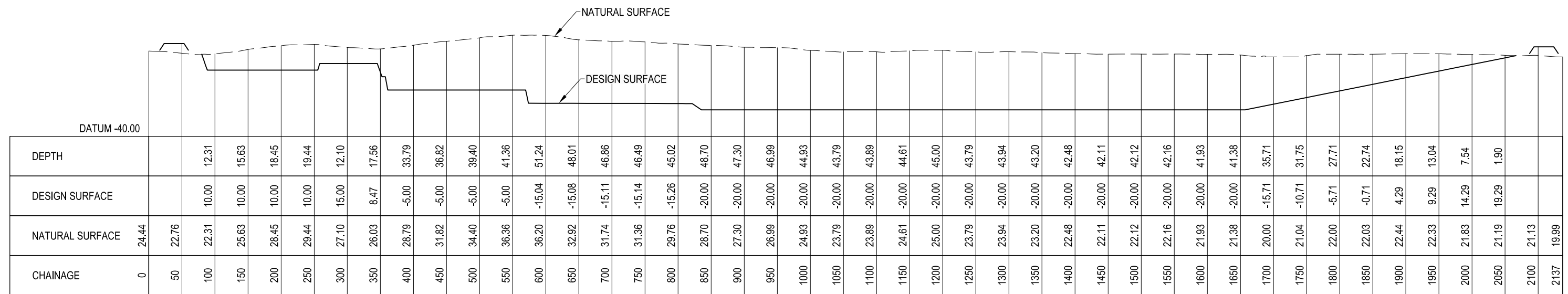


|                     |  |  |  |  |  |  |  |                                                                                                                                                                                                                                                  |  |                                                                                                                         |  |                                         |  |                    |  |
|---------------------|--|--|--|--|--|--|--|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|-------------------------------------------------------------------------------------------------------------------------|--|-----------------------------------------|--|--------------------|--|
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|                     |  |  |  |  |  |  |  |                                                                                                                                                                                                                                                  |  | PROJECT<br>Roper Bar Project - Ephemeral Creek Re-Alignment                                                             |  | DRAWING TITLE<br>TYPICAL CROSS SECTIONS |  |                    |  |
| A PRELIMINARY ISSUE |  |  |  |  |  |  |  | LEAD PROJECT DRAFTER<br>ESK                                                                                                                                                                                                                      |  | PROJECT MANAGER<br>MG                                                                                                   |  | SCALE<br>AS SHOWN                       |  | SHEET SIZE<br>A3   |  |
| REVISION            |  |  |  |  |  |  |  | PROJECT No<br>127646013                                                                                                                                                                                                                          |  | DOC No<br>004                                                                                                           |  | DOC TYPE<br>M                           |  | DRAWING No<br>D007 |  |
| DESCRIPTION         |  |  |  |  |  |  |  | DRAWN                                                                                                                                                                                                                                            |  | DRAWN CHECK                                                                                                             |  | DESIGN                                  |  | DESIGN CHECK       |  |
|                     |  |  |  |  |  |  |  | AUTHORISED                                                                                                                                                                                                                                       |  | DATE                                                                                                                    |  |                                         |  | REVISION           |  |
|                     |  |  |  |  |  |  |  |                                                                                                                                                                                                                                                  |  |                                                                                                                         |  |                                         |  | 1                  |  |





