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Calibre Rail
Alpha Coal Project - Rail
Phase 1B

Detailed Floodplain Study
Belyando River /
Native Companion Creek

HC-CRL-24100-RPT-0130
CJVP10007-REP-C-011

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1.0 PURPOSE

The purpose of this report is to analyse and assess the impact of the Alpha Coal Project (ACP) railway line as it traverses the Belyando River/Native Companion Creek floodplain system. The analysis provides recommendations of the cross-drainage infrastructure required to minimise impacts to existing flowpaths and to meet the conditions set in the Environmental Impact Study (EIS) and the Supplementary Environmental Impact Study (SEIS).

This report provides details of the floodplain analysis undertaken for the Belyando River and Native Companion Creek systems. It details the pre- and post-development inundation extents for the 5, 50 and 100 year Average Recurrence Interval (ARI) events. The results for depths of flow, velocity fields and afflux from the development of the railway have been assessed for the approved design criteria of the 50 year ARI event.

2.0 PROJECT BACKGROUND

Hancock Coal Infrastructure Pty Ltd (HCIPL) are undertaking an investigation into the development of a 30 Mtpa open pit, thermal coal mine within the Galilee Basin 50km north of the Alpha township in central Queensland. This project is known as the Alpha Coal Project (ACP). A project overview can be seen in Figure 1.

As part of this project, a 500km standard gauge rail alignment and its associated infrastructure is required to transport the coal from the mine, at Alpha, to the port, at Abbot Point, north of Bowen. Calibre has recently completed the Bankable Feasibility Study (BFS) for the rail alignment and is continuing to progress the identified critical path detail design activities.

Subsequent to this, an EIS has been prepared and corresponding SEIS compiled to clearly define design parameters to be adhered to in any further investigations, and eventually, design.

Part of the stakeholder response to the EIS identified specific concerns that were raised in relation to the drainage criteria approved by Hancock Coal in the BFS. The SEIS has taken into account these concerns and the drainage criteria updated to address the issues raised in the EIS. This Detail Floodplain Study takes into account these changes in the drainage criteria developed for the SEIS.

Figure 1: Proposed Alpha Coal Railway Alignment

3.0 REFERENCES, CODES AND STANDARDS

The following reports and codes were used as part of the floodplain modelling:

- BFS Drainage Engineering Report (CJVP10007-REP-C-001/ HC-CRL-24100-RPT-0022);
- Queensland Government Climate Change Guidelines: Increasing Queensland's resilience to inland flooding in a changing climate (2010);
- Australian Rainfall and Runoff (AR&R);
- C&R land holder consultation;
- EIS and SEIS.

The following data sources were used for the hydrologic and hydraulic modelling:

- Department of Environment and Resource management (DERM) blended topographic survey data (Shuttle Radar Topography Mission (SRTM) and combined contour data);
- LiDAR data for current alignment (600m wide corridor with a vertical accuracy of ±100mm) provided by HCIPL;
- LiDAR data flown for BFS alignment (1600m wide corridor with a vertical accuracy of ±500mm) provided by HCIPL;
- LiDAR Flood Study data provided by HCIPL (vertical accuracy of ±500mm);
- DERM stream-gauge historical data;
- Bureau of Meteorology (BoM) Intensity-Frequency-Duration (IFD) regional data.

4.0 ABBREVIATIONS

ACP	Alpha Coal Project
AEP	Average Exceedance Probability
AR&R	Australian Rainfall and Runoff
ARI	Average Recurrence Interval
BFS	Bankable Feasibility Study
BoM	Bureau of Meteorology
C&R	C&R Consulting Pty Ltd
CatchmentSIM	Hydrologic catchment delineation program
CSP	Corrugated Steel Pipe
DERM	Department of Environment and Resource Management
EIS	Environmental Impact Statement
FFA	Flood Frequency Analysis
HCPL	Hancock Coal Pty Ltd
HCIPL	Hancock Coal Infrastructure Pty Ltd
IFD	Intensity-Frequency-Duration
LiDAR	Light Detection and Ranging
RORB	Rainfall and runoff routing program
SEIS	Supplementary Environmental Impact Statement
SRTM	Shuttle Radar Topography Mission
TOF	Top of Formation

5.0 INTRODUCTION

The proposed rail alignment for the ACP currently crosses the Belyando-Native Companion floodplain. The analysis was conducted for this system during the BFS and identified that further detailed hydraulic analysis was required due to the complex floodplain interaction that exists between the two systems. More accurate LiDAR along the alignment, Landholder consultation and extended historical stream-gauge records were all incorporated into this study.

The primary output of the Detailed Floodplain Study was to provide detailed mapping of the pre- and post-development flood extents, inundation durations, flow velocities and afflux predictions for the Native Companion - Belyando system. Of particular interest in this study was to assess the impacts that the proposed rail alignment would have on the existing surrounding environment and Landholders.

5.1 Floodplain Location and Description

The Native Companion-Belyando system has a combined catchment area of 10,750km^2 and is a major portion of the Belyando Sub-Basin (35,000km^2) in the Burdekin River Catchment. The terrain is predominantly very flat with vast floodplains, primarily used for grazing on natural pastures. The landscape is semi-arid with predominantly ephemeral streams (typically flow each year during the wet season between December and April).

A locality plan of the affected catchments that interface with the Alpha Coal Railway is illustrated in Figure 2.

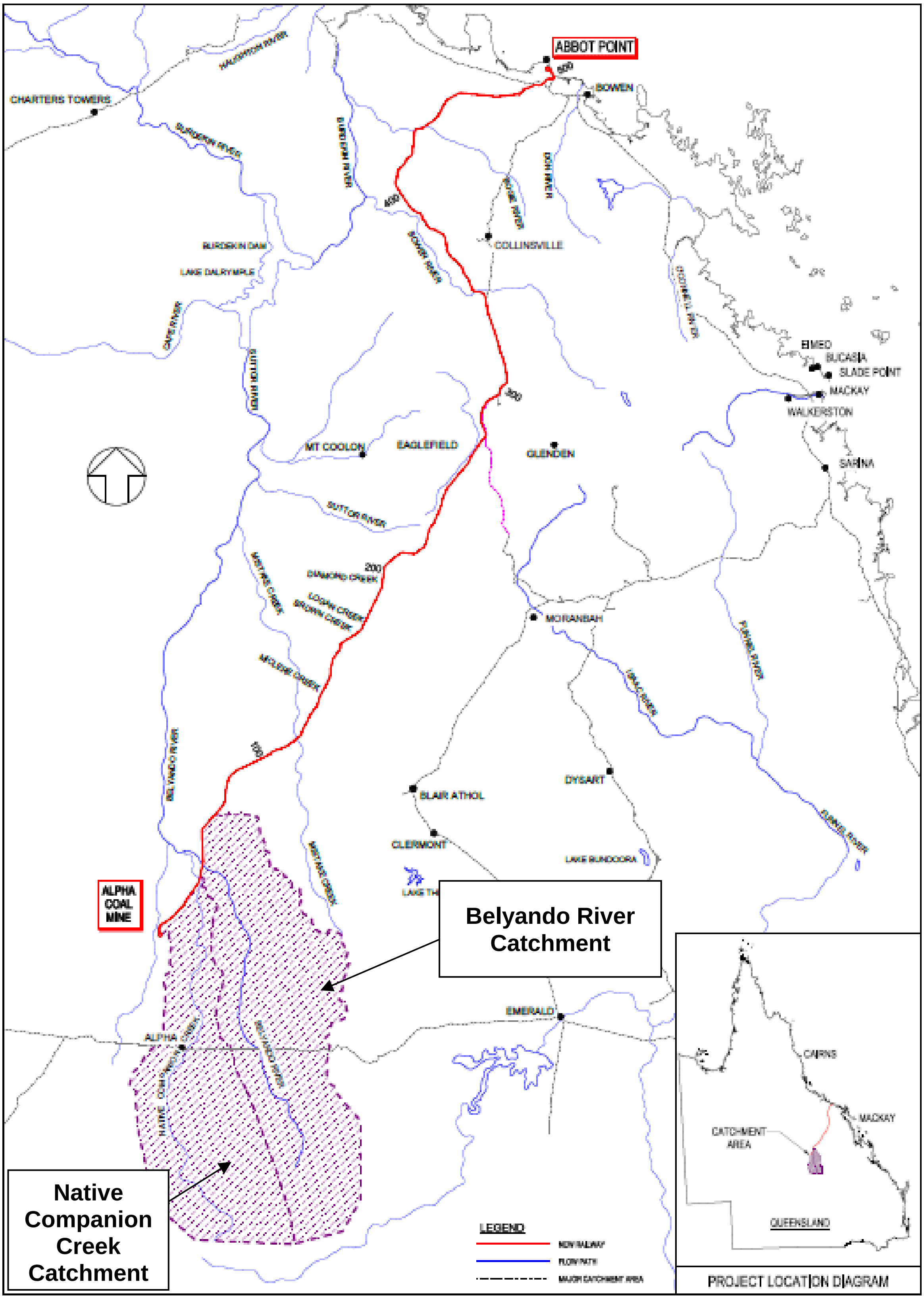


Figure 2: Belyando River-Native Companion Creek Catchments

5.2 Native Companion Creek

Native Companion Creek has a contributing catchment area of approximately 5,125km^2 at the proposed ACP rail alignment interface (Rail Chainage 38,690m). The catchment is undeveloped (with the exception of Alpha township) and consists of mostly pastoral land. The main channel is well defined and sits relatively higher than the adjacent Belyando River. Anecdotal evidence from Landholders suggests that the Creek breaks out under events upstream of the proposed railway and becomes part of the Belyando River system.

5.3 Belyando River

The catchment area of the Belyando River at the proposed ACP rail alignment (Rail Chainage 44,000m) is approximately 5,625km^2. The catchment is undeveloped and consists of mostly pastoral land. The main channel consists of many braids and does not have a major defined flow path. As such, during flood events, a complex interaction between channel and floodplain flows occur.

The confluence of Native Companion Creek and the Belyando River occurs approximately 15km downstream of the proposed railway.

6.0 COMMUNITY CONSULTATION

As part of the Detailed Floodplain Study, community consultation was undertaken to correlate the current modelling to the historical knowledge of stakeholders in relation to individual floodplains. The feedback received was then incorporated into the modelling where appropriate. Additional details can be found in Section 10.

7.0 BANKABLE FEASIBILITY STUDY

Prior to this detailed floodplain analysis, Calibre undertook a BFS level design of all drainage structures on the proposed ACP rail alignment, details of which are summarised in the BFS Drainage Engineering Report (CJVP10007-REP-C-001 / HC-CRL-24100-RPT-0022). The design proposed in the BFS report was used as the basis for the analysis detailed in this study.

7.1 Design Criteria

The approved drainage design criteria for the BFS are specified in Tables 1 and 2.

Table 1: General Drainage Design Criteria

Design Aspect	Design Criteria
Culvert Classification	Major culverts: culvert locations with a 50 years ARI design flow ≥ 50 m^3/sec. Minor culverts: culvert locations with a 50 year ARI design flow < 50 m^3/sec.
Design Flood	Minor culverts shall pass the 20 year ARI design event flow. Major culverts shall pass the 50 year ARI design event flow.

Design Aspect	Design Criteria
Freeboard	Min. 300mm to the formation surface for design event.
Headwater	Max. headwater to be 1.5 x culvert diameter.
Max. Outlet Velocity	5.0m/sec for design event with appropriate scour protection.
Scour Protection	Capable of passing 20 years ARI design flood without damage. Rock sizing to be designed in accordance with AUSTROADS Waterway Design, 1994.
Culvert Type & Size	CSP (galvanised corrugated steel pipes). CSP Culverts shall be provided with minimum 600mm earthwork cover. Min. diameter to be 900mm for engineering culverts.
Diversion drains	Unlined diversion drains shall be used to divert catchment flows from one catchment to another, where culverts cannot be used through the rail formation. These should cater for the 20 year ARI design flood without overtopping or scour. Drain design should minimise drain scour for the design event.
Cut off drains	Unlined cut off drains (with a minimum 20 year ARI design flow capacity) should be provided on the upstream side of the railway in cuttings to prevent surface water runoff entering the cuttings and causing scour and washouts.
Levees	Designed to ensure that there is 100mm freeboard above the culvert headwater design level.