PLAN  
SCALE 1:6000

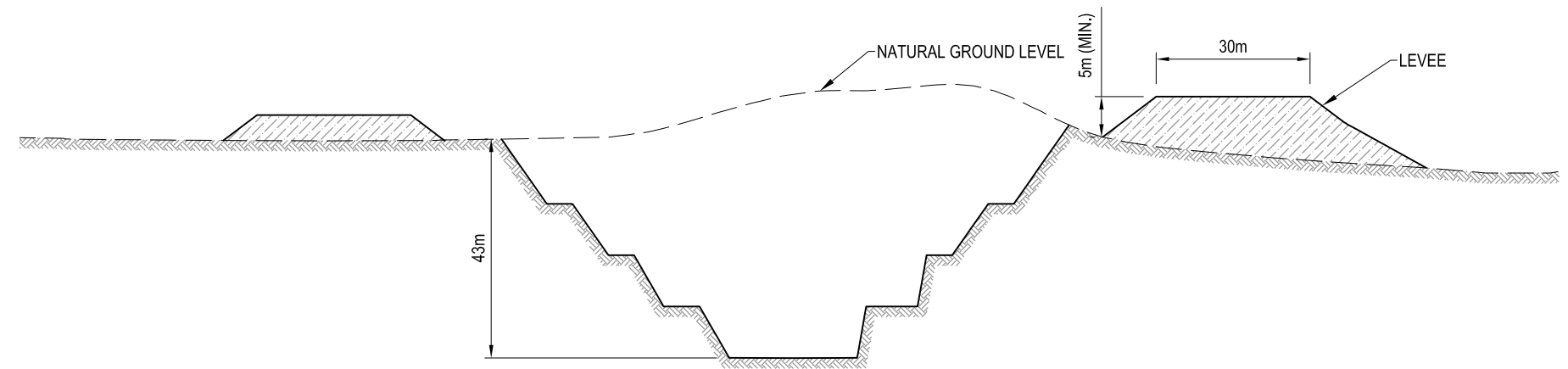


LONGITUDINAL SECTION  
HOR. SCALE 1:3,000  
VER. SCALE 1:6,000

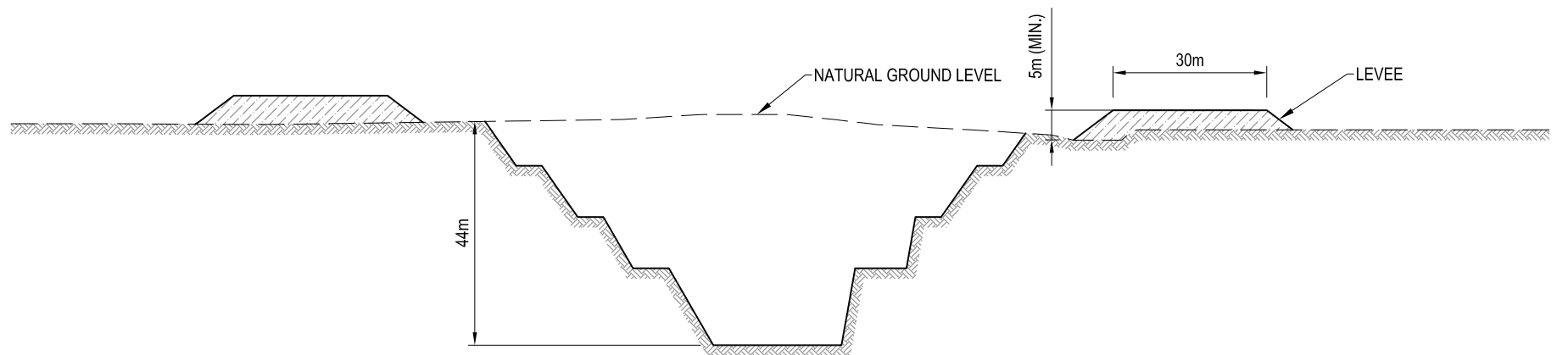
ISSUED FOR  
**DRAFT**  
NOT FOR CONSTRUCTION



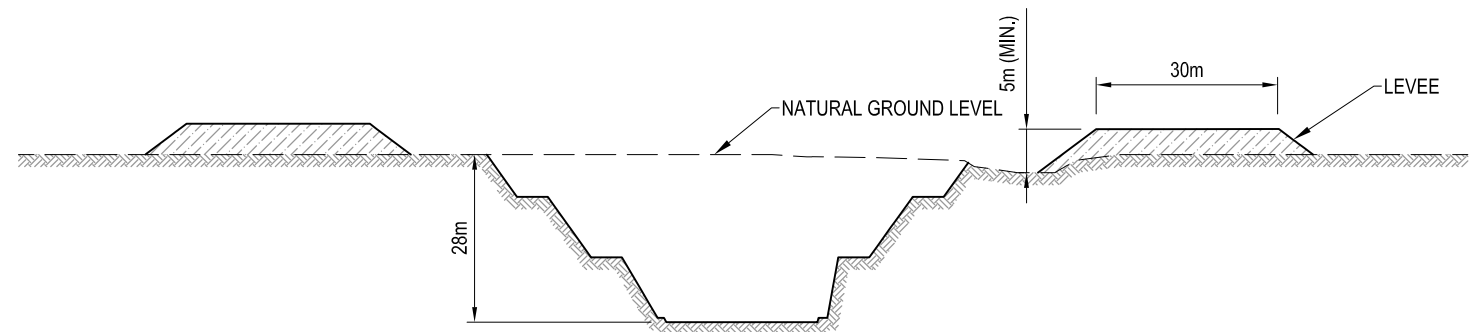
|                                        |             |  |  |  |  |  |                                                                                                                        |             |        |              |            |      |  |                                                                                                                                                                                                                                          |  |                   |  |                                                                          |  |               |  |                    |  |               |  |
|----------------------------------------|-------------|--|--|--|--|--|------------------------------------------------------------------------------------------------------------------------|-------------|--------|--------------|------------|------|--|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|-------------------|--|--------------------------------------------------------------------------|--|---------------|--|--------------------|--|---------------|--|
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|                                        |             |  |  |  |  |  | © GOLDER ASSOCIATES PTY. LTD.                                                                                          |             |        |              |            |      |  | PROJECT No<br>127646013                                                                                                                                                                                                                  |  |                   |  | DOC No<br>004                                                            |  | DOC TYPE<br>M |  | DRAWING No<br>D008 |  | REVISION<br>1 |  |
|                                        |             |  |  |  |  |  | LEAD PROJECT DRAFTER<br>ESK                                                                                            |             |        |              |            |      |  | PROJECT MANAGER<br>MG                                                                                                                                                                                                                    |  | SCALE<br>AS SHOWN |  | SHEET SIZE<br>A3                                                         |  |               |  |                    |  |               |  |
| A PRELIMINARY ISSUE FOR CLIENT COMMENT |             |  |  |  |  |  |                                                                                                                        |             |        |              |            |      |  |                                                                                                                                                                                                                                          |  |                   |  |                                                                          |  |               |  |                    |  |               |  |
| REVISION                               | DESCRIPTION |  |  |  |  |  | DRAWN                                                                                                                  | DRAWN CHECK | DESIGN | DESIGN CHECK | AUTHORISED | DATE |  |                                                                                                                                                                                                                                          |  |                   |  |                                                                          |  |               |  |                    |  |               |  |



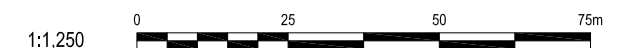
SECTION E SECTION CHN: 600  
SCALE 1:1,250