Table 2: Bridge Hydraulic Design Criteria

Design Aspect	Design Criteria
Design Flood	Bridges shall pass the 50 year ARI design event flow.
Freeboard	Min. 500mm to bridge soffit for 50 year ARI design flow. Min. 300mm to Top Of Formation (TOF) (embankments and guide banks) for 50 year ARI design flow.
Max Velocity	3.8m/s to allow for the adoption of a practical limit of 1 tonne rock class protection for economy.
Scour Protection	Provide rock protection to cater for 50 year ARI design flow velocities. Rock sizing to be designed in accordance with AUSTROADS Waterway Design, 1994.
Maximum afflux	1.5m with reduction at sensitive locations.
Guide banks	To be designed in accordance with AUSTROADS Waterway Design, 1994.

7.2 Design Process

Hydrologic and hydraulic modelling was completed for all drainage structures along the ACP alignment during the BFS. For major crossings, design flows were estimated using either the rational method, a preliminary hydrologic model (CatchmentSim and RORB) or a Flood Frequency Analysis (FFA) where stream-gauge data was available. Design flows were then selected based on the best information available at the time of the study and what method was considered most appropriate for the level of analysis required for the BFS.

These flows were then hydraulically modelled depending upon the proposed structure type:

- Culverts were analysed using HY-8 (a 1-D modelling program design for culvert analysis) and sizes were determined to ensure afflux was less than 1.5m or the equivalent to the upstream bridge water levels determined from bridge modelling.
- Bridges were assessed using Afflux (a 1-D bridge hydraulic modelling program) to determine span widths that allowed less than 1.5m of afflux (as per the original design criteria). Supplementary culverts for the bridge were sized if the proposed bridge structure was not able to pass flows within the allowable afflux limits.

This level of analysis was sufficient for the purposes of the BFS and was used as a basis for the Detailed Floodplain Study.

8.0 FLOODPLAIN MODELLING DESIGN CRITERIA

A Supplementary Environmental Impact Statement (SEIS) was prepared after the conclusion of the BFS and this resulted in certain design criteria (from Table 1 and Table 2) being modified to meet stakeholder requirements. Table 3 shows the modified drainage design criteria adopted for the Detailed Floodplain Modelling.

Table 3: Modified Drainage Design Criteria

Design Aspect	Design Criteria
Design Flood	Acceptable increases in inundation extent (above the existing conditions for a given return period to the 50 year ARI event) will be proposed where such an increase will not alter rural land use and result in significant impacts.
Inundation Duration	Inundation duration not more than 3 days on valued pasture land that had previously been inundated for 3 days or less for similar rainfall events.
Max Velocity	Bridge outlet velocity = maximum of 1.2 x existing velocity at a distance equal to the bridge span downstream of bridge. Culverts outlet velocity: = 1.5m/s where erodible soils are present. = 2.5m/s for normal soils (with no erosion control).
Maximum afflux	Maximum 0.5m – normally (unless justifiable). Maximum 0.2m – around critical infrastructure. Maximum 0.1m – around dwellings.

Unless specified in Table 3, the design criteria used for the detailed floodplain analysis are identified in Table 1 and Table 2.

9.0 DETAILED FLOODPLAIN ANALYSIS

9.1 Introduction

In order to assess the impacts that the proposed ACP rail will have on the Belyando River-Native Companion Creek floodplain, a detailed floodplain analysis was conducted on the system. This detailed analysis was then used to assess the adequacy of the proposed cross-drainage structures determined from the BFS.

A detailed hydrologic analysis was completed for both systems and a combined hydraulic model that covers the area of interest, within the floodplain, was developed. The modelling results were then used to assess impacts on inundation extents, time of inundation, afflux and velocities as a result of the ACP railway. From the results of the hydraulic modelling, detailed flood mapping has been produced.

The following sections outline the methodology used to derive the required outputs for the Detailed Floodplain study.

9.1.1 Hydrology

9.1.1.1 Previous hydrology

During the BFS, the hydrology for both Native Companion Creek and Belyando River were based on RORB models and a Flood Frequency Analysis (FFA) of the Native Companion Creek stream-gauge (120305A - Native Companion Creek at Violet Grove). At the time of the analysis, the stream-gauge had 37 years of recorded data (daily streamflow readings from 1968 to 2005). The estimated 50 year ARI event flow was used for the sizing of the Native Companion Creek cross-drainage structure.

It should be noted that the stream-gauge is located a significant way upstream of the ACP railway as shown in Figure 3 below.

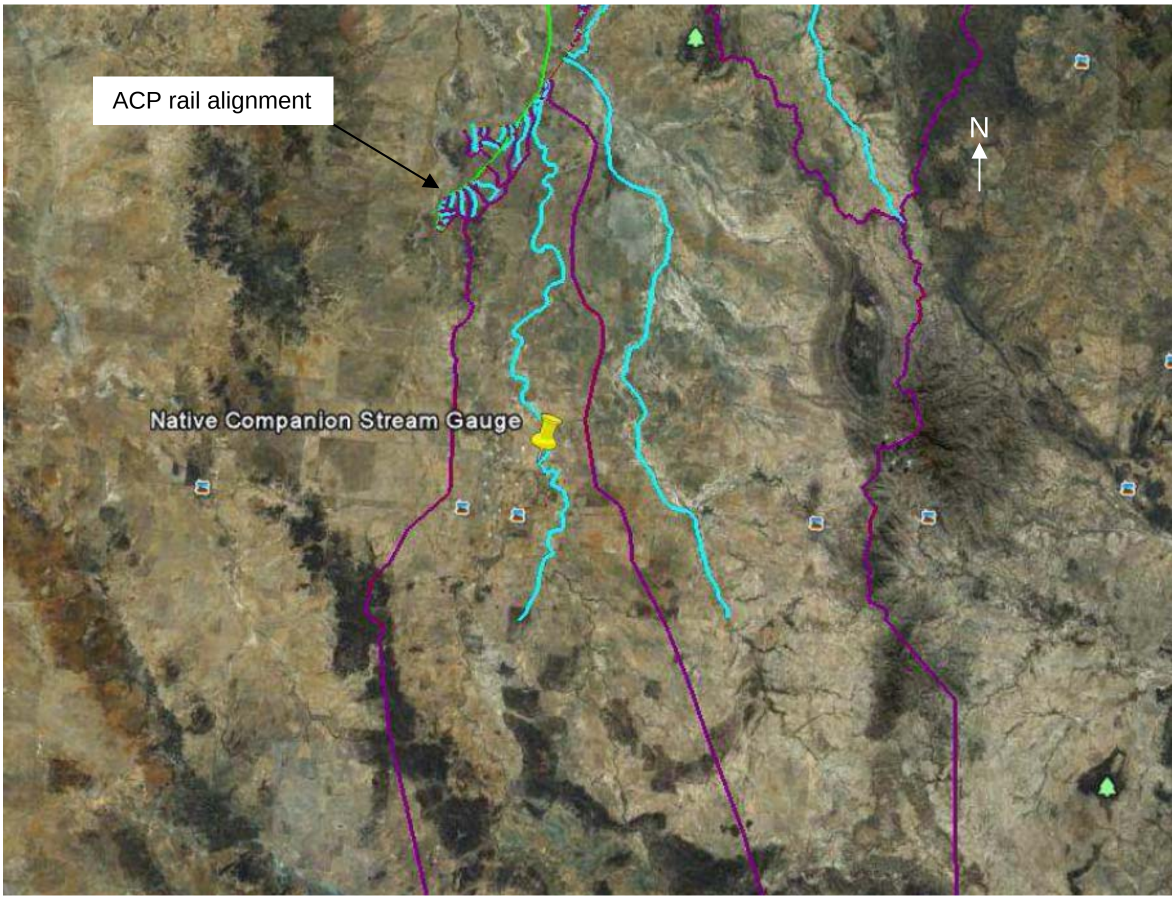


Figure 3: Native Companion Creek stream-gauge

Due to the similarities in the catchment characteristics between Native Companion Creek and Belyando River, a direct comparison was adopted from the Native Companion Creek FFA. As the Belyando River has a larger catchment, the estimated 50 year ARI event flows was increased via a catchment area ratio.

For full details on the BFS analysis, refer to the BFS Drainage Engineering Report (CJVP10007-REP-C-001/ HC-CRL-24100-RPT-0022).

9.1.1.2 Additional Information

As a result of the additional flooding information that was obtained from Landholder consultation and a floodplain field investigation (undertaken by C&R consulting), a more holistic and representative modelling approach for the floodplain system was able to be generated.

This information contained more accurate details regarding the hydrologic parameters and existing system flooding behaviour. More accurate LiDAR survey along the rail corridor was also obtained for the detailed analysis. These data sets were all incorporated as additional design inputs.

The following additional data sets were made available for the Detailed Floodplain Study:

Landholder Inputs

Of key importance in this floodplain study was the identification of the break-out point of Native Companion Creek into the Belyando River. From discussions with Landholders, it was acknowledged that flows in Native Companion Creek at the proposed rail alignment were minimal and could be attributed to local runoff only. From this, it was determined that the majority of Native Companion Creek flows into the Belyando River upstream of the ACP rail alignment.

Additional Survey

Additional LiDAR was flown along the proposed rail alignment in a 600m wide corridor with a vertical accuracy of ±100mm. Supplementary LiDAR was provided by HCIPL for the floodplain with a vertical accuracy of ±500mm.

Additional Stream-Gauge Data

For the BFS hydrologic analysis, stream-gauge data up until 2005 was available for the analysis. At the time of the Detailed Floodplain Study, recorded data up until August 2011 was available. This additional recorded data included 3 of the wettest years on record. The inclusion of this data in the historical stream-gauge statistical analysis had a significant effect on the predicted peak discharges.

9.1.1.3 Flood Frequency Analysis

A Flood Frequency Analysis was completed for the Native Companion Creek stream-gauge at Violet Grove based on the methods prescribed by Australian Rainfall and Runoff (AR&R). A summary of the data set obtained from the Department of Environment and Resource Management (DERM) online database is shown below in Table 4.

Table 4: Native Companion Creek gauge data

Catchment	DERM stream-gauge	Years of data	Start - finish
Native Companion Creek	120305A	44	15/12/1967 – 15/08/2011

The stream-gauge has a contributing catchment area of 4065km^2. An annual series based on water years (1 September to 30 August) was extracted from the daily data and analysed based on a Log-Pearson III probability distribution. The results are shown below in Figure 4.

The results of the FFA are presented in Appendix A.

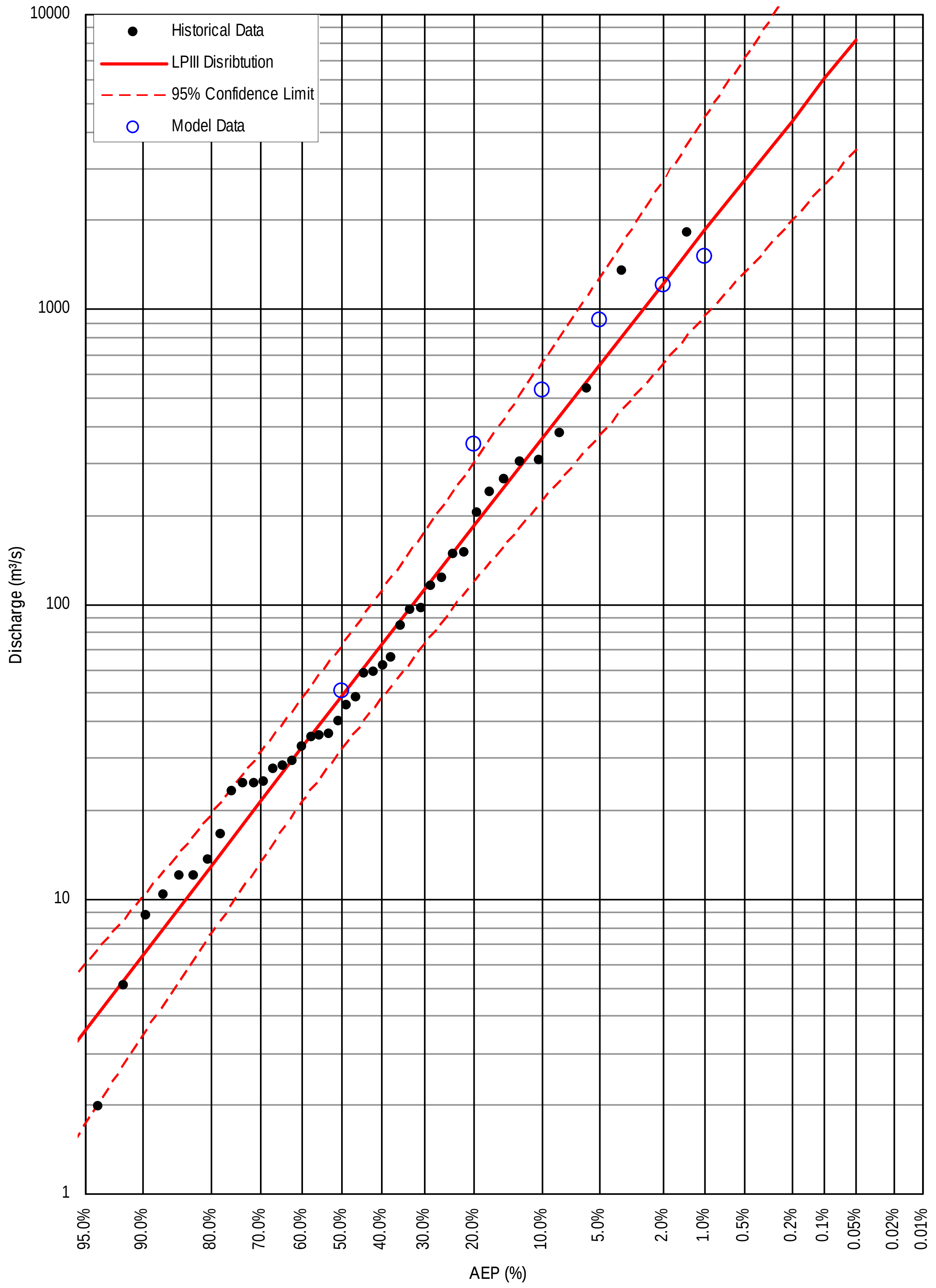


Figure 4: Native Companion Creek stream-gauge FFA

From the FFA, the following design event flows have been derived and are shown below:

Table 5: Flood Frequency Analysis event analysis results

Event ARI (years)	Design discharge (m^3/s)	Upper confidence limit discharge (m^3/s)	Lower confidence limit discharge (m^3/s)
100	1867	4571	966
50	1224	2769	667
20	648	1310	380
10	368	677	228
5	185	308	121

9.1.1.4 RORB Analysis

The contributing catchment areas for both Native Companion Creek and Belyando River were delineated using the GIS based terrain analysis software, CatchmentSim. A visual check was performed against the BFS delineated catchments, stream-gauge catchment areas and SRTM contours to ensure the CatchmentSim delineation was accurate.

Both systems were delineated in CatchmentSim using the DERM SRTM survey data as this was deemed to have sufficient accuracy for the purposes of hydrologic analyses. Catchments were generated for both systems and exported into the rainfall-runoff routing program, RORB.

A sub-catchment node was specifically placed at the location of the Native Companion Creek stream-gauge in order to calibrate the model.

A summary of the catchment analysis for Native Companion Creek and the Belyando River are shown below in Tables 6 and 7.

Table 6: Native Companion Creek catchment properties

Item	Value
Catchment area	5124.8km^2
d_{av}	168.4km

Table 7: Belyando River catchment properties

Item	Value
Catchment area	5652.3km^2
d_{av}	98.44km

The RORB analysis results are contained in Appendix B.

Parameters

RORB model parameters were initially set to those recommended by AR&R for Queensland. These were then varied via a calibration exercise to achieve a best-fit for the particular catchment.

The initial parameters for the RORB model were set using the formulae outlined in AR&R guidelines for Queensland. These are shown below:

$k_c = 0.88\ A^{0.53}$ (Equation 9.1)
where A is the catchment area in square kilometres

$(k_c/d_{ave}) = -13.5\ m^3 + 45.8\ m^2 - 53\ m+21.2$ (Equation 9.2)
where d_{ave} is the average stream length from sub-catchment centroids to the catchment outlet

The RORB manual suggests that the k_c parameter is better estimated using the following formula:

$k_c = 2.2\ (A^{0/5})\ (Q_p/2)^{(0.8-m)}$ (Equation 9.3)
where Q_p is the predicted peak discharge

Using the above formula (equation 9.2) as recommended by AR&R, initial catchment parameters for Native Companion Creek and Belyando River were calculated and are shown in Tables 8 and 9 along with an estimate of the initial and continuing loss in Table 10.

Table 8: Native Companion Creek initial RORB parameters

Item	Value
k_c	81.4
M	1.009

Table 9: Belyando River initial RORB parameters

Item	Value
k_c	85.74
M	0.983

Table 10: Initial and continuing loss estimation

Event ARI (years)	Initial loss (mm)	Continuing loss (mm/hr)
100	10	2.5
50	15	2.5
20	15	2.5
10	35	2.5
5	35	2.5

Calibration

As Native Companion Creek has a stream-gauge upstream of the proposed ACP alignment, a hydrologic calibration was able to be performed. Using the RORB model generated for the system and the adopted initial parameters as described previously, initial loss and k_c values were adjusted to achieve a best-fit for the 5, 10, 20, 50 and 100 year ARI events at the gauging station node against the stream-gauge FFA. These calibrated values are shown below in Tables 11 and 12.

Table 11: Native Companion Creek calibrated RORB parameters

Item	Value
k_c (calibrated)	130
M	1.009

Table 12: Native Companion Creek calibrated losses

Event ARI (years)	Initial loss (mm)	Continuing loss (mm/hr)
100	10	2.5
50	15	2.5
20	15	2.5
10	35	2.5
5	70	2.5

A good calibration was achieved for the 50 year ARI event (design event) with the FFA predicted a peak flow of 1224m^3/s and the RORB model estimating 1204m^3/s. A results comparison between the calibrated RORB model and the FFA estimates are shown below in Table 13.

Table 13: Calibration results at Native Companion Creek stream-gauge

Event ARI (years)	FFA estimate (m^3/s)	RORB estimate (m^3/s)
100	1867	1504
50	1224	1204
20	648	919
10	368	532
5	185	347

The peak discharges extracted from the RORB model have been plotted (blue circles) on the FFA provided in Figure 4.

The calibrated parameters in Tables 11 and 12 were also used for the Belyando River system due to their similar catchment characteristics and close proximity.

Results

The results extracted from the hydrologic modelling for Native Companion Creek and Belyando River systems at the ACP rail interface are shown below:

Table 14: Native Companion Creek and Belyando River peak storm durations

Event ARI (years)	Peak discharge storm duration (hours)
100	72
50	72
5	36

Table 15: Native Companion Creek predicted peak discharges

Event ARI (years)	Peak predicted discharge (m^3/s)
100	1066
50	824
5	214

Table 16: Belyando River predicted peak discharges

Event ARI (years)	Peak predicted discharge (m^3/s)
100	1039
50	804
5	218

Full hydrographs have been extracted from the RORB model for the 5, 10, 20, 50 and 100 year ARI events are provided in Appendix B. The predicted peak discharges for both systems were then used as inflows into the Native Companion Creek and Belyando River floodplain hydraulic model as described in Section 9.1.2.

9.1.2 Hydraulic Modelling

It had been identified during the BFS that the Native Companion Creek and Belyando River floodplain system could be modelled using a quasi 2-D hydraulic model. After an initial assessment of this system using HEC-RAS (1-D unsteady hydraulic modelling package), it was identified that significant lateral flows (i.e. breakout points) and complex floodplain interactions meant that the quasi 2-D model would be insufficient to adequately model the system.

As such, a full hydrodynamic 2-D model was generated using the software package MIKE Flood. The advantage of using MIKE Flood is the program's ability to model large grid-scale features such as complex floodplains while also allowing sub grid-scale features such as culverts and bridges to be modelled with a greater degree of accuracy.

The following section outlines the process used to generate the 2-D model, sensitivity analyses conducted and modelling results.

9.1.2.1 MIKE Flood Model

Bathymetry

The hydraulic model required a significant model domain in order to adequately capture the upstream breakout points of Native Companion Creek into the Belyando River and be sufficiently downstream to reduce the effects of the downstream boundary. This resulted in a bathymetry of 1065 x 1393 cells at a grid cell size of 25m x 25m (model area of 927km^2). The final bathymetry used for the pre- and post-development cases is shown in Figure 5.

A significant portion of the bathymetry has been based on a combination of LiDAR sources (flood study LiDAR, BFS LiDAR and current alignment LiDAR) and covers all of the area downstream of the railway and a minimum of approximately 2.5km upstream of the rail (varies depending on location as per the "approximate SRTM/LiDAR interface" shown in Figure 5). At the time of the Detailed Floodplain Study, the only available survey data outside of these extents was the SRTM survey. Due to the significant accuracy reduction of the SRTM in comparison to the LiDAR, it was assessed that some manipulation of the relative levels of the SRTM was needed to ensure boundary levels matched the LiDAR data at stream inverts. For this model, the SRTM tiles were lowered by 1m and a variable interpreted transition was generated between the SRTM and LiDAR boundary to provide a smoothed surface between the two data sets.

This bathymetry manipulation was considered appropriate for the purposes of the assessment of impacts from the proposed ACP rail alignment and utilised the best data available at the time of this Detailed Floodplain Study.

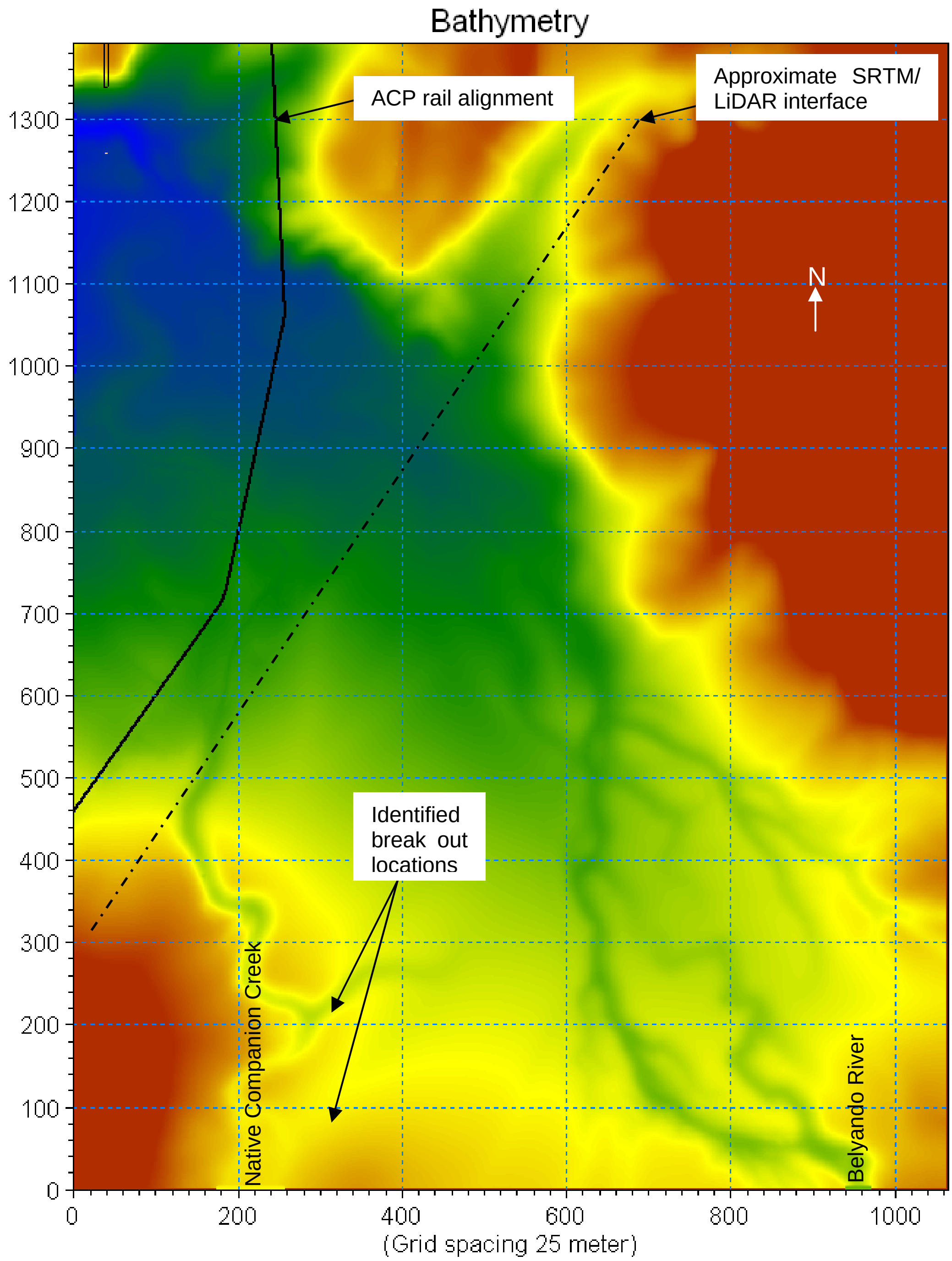


Figure 5: Hydraulic model extent

Boundary conditions

Native Companion Creek and Belyando River inflow hydrographs were input into the model over an appropriate width to ensure minimal dispersion of flows laterally during peak hydrograph inflows. The downstream boundary condition was set using a combined flow value for the system and a rating curve (discharge-height relationship) generated from the downstream cross section and average stream slope.