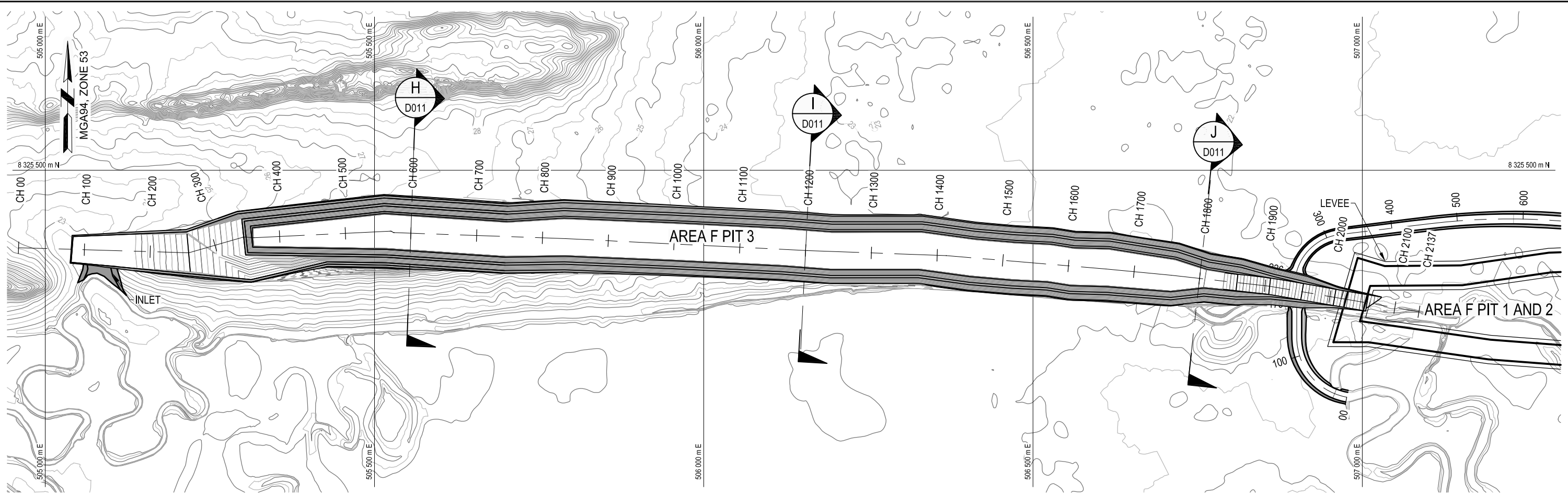
SECTION F SECTION CHN: 1200  
SCALE 1:1,250