Initial water surface levels from the downstream boundary condition were projected back upstream to account for the loss of storage due to tailwater affects. The selection of downstream boundary levels was subject to sensitivity testing as outlined in Section 9.1.3.

Roughness coefficients

The Native Companion Creek and Belyando River systems have two distinct types of roughness: a relatively smooth and well defined flowpath for the main conveyance channels; and a rough, low velocity, low water depth floodplain. As such, two Manning's values were adopted for this Detailed Floodplain Study:

- Channel: n = 0.04
- Floodplain: n = 0.1

In order to easily and accurately define the two separate roughness areas, 5 year ARI event flows were halved and input into the hydraulic model (to simulate a bank-full stream event). Where depths exceeded 0.2m and velocities above approximately 0.15m/s, a roughness value attributed to a channel was assigned. The remaining model domain was set to a roughness equivalent to floodplain. The adopted values are shown in Figure 6. The selection of roughness values was subject to sensitivity testing as outlined in Section 9.1.3.

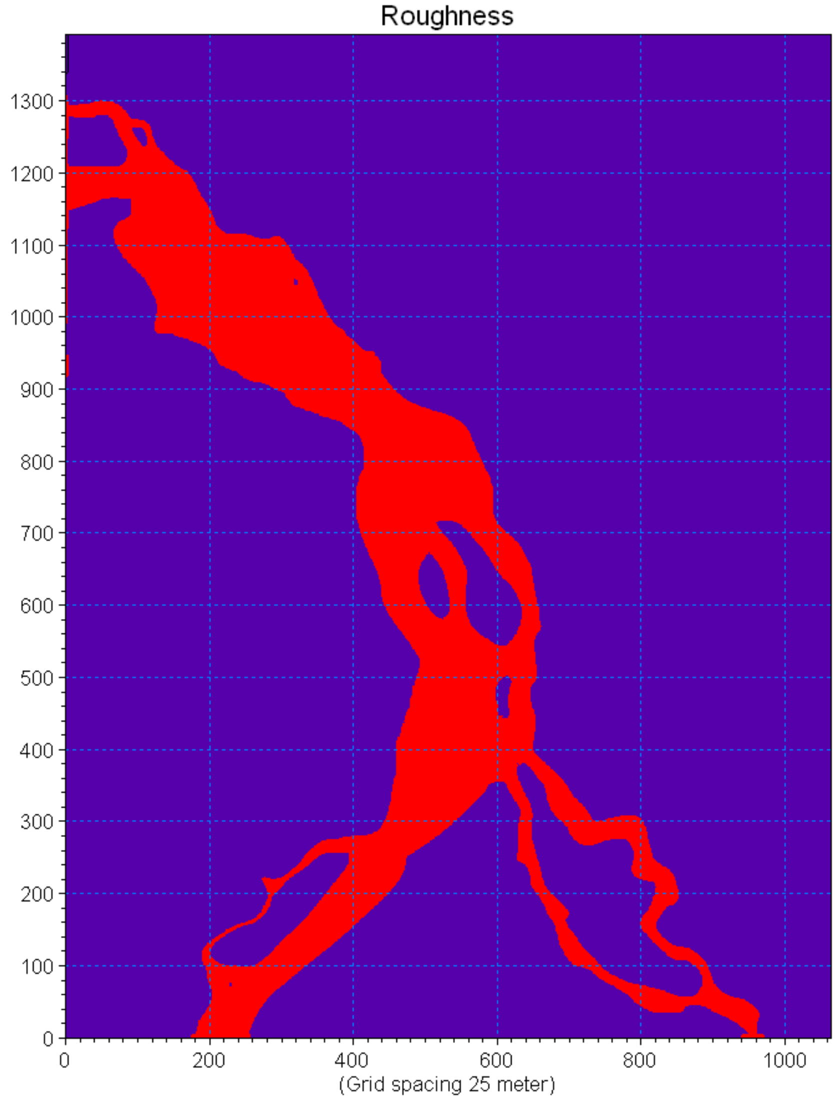


Figure 6: Manning's roughness

MIKE Flood coupling

The MIKE Flood modelling package allows for the input of 1-D modelling elements (MIKE11) within the 2-D model domain (MIKE21). These links are known as 'couples'. For this Detailed Floodplain Study, bridges and culverts have been input into the model as 1-D elements to accurately assess the headloss through cross-drainage structures. All structures have been modelled implicitly with standard MIKE11 variables. Coupled locations are shown in Figure 7.

In order to maintain inundation extents post-development and as specified in the SEIS, floodplain relief culverts are proposed for the Native Companion Creek and Belyando River System at 25m spacing. These relief culverts consist of 900mm diameter Corrugated Steel Pipes (CSP). Through sensitivity testing it was determined that in order to minimise geometric grid-scale problems and minimising the required number of couples within the model, it was feasible to group 5 floodplain relief culverts from adjacent 2-D grid cells. This resulted in a grouping a 5/900mm CSP every 125m within the model.

Flows through the floodplain relief culverts in MIKE Flood were verified against a 1-D model of a single 900mm diameter CSP using the HY-8 modelling package.

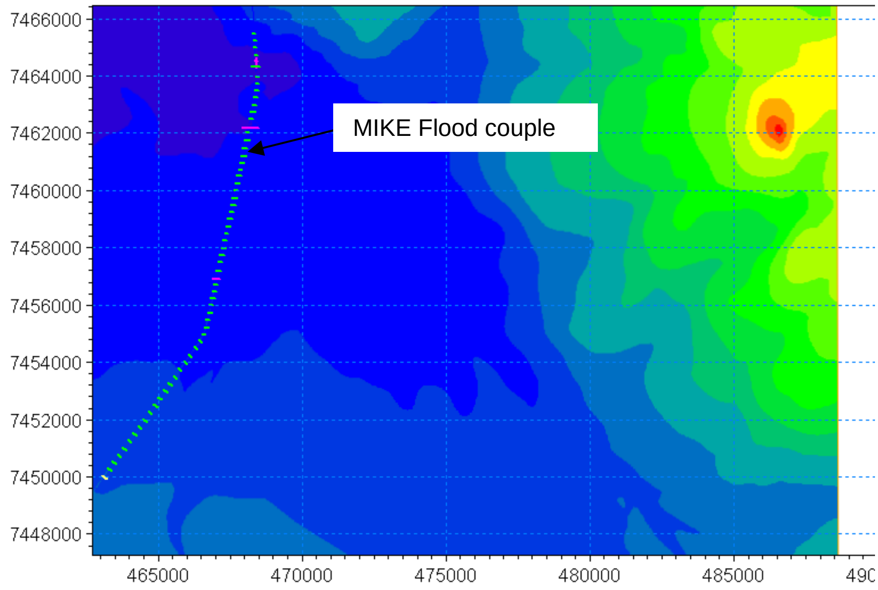


Figure 7: MIKE Flood couple locations

In addition to the floodplain relief culverts, the BFS proposed a single bridge span of 60m for Native Companion Creek and a combination of a 156m bridge and 49/ 3000mm diameter supplementary CSPs for the Belyando River. These were also inserted as couples into the MIKE Flood model.

9.1.3 Sensitivity Testing

Due to the lack of anecdotal evidence available to calibrate the hydraulic model, a sensitivity range of ± 30% on roughness values, inflow hydrographs and downstream boundary water levels was tested. Sensitivity testing was undertaken for the 50 year ARI event and for the pre-development case only at locations shown in Figure 8.

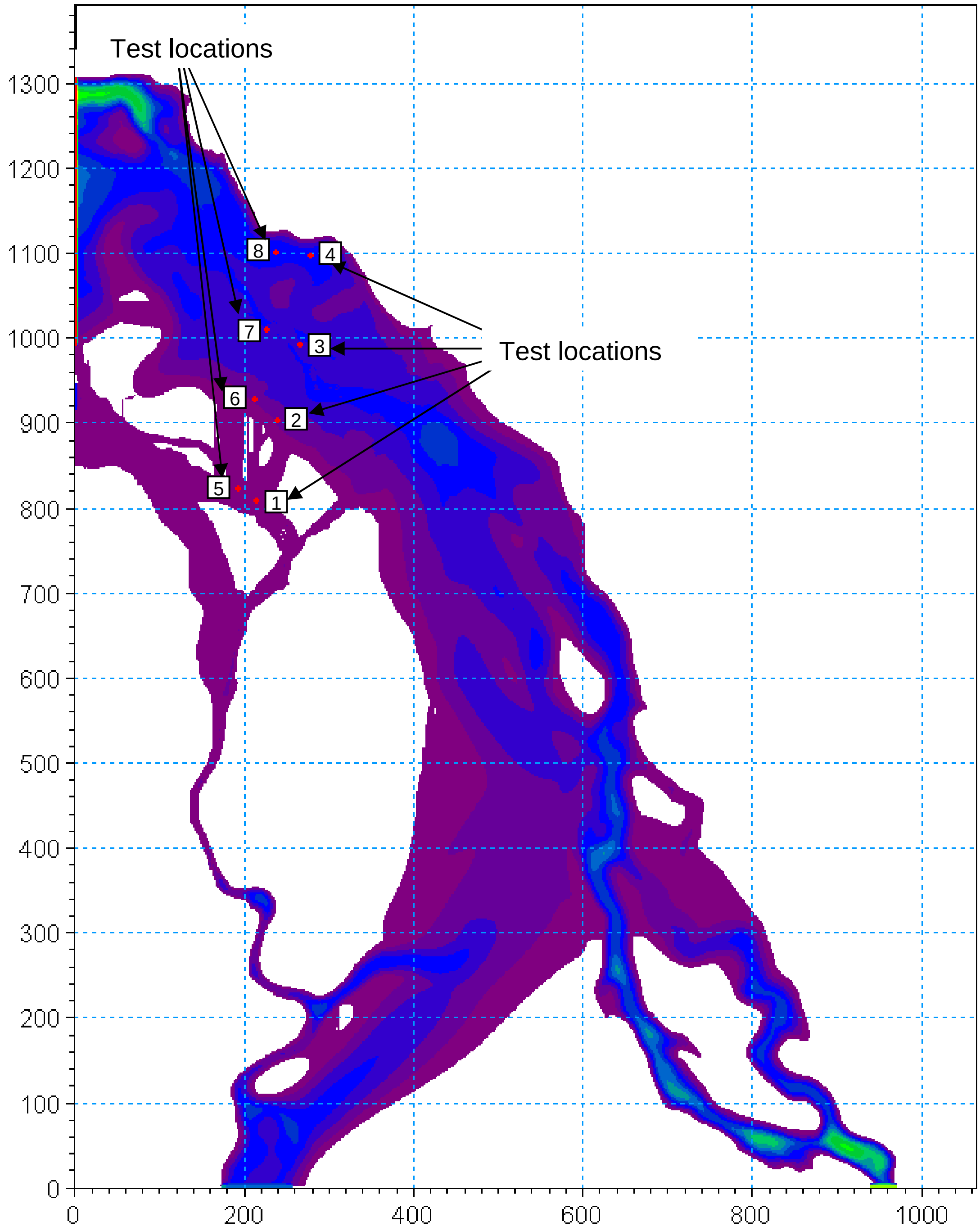


Figure 8: Sensitivity testing locations

Eight locations were selected both upstream and downstream of the proposed railway alignment and included main channel and floodplain locations in order to assess the sensitivity of certain parameters on the predicted water levels and velocities.

Manning's values

The value of Manning's 'M' (M=1/n) was adjusted by ±30% to assess the impacts of this parameter on the predicted maximum inundation depths and velocities at the locations shown in Figure 8. The sensitivity of the Manning's 'M' value is shown in Table 17.

Table 17: Manning's 'M' value sensitivity (depth)

Location	Adopted value (m)	+30% value	Change (m)	-30% value	Change (m)
1	0.099	0.083	-0.016	0.108	0.009
2	0.713	0.509	-0.204	1.020	0.307
3	1.718	1.524	-0.194	2.023	0.305
4	2.130	1.883	-0.247	2.490	0.360
5	0.089	0.071	-0.018	0.093	0.004
6	0.716	0.533	-0.183	1.003	0.287
7	1.814	1.605	-0.209	2.136	0.322
8	2.197	1.938	-0.259	2.557	0.360

The Manning's value has an impact ranging from -260mm to +360mm on the predicted water surface level. This has an equivalent inundation extent impact of -7.6% and +8.8%. The Belyando River model shows that the predicted extents and water levels have a high sensitivity to the Manning's values selected.

At the same testing locations, the peak velocities were also extracted. From Table 18, it can be seen that there is a large change in velocity percentage. However the flow velocity change is small and remains in the same order of magnitude as the adopted existing case.

Table 18: Manning's 'M' value sensitivity (velocity)

Location	Adopted value (m/s)	+30% value	Change (%)	-30% value	Change (%)
1	0.066	0.077	14.3	0.050	-24.2
2	0.166	0.167	0.6	0.154	-7.2
3	0.318	0.380	16.3	0.249	-21.7
4	0.251	0.299	16.1	0.198	-21.1
5	0.066	0.075	12.0	0.048	-27.3
6	0.187	0.194	3.6	0.168	-10.2
7	0.344	0.426	19.2	0.260	-24.4
8	0.308	0.368	16.3	0.245	-20.5

Inflow hydrographs

The inflow values were adjusted by ±30% to assess the impacts of this parameter on the predicted maximum inundation depths at the locations shown in Figure 8. The sensitivity of the inflow hydrograph is shown in Table 19.

Table 19: Inflow hydrograph sensitivity

Location	Adopted value (m)	+30% value	Change (m)	-30% value	Change (m)
1	0.099	0.107	0.008	0.073	-0.026
2	0.713	0.989	0.276	0.434	-0.279
3	1.718	1.989	0.271	1.456	-0.262
4	2.130	2.452	0.322	1.794	-0.336
5	0.089	0.094	0.005	0.062	-0.027
6	0.716	0.973	0.257	0.468	-0.248
7	1.814	2.102	0.288	1.534	-0.280
8	2.197	2.519	0.322	1.847	-0.350

The inflow values have an impact ranging from -350mm to +330mm on the predicted water surface level. This has an equivalent inundation extent impact of -10.6% and +7.4% The Belyando River model shows that the predicted extents and water levels have a high sensitivity to the magnitude of the predicted inflows.

Downstream boundary

The downstream boundary water surface levels were adjusted by ±30% to assess the impacts of this parameter on the predicted maximum inundation depths at the locations shown in Figure 8. The sensitivity of the downstream boundary is shown in Table 20.

Table 20: Downstream boundary sensitivity

Location	Adopted value (m)	+30% value	Change (m)	-30% value	Change (m)
1	0.099	0.099	0.000	0.095	-0.004
2	0.713	0.713	0.000	0.710	-0.003
3	1.718	1.718	0.000	1.715	-0.003
4	2.130	2.130	0.001	2.123	-0.007
5	0.089	0.089	0.000	0.081	-0.008
6	0.716	0.716	0.000	0.712	-0.004
7	1.814	1.814	0.000	1.809	-0.005
8	2.197	2.202	0.005	2.188	-0.009

The downstream boundary level has a negligible impact on the predicted water surface level.

The sensitivity analysis has shown that the magnitude of the hydraulic model inflows has the most significant impact on the predicted water surface levels within the 2-D model. Although the relative change in level is high when compared to the predicted water depth, the change in inundation extent is minimal.

For this study, conservative values for all variables have been adopted, and it is considered that the outcomes of the study are adequate without hydraulic model calibration and are conservative in nature.

10.0 LANDHOLDER CONSULTATION OUTCOMES

The initial findings and resulting flood maps from the modelling of the Belyando/Native Companion floodplain system were presented to the affected Landholders for review. The flood maps presented for review included the 5, 50 and 100 year ARI events displaying inundation extent, inundation depth, water surface elevation, velocity profiles and afflux.

Landholder feedback identified that the mapping for the 100 year ARI event under-estimated inundation extents and depths seen during the 2008 flood event (approximately a 70 year event). This information was incorporated into the hydrologic and hydraulic modelling by adjusting the roughness parameters and inflows, as these were determined to have the greatest uncertainty and the highest impact on predicted water levels from the sensitivity analysis undertaken.

It was decided that an increase in model inflows by 30% for all events in combination with redefining the roughness map would more accurately correlate to the observed flood conditions within the system as identified by Landholders.

Manning's values were redefined using two separate roughness areas assigned to a channel roughness (n=0.04) for the main streamflow path only (delineated by contour maps), and a roughness value equivalent to a floodplain for the remaining model domain (n=0.1). The downstream boundary condition was also altered accordingly to reflect the increase in system roughness.

The increased flows and modified Manning's roughness map are shown in Table 21 and Figure 8 respectively.

Table 21: Adjusted peak hydrograph inflows (+30%)

Event ARI (years)	Native Companion Creek	Belyando River
	30% Increase Q(m^3/s)	30% Increase Q(m^3/s)
100	1385.8	1350.7
50	1071.2	1045.2
5	278.2	283.4

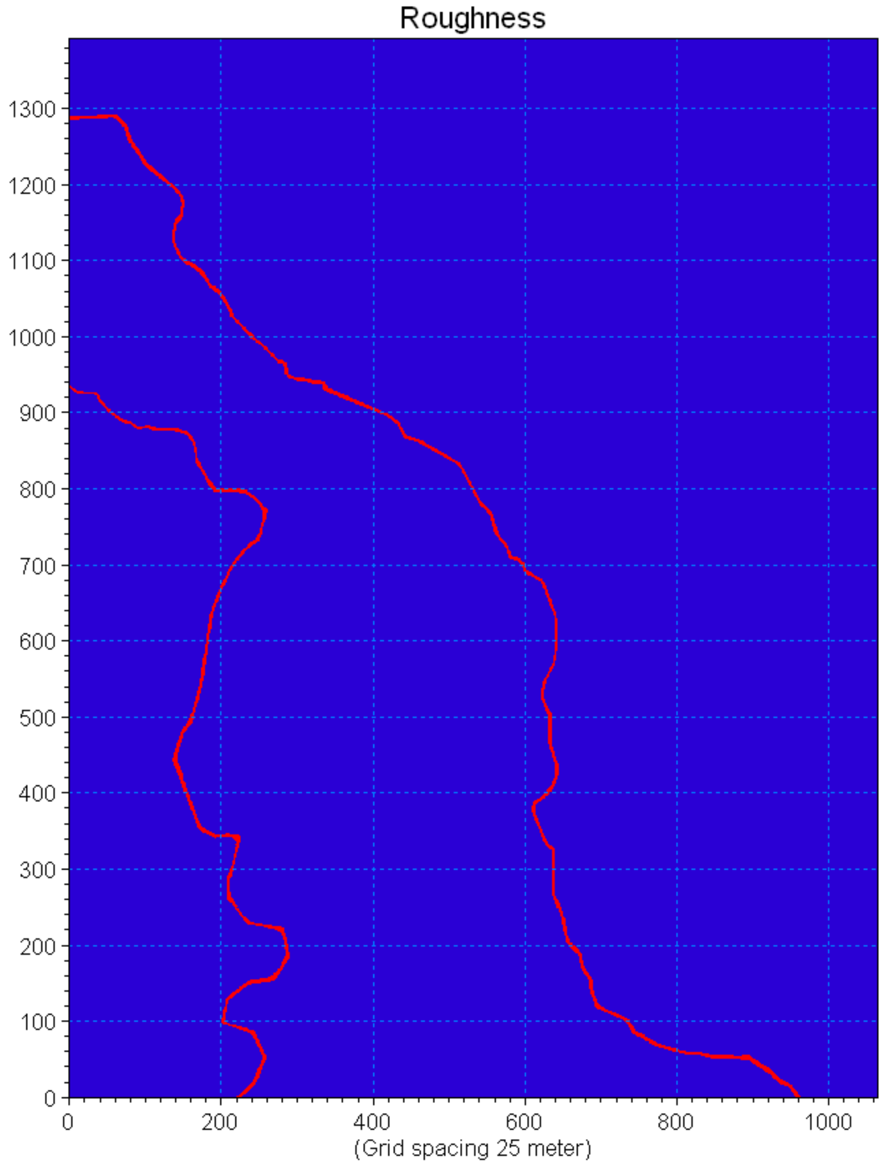


Figure 8: Revised Manning's roughness

10.1 Floodplain Drainage Structure Recommendations

As discussed in previous sections, with the additional data received and incorporated as part of the Detailed Floodplain Study, additional analysis was required on the proposed BFS cross-drainage infrastructure in order to demonstrate that the impacts of the proposed ACP rail alignment could be mitigated to levels that comply with the EIS and SEIS.

With the additional information received and incorporated as part of the Landholder consultation process, additional analysis was undertaken on the proposed BFS cross-drainage structures. Due to the increase in flows and roughness values, an additional 600/ 3000mm diameter supplementary culverts are required on the Belyando River in order to mitigate the impacts of the proposed railway to levels that comply with the EIS and SEIS. This resulted in a significant increase in cross-drainage infrastructure.

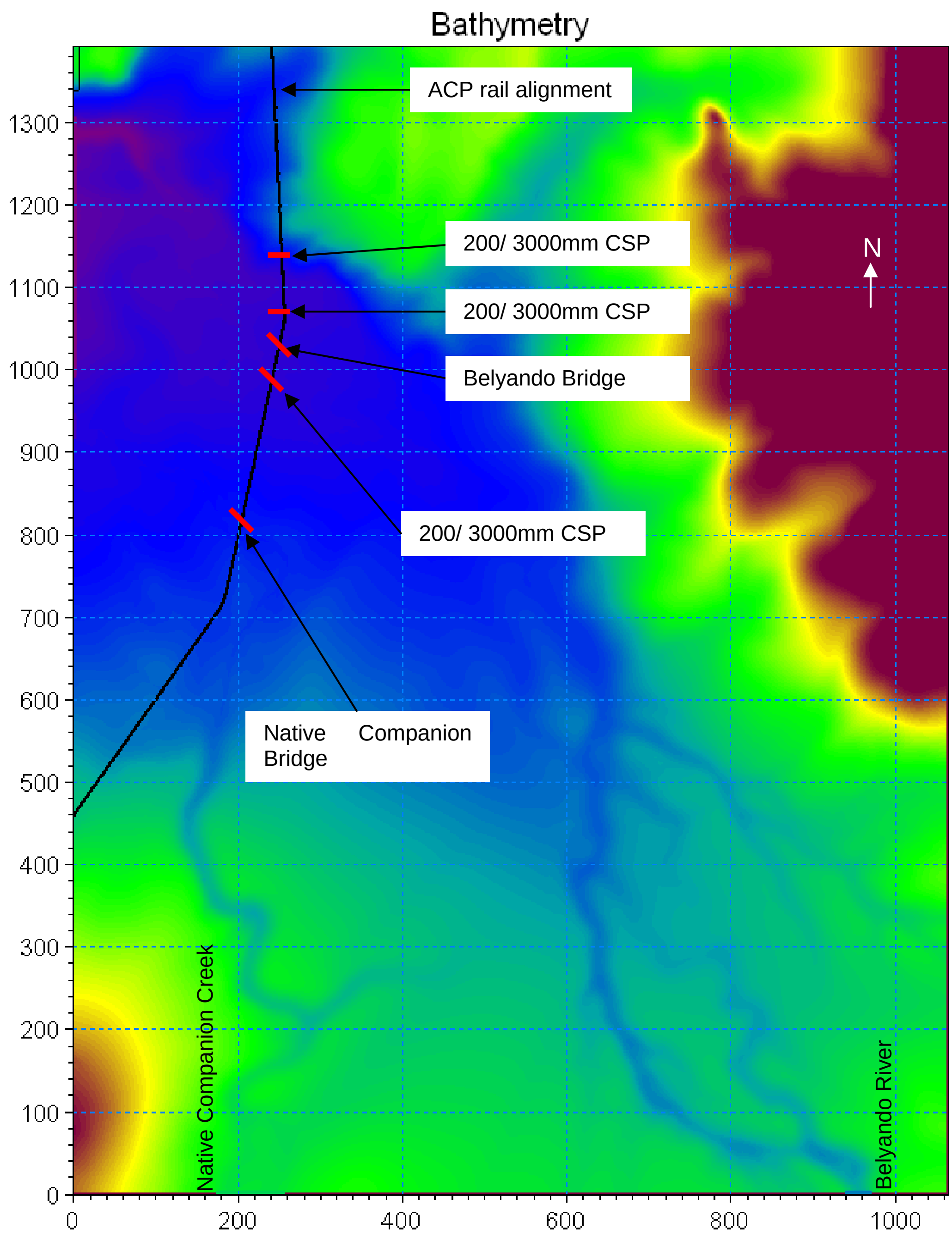


Figure 9: Belyando River supplementary culvert locations

10.2 Results

Following the collation of information received from Landholders during the consultation process, the findings from this Detailed Floodplain Study have been presented to specific Landholders who have an interest in and/or are influenced by the proposed Alpha Coal rail alignment and its impact on the Belyando River / Native Companion Creek system.