SECTION G SECTION CHN: 1800  
SCALE 1:1,250

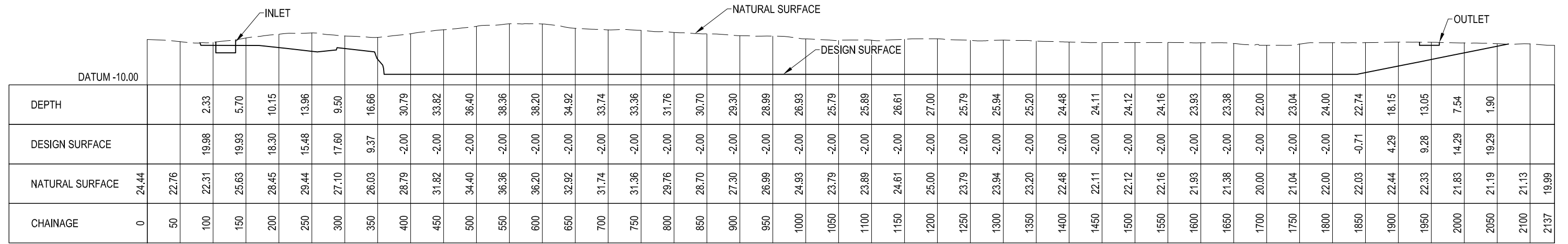


|                             |                   |  |  |  |  |  |  |                                                                                                                        |             |        |              |                                                                                                                         |      |               |               |                                                  |               |  |  |
|-----------------------------|-------------------|--|--|--|--|--|--|------------------------------------------------------------------------------------------------------------------------|-------------|--------|--------------|-------------------------------------------------------------------------------------------------------------------------|------|---------------|---------------|--------------------------------------------------|---------------|--|--|
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|                             |                   |  |  |  |  |  |  | © GOLDER ASSOCIATES PTY. LTD.                                                                                          |             |        |              | LEAD PROJECT DRAFTER<br>ESK                                                                                             |      |               |               | PROJECT MANAGER<br>MG                            |               |  |  |
|                             |                   |  |  |  |  |  |  | SCALE<br>AS SHOWN                                                                                                      |             |        |              | SHEET SIZE<br>A3                                                                                                        |      |               |               | PROJECT No<br>127646013                          |               |  |  |
| REVISION                    | DESCRIPTION       |  |  |  |  |  |  | DRAWN                                                                                                                  | DRAWN CHECK | DESIGN | DESIGN CHECK | AUTHORISED                                                                                                              | DATE | DOC No<br>004 | DOC TYPE<br>M | DRAWING No<br>D009                               | REVISION<br>1 |  |  |
| A                           | PRELIMINARY ISSUE |  |  |  |  |  |  |                                                                                                                        |             |        |              |                                                                                                                         |      |               |               |                                                  |               |  |  |



PLAN

SCALE 1:6000



LONGITUDINAL SECTION

HOR. SCALE 1:3,000

VER. SCALE 1:6,000

ISSUED FOR  
**DRAFT**  
NOT FOR CONSTRUCTION

1:3,000

1:6,000



|                             |  |  |  |  |  |  |  |                                                                                                                                                                                                                                                                             |  |  |  |  |  |  |  |                                                                                                                                                                                                                                                                                                                                                                      |  |  |  |                                                                                                                                                                                                                   |  |  |  |                       |  |  |  |                   |  |  |  |                  |  |  |  |                         |  |  |  |               |  |  |  |               |  |  |  |                    |  |  |  |               |  |  |  |
|-----------------------------|--|--|--|--|--|--|--|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|--|--|--|--|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|-----------------------|--|--|--|-------------------|--|--|--|------------------|--|--|--|-------------------------|--|--|--|---------------|--|--|--|---------------|--|--|--|--------------------|--|--|--|---------------|--|--|--|
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|                             |  |  |  |  |  |  |  |                                                                                                                                                                                                                                                                             |  |  |  |  |  |  |  |                                                                                                                                                                                                                                                                                                                                                                      |  |  |  |                                                                                                                                                                                                                   |  |  |  |                       |  |  |  |                   |  |  |  |                  |  |  |  |                         |  |  |  |               |  |  |  |               |  |  |  |                    |  |  |  |               |  |  |  |
|                             |  |  |  |  |  |  |  | A PRELIMINARY ISSUE FOR CLIENT COMMENT                                                                                                                                                                                                                                      |  |  |  |  |  |  |  |                                                                                                                                                                                                                                                                                                                                                                      |  |  |  |                                                                                                                                                                                                                   |  |  |  |                       |  |  |  |                   |  |  |  |                  |  |  |  |                         |  |  |  |               |  |  |  |               |  |  |  |                    |  |  |  |               |  |  |  |
|                             |  |  |  |  |  |  |  | REVISION DESCRIPTION                                                                                                                                                                                                                                                        |  |  |  |  |  |  |  | DRAWN                                                                                                                                                                                                                                                                                                                                                                |  |  |  | DRAWN CHECK                                                                                                                                                                                                       |  |  |  | DESIGN                |  |  |  | DESIGN CHECK      |  |  |  | AUTHORISED       |  |  |  | DATE                    |  |  |  |               |  |  |  |               |  |  |  |                    |  |  |  |               |  |  |  |
|                             |  |  |  |  |  |  |  |                                                                                                                                                                                                                                                                             |  |  |  |  |  |  |  |                                                                                                                                                                                                                                                                                                                                                                      |  |  |  | LEAD PROJECT DRAFTER<br>ESK                                                                                                                                                                                       |  |  |  | PROJECT MANAGER<br>MG |  |  |  | SCALE<br>AS SHOWN |  |  |  | SHEET SIZE<br>A3 |  |  |  | PROJECT No<br>127646013 |  |  |  | DOC No<br>004 |  |  |  | DOC TYPE<br>M |  |  |  | DRAWING No<br>D010 |  |  |  | REVISION<br>1 |  |  |  |