Feedback from Landholders through continued consultation has shown the pre-development flood modelling correlates well with what has been observed on-site during major flood events. The post-development models utilise the same hydrologic parameters and same hydraulic modelling methods as the pre-development models to ensure consistency. Preliminary drainage structures have been modelled in the post-development case to conform to the SEIS requirements.

Peak floodplain inundation depths, water surface elevations, velocities and inundation extents have all been plotted and are shown in Appendix C.

Drawings include:

- Inundation extents:
  - 5, 50 and 100 year ARI events pre - and post-development.
- Inundation depths:
  - 50 year ARI event post-development.
- Water surface elevations:
  - 50 year ARI event post-development.
- Velocity profiles:
  - 50 year ARI event post-development.
- Afflux:
  - 50 year ARI event.

A summary of the findings from the Detailed Floodplain Study compared to the SEIS drainage criteria is shown in Table 22.

Table 22: Results Summary

Design Aspect	SEIS Design Criteria	Result Summary
Inundation Extent	Acceptable increases in inundation extent (above the existing conditions for a given return period to the 50 year ARI event) will be proposed where such an increase will not alter rural land use and result in significant impacts.	Conforms to SEIS requirements. There is an overall increase of 0.01% in inundation extent of the modelled area during the design flood event.
Inundation Duration	Inundation duration not more than 3 days on valued pasture land that had previously been inundated for 3 days or less for similar rainfall events.	Conforms to SEIS requirements.

Design Aspect	SEIS Design Criteria	Result Summary
Max Velocity	Bridge outlet velocity = maximum of 1.2 x existing velocity at a distance equal to the bridge span downstream of bridge. Culverts outlet velocity: = 1.5m/s where erodible soils are present. = 2.5m/s for normal soils (with no erosion control).	Conforms to SEIS requirements. Refer Velocity drawing in Appendix C for details.
Maximum afflux	Maximum 0.5m – normally (unless justifiable). Maximum 0.2m – around critical infrastructure. Maximum 0.1m – around dwellings.	Conforms to SEIS requirements. Refer Afflux drawing in Appendix C for details.

Further to the above table, results show that there is a minimal change in overall inundation extents due to the current alignment and proposed floodplain drainage structures. This is shown below in Table 23.

Table 23: Change in inundation extents

Event ARI (years)	% change in "wet" cells	Change in area (ha)
5	-0.22	-37.8
50	0.01	<1

With the inclusion of additional cross-drainage structures, the proposed ACP rail alignment will meet the afflux limits specified in the SEIS with the exception of minor localised areas. These areas are small in extent, localised to areas adjacent to the alignment and currently have no impact to existing infrastructure, inundation times, velocities and minimal increase in inundation extents. Afflux and velocity results for the nominated design criteria post-development meet the requirements of the SEIS and stakeholder requirements. Results are shown in Appendix C.

Inundation Duration

One of the primary concerns of Landholders from the EIS and during the consultation process is related to the change in duration of inundation due to the development of the Alpha Coal rail alignment.

Detailed 2-D modelling with time-step analysis on areas of interest reports that inundation duration has been maintained across the floodplain to the requirements of the SEIS i.e.; inundation duration of not more than 3 days on valued pasture land that had previously been inundated for 3 days or less for similar rainfall events.

11.0 CONCLUSION

Detailed hydrologic and hydraulic modelling has been completed for Native Companion Creek and Belyando River at the proposed ACP rail alignment. It has been shown that the proposed railway can mitigate its hydraulic impacts to an acceptable level with only localised areas that exceed the limits placed on the project by the SEIS. The recommended cross-drainage structures for Belyando River and Native Companion Creek are shown below in Tables 24 to 26. Alternative drainage structures may be utilised providing equivalent hydraulic performance is maintained or improved.

Table 24: Native Companion Creek

Item	Value
Proposed cross-drainage infrastructure	1/ 60m bridge

Table 25: Belyando River

Item	Value
Proposed cross-drainage infrastructure	1/ 156m bridge and 600/ 3000mm diameter supplementary CSPs

Table 26: Floodplain relief culverts

Item	Value
Proposed cross-drainage infrastructure	900mm diameter CSPs at 25m in the floodplain

The findings can be further optimised when further hydraulic analysis is undertaken during the Detailed Design phase of the project.

APPENDIX A
FFA ANALYSIS

Client:	Hancock coal			Date:	17/8/2011
Project/Job:	ACP	Job No:		Sheet No:	
Subject:	**FFA Native Companion Creek**			By:	ARB

HISTORICAL DATA

Sample Period (Years)	44	Adjusted Mean, *M*	1.689
Number of Samples to Use, *N*	44	Adjusted Std Deviation, *S*	0.686
Plotting Position Parameter, α	0.4	Coefficient of Skewness, *g*	-0.027

Rank	**Discharge** (m^3/s)	P_N **AEP**	Y_P **ARI**	**Plotting Position**	$\sum Log(Q)$	$\sum Log(Q)^2$	$\sum Log(Q)^3$
1	1819.308	1.4%	73.67	2.209	3.260	10.627	34.643
2	1359.113	3.6%	27.63	1.797	6.393	20.444	65.403
3	540.655	5.9%	17.00	1.565	9.126	27.913	85.815
4	381.797	8.1%	12.28	1.395	11.708	34.579	103.025
5	306.953	10.4%	9.61	1.259	14.195	40.765	118.409
6	303.109	12.7%	7.89	1.142	16.677	46.923	133.691
7	264.53	14.9%	6.70	1.039	19.099	52.791	147.907
8	239.858	17.2%	5.82	0.947	21.479	58.455	161.388
9	205.276	19.5%	5.14	0.861	23.791	63.802	173.752
10	149.034	21.7%	4.60	0.782	25.965	68.525	184.017
11	148.18	24.0%	4.17	0.707	28.135	73.238	194.246
12	122.2	26.2%	3.81	0.636	30.222	77.594	203.337
13	115.948	28.5%	3.51	0.568	32.287	81.855	212.133
14	97.399	30.8%	3.25	0.502	34.275	85.809	219.997
15	96.297	33.0%	3.03	0.439	36.259	89.744	227.802
16	84.288	35.3%	2.83	0.377	38.185	93.453	234.943
17	65.909	37.6%	2.66	0.317	40.004	96.761	240.962
18	62.306	39.8%	2.51	0.258	41.798	99.981	246.741
19	58.806	42.1%	2.38	0.200	43.568	103.112	252.280
20	58.043	44.3%	2.26	0.142	45.331	106.223	257.767
21	48.477	46.6%	2.15	0.085	47.017	109.064	262.556
22	45.611	48.9%	2.05	0.028	48.676	111.817	267.122
23	39.985	51.1%	1.96	-0.028	50.278	114.383	271.233
24	36.495	53.4%	1.87	-0.085	51.840	116.823	275.046
25	35.662	55.7%	1.80	-0.142	53.392	119.233	278.785
26	35.431	57.9%	1.73	-0.200	54.942	121.633	282.505
27	32.796	60.2%	1.66	-0.258	56.457	123.931	285.988
28	29.426	62.4%	1.60	-0.317	57.926	126.088	289.156
29	28.454	64.7%	1.55	-0.377	59.380	128.203	292.231
30	27.69	67.0%	1.49	-0.439	60.823	130.283	295.231
31	24.945	69.2%	1.44	-0.502	62.220	132.234	297.958
32	24.733	71.5%	1.40	-0.568	63.613	134.176	300.662
33	24.619	73.8%	1.36	-0.636	65.004	136.111	303.355
34	23.187	76.0%	1.32	-0.707	66.369	137.975	305.900
35	16.548	78.3%	1.28	-0.782	67.588	139.461	307.710
36	13.641	80.5%	1.24	-0.861	68.723	140.748	309.172
37	12.008	82.8%	1.21	-0.947	69.803	141.914	310.430
38	11.991	85.1%	1.18	-1.039	70.881	143.078	311.685
39	10.308	87.3%	1.15	-1.142	71.895	144.104	312.725
40	8.801	89.6%	1.12	-1.259	72.839	144.996	313.568
41	5.106	91.9%	1.09	-1.395	73.547	145.498	313.923
42	1.972	94.1%	1.06	-1.565	73.842	145.585	313.949
43	1.738	96.4%	1.04	-1.797	74.082	145.642	313.963
44	1.643	98.6%	1.01	-2.209	74.298	145.689	313.973

Client: Hancock coal		Date:	17/8/2011
Project/Job: ACP	Job No:	Sheet No:	
Subject: **FFA Native Companion Creek**		By:	ARB

LOG-PEARSON III DISTRIBUTION

Mean Override, *M*	1.689	1.689
Std Deviation Override, *S*	0.686	0.686
Skewness Override, *g*	-0.027	-0.027

Gridline Data

	Min	Max
Discharge (r	1	10000
AEP	0.95	0.0001
	-1.645	3.719

Y_P	P_N	LPIII	LPIII Confidence Limit		Plotting	Frequency
ARI	**AEP**	**Discharge**	**Lower**	**Upper**	Position	Factor
2000	0.05%	8240.7	3510.2	26995.8	3.291	3.246
1000	0.1%	6060.5	2691.1	18668.4	3.090	3.052
500	0.2%	4374.6	2028.9	12631.1	2.878	2.845
200	0.5%	2745.5	1353.2	7237.0	2.576	2.550
100	1.0%	1867.5	966.6	4571.8	2.326	2.306
50	2.0%	1224.4	667.3	2769.9	2.054	2.039
20	5.0%	648.8	380.1	1310.0	1.645	1.637
10	10.0%	368.3	228.4	677.1	1.282	1.279
5	20.0%	185.0	121.1	308.2	0.842	0.843
2	50.0%	49.2	33.1	73.3	0.000	0.004
1.667	60.0%	33.0	21.7	48.8	-0.253	-0.249
1.429	70.0%	21.5	13.6	32.0	-0.524	-0.521
1.250	80.0%	13.0	7.8	19.8	-0.842	-0.840
1.111	90.0%	6.4	3.5	10.4	-1.282	-1.284
1.053	95.0%	3.6	1.8	6.1	-1.645	-1.653
1.010	99.0%	1.2	0.5	2.3	-2.326	-2.346

HYDROLOGIC MODEL DATA

ARI	AEP	Discharge		Position
2000	0.0005			3.291
1000	0.001			3.090
500	0.002			2.878
200	0.005		1816	2.576
100	0.01	1504	1534	2.326
50	0.02	1204	1221	2.054
20	0.05	919	928	1.645
10	0.1	532	528	1.282
5	0.2	347	342	0.842
2	0.5	51	48	0.000

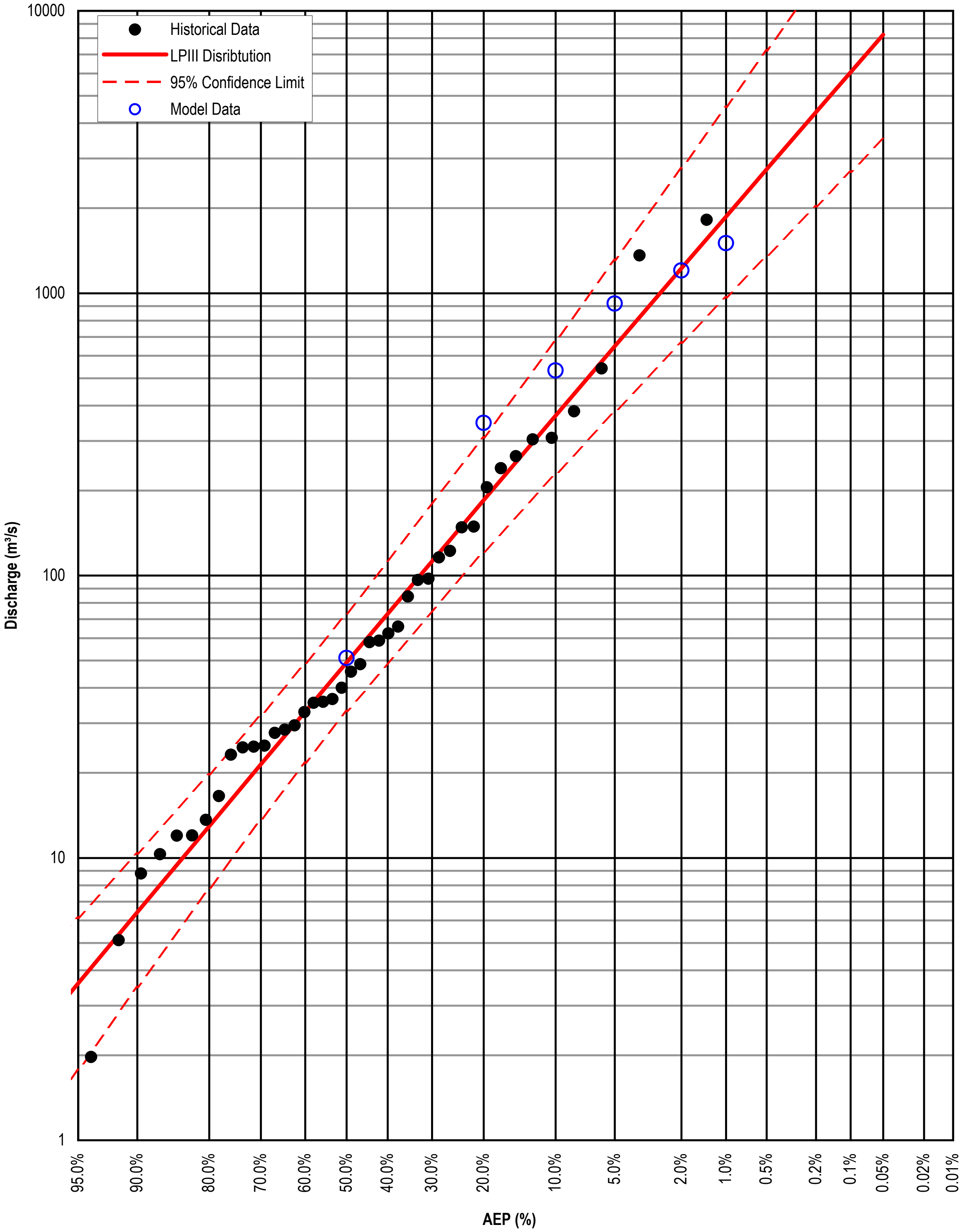
m=1.1, IL=10, CL=2

1437
1224
975
771
618
382

Client:	Hancock coal			Date:	17/8/2011
Project/Job:	ACP	Job No:		Sheet No:	
Subject:	**FFA Native Companion Creek**			By:	ARB

Sample Period (Years)	44
Number of Samples Used, *N*	44
Plotting Position Parameter, α	0.4

Adjusted Mean, *M*	1.689
Adjusted Std Deviation, *S*	0.686
Coefficient of Skewness, *g*	-0.027



1

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# # #

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# # #

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# # #

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0.# # # 99.95%
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0. # # # 99.9%
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0.# # # 99.8%
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0.# # # 99.5%
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1.# # # 99.0%
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2.# # # 98.0%
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# # #

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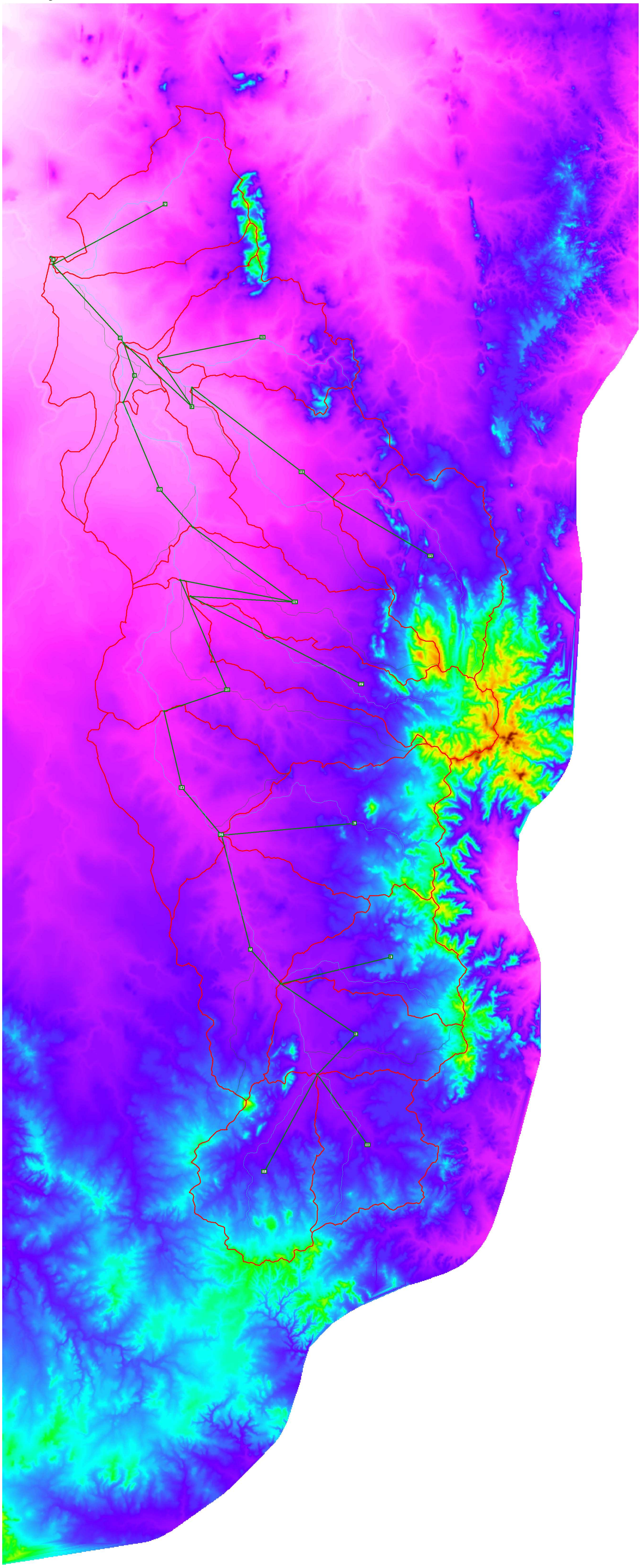
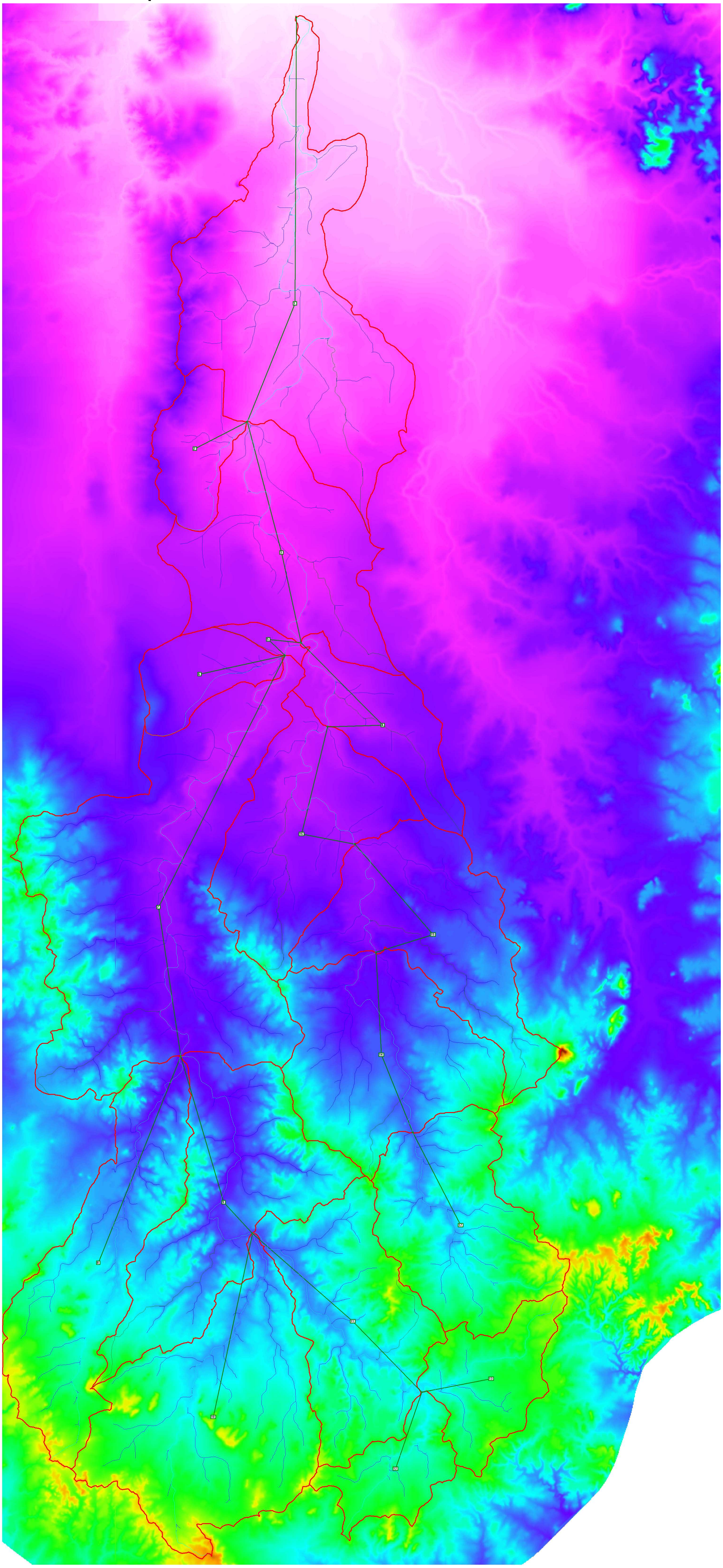
5(#
# #

APPENDIX B
RORB RESULTS

Belyando River Catchment Deliniation



Native Companion Creek Catchment deliniation



Kc and m parameters - Belyando River

Belyando River

ARR Book 5

Catchment area	5652.3	km^2	
d_{av}	98.44	km	(from RORB model)
K_c (Weeks, QLD)	85.74		

adjusted K_c	85.74	
m	0.982649	for 0.6<m<1.2

LHS	RHS (goal seek to LHS by changing m)
0.870987403	0.534633

RORB manual	**Iteration1**		**Iteration2**	
K_c	165.3999		42.43134	
Q_p	1800	m^3/s	1800	m^3/s
m_1	0.8		1	
m_2	1		1.1	
K_c adjustment factor	0.256538		0.506496	
new K_c	42.43134		21.49129	

Kc and m parameters - Native Companion Creek

Native Companion

ARR Book 5

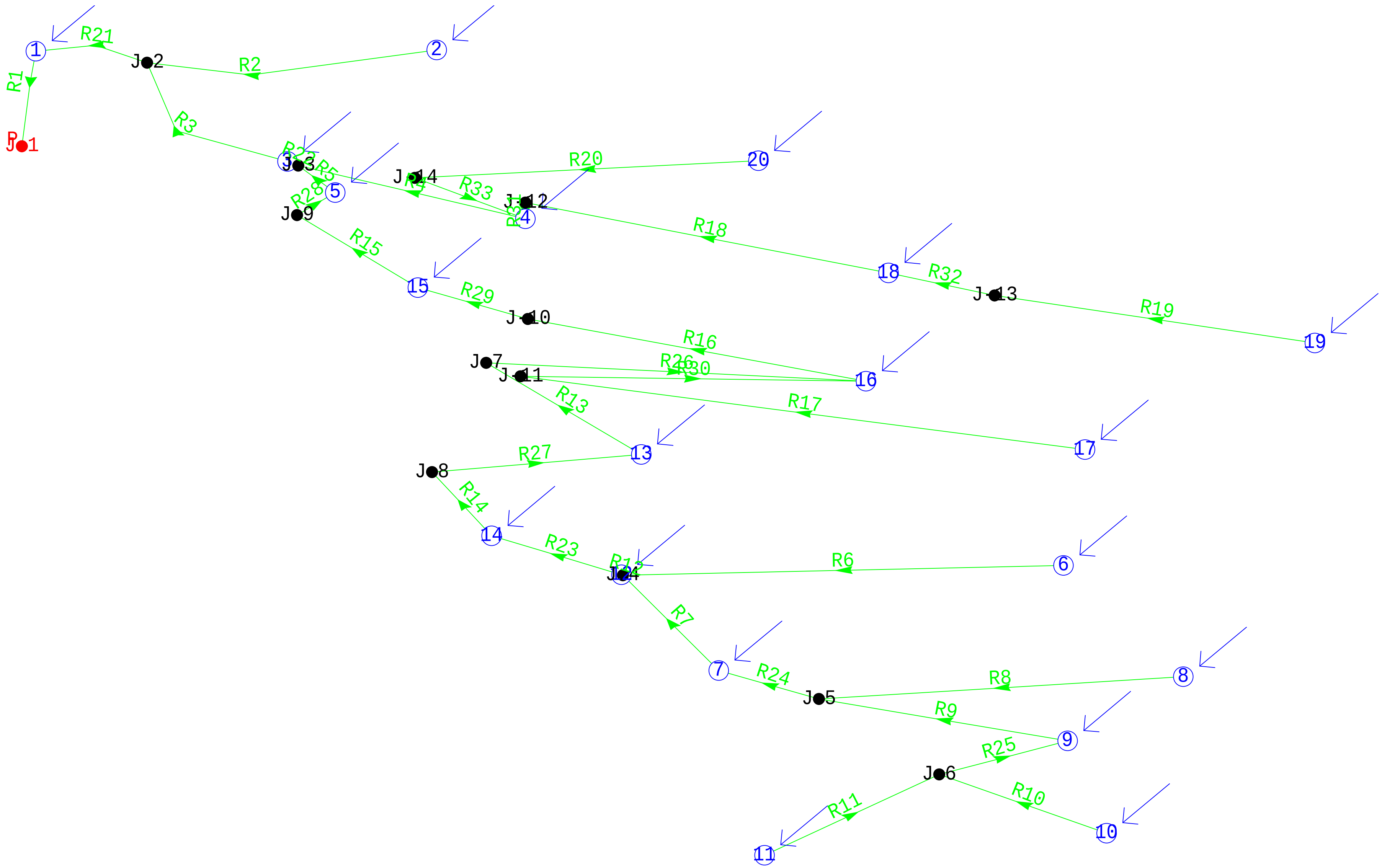
Catchment area	5124.8	km^2	
d_{av}	168.35	km	(from RORB model)
K_c (Weeks, QLD)	81.40		

adjusted K_c	81.4	
m	1.008839	for 0.6<m<1.2

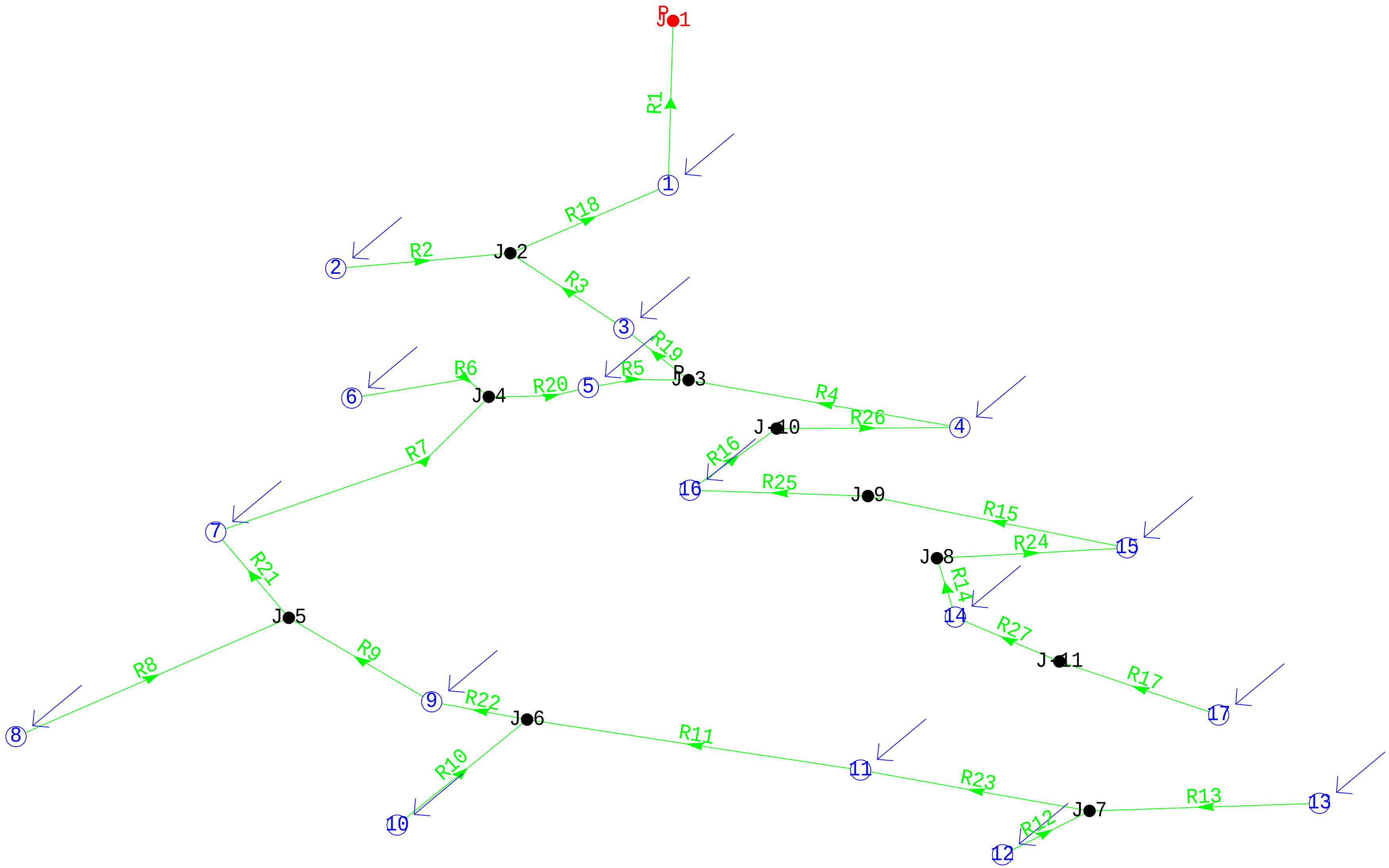
LHS	RHS (goal seek to LHS by changing m)
0.483516484	0.48361

RORB manual	**Iteration1**	
K_c	41.10072	
Q_p	1200	m^3/s
m_1	1.01	

Belyando River RORB



Native Companion Creek RORB



Belyando River RORB Result File

```
 RORBWin Output File
 *******************

 Program version 6.15 (last updated 30th March 2010)
 Copyright Monash University and Sinclair Knight Merz

 Date run: 09 Sep 2011 09:58

 Vector file       : \\calibre.network\PROJECTS\CEJV\BRI\Projects\PRO-Projects\2011
\CARP11064 HCPL Alpha FEED\06 Engineering\6.4 Hydrology\Belyando River\RORB\Belyando
River.catg
 Storm file        : S:\PRO-Projects\2011\CARP11064 HCPL Alpha FEED\06 Engineering
\6.4 Hydrology\Belyando River\RORB\Belyando River_72h50y.stm
 Output information: Flows & all input data


 Data checks:
 ************
 Next data to be read & checked:

 Catchment name & reach type flag
 Control vector & storage data
 Code no.  50     7.0 Location read as outlet
 Sub-area areas
 Impervious flag
 Initial storm data
 Rainfall burst times
 Pluviograph 1
 Sub-area rainfalls

 Data check completed



 Data:
 ****

 belyando


 Time data, in increments from initial time
 belyando: 72 hour 50 year Design Storm
 Time increment (hours)=  4.00

                    Start   Finish
 Rainfall times:     0       18


 End of hyeto/hydrographs:   18
 Duration of calculations:  300



 Pluviograph data (time in incs, rainfall in mm, in
                   increment following time shown)

        1:Temporal pattern (% of depth
   Time     1
     0    25.8
     1     4.7
     2     1.7
     3     0.7
     4     1.3
     5     2.6
     6    12.0
     7    17.0
     8     6.0
     9     3.1
    10     1.0
    11     2.1
    12     7.5
    13     9.4
```

14	3.8
15	0.5
16	0.5
17	0.3
Total	100.0

DESIGN run control vector

Step	Code	Description
1	1	Add sub-area 'A' inflow & route thru normal storage 1
2	3	Store hydrograph from step 1; reset hydrograph to zero
3	1	Add sub-area 'B' inflow & route thru normal storage 2
4	4	Add h-graph ex step 2 to h-graph ex step 3
5	5	Route hydrograph thru normal storage 3
6	2	Add sub-area 'C' inflow & route thru normal storage 4
7	3	Store hydrograph from step 6; reset hydrograph to zero
8	1	Add sub-area 'D' inflow & route thru normal storage 5
9	4	Add h-graph ex step 7 to h-graph ex step 8
10	5	Route hydrograph thru normal storage 6
11	2	Add sub-area 'E' inflow & route thru normal storage 7
12	3	Store hydrograph from step 11; reset hydrograph to zero
13	1	Add sub-area 'F' inflow & route thru normal storage 8
14	4	Add h-graph ex step 12 to h-graph ex step 13
15	3	Store hydrograph from step 14; reset hydrograph to zero
16	1	Add sub-area 'G' inflow & route thru normal storage 9
17	4	Add h-graph ex step 15 to h-graph ex step 16
18	5	Route hydrograph thru normal storage 10
19	2	Add sub-area 'H' inflow & route thru normal storage 11
20	5	Route hydrograph thru normal storage 12
21	2	Add sub-area 'I' inflow & route thru normal storage 13
22	5	Route hydrograph thru normal storage 14
23	3	Store hydrograph from step 22; reset hydrograph to zero
24	1	Add sub-area 'J' inflow & route thru normal storage 15
25	5	Route hydrograph thru normal storage 16
26	4	Add h-graph ex step 23 to h-graph ex step 25
27	2	Add sub-area 'K' inflow & route thru normal storage 17
28	5	Route hydrograph thru normal storage 18
29	2	Add sub-area 'L' inflow & route thru normal storage 19
30	5	Route hydrograph thru normal storage 20
31	2	Add sub-area 'M' inflow & route thru normal storage 21
32	3	Store hydrograph from step 31; reset hydrograph to zero
33	1	Add sub-area 'N' inflow & route thru normal storage 22
34	5	Route hydrograph thru normal storage 23
35	2	Add sub-area 'O' inflow & route thru normal storage 24
36	5	Route hydrograph thru normal storage 25
37	3	Store hydrograph from step 36; reset hydrograph to zero
38	1	Add sub-area 'P' inflow & route thru normal storage 26
39	5	Route hydrograph thru normal storage 27
40	4	Add h-graph ex step 37 to h-graph ex step 39
41	2	Add sub-area 'Q' inflow & route thru normal storage 28
42	4	Add h-graph ex step 32 to h-graph ex step 41
43	5	Route hydrograph thru normal storage 29
44	2	Add sub-area 'R' inflow & route thru normal storage 30
45	3	Store hydrograph from step 44; reset hydrograph to zero
46	1	Add sub-area 'S' inflow & route thru normal storage 31
47	4	Add h-graph ex step 45 to h-graph ex step 46
48	5	Route hydrograph thru normal storage 32
49	2	Add sub-area 'T' inflow & route thru normal storage 33
50	7.0	Print hydrograph, outlet
51	0	**********End of control vector**********

Sub-area data

Sub-area	Area km²	Dist. km*
A	2.66E+02	1.86E+02

B	3.21E+02	1.90E+02
C	2.62E+02	1.61E+02
D	2.41E+02	1.71E+02
E	4.41E+02	1.38E+02
F	4.18E+02	1.50E+02
G	1.50E-01	1.24E+02
H	3.67E+02	1.10E+02
I	4.46E+02	8.31E+01
J	3.15E+02	1.01E+02
K	3.24E+02	6.41E+01
L	3.24E+02	4.51E+01
M	3.27E+01	2.63E+01
N	4.00E+02	9.58E+01
O	4.37E+02	5.37E+01
P	3.02E+02	5.70E+01
Q	7.98E+01	2.89E+01
R	3.42E+02	1.13E+01
S	3.32E+02	2.46E+01
T	8.90E-01	6.25E-01

Total 5.652E+03

For whole catchment ; Av. Dist., km* = 98.44
For interstation area 1; Av. Dist., km* = 98.44; ISA Factor = 1.000

* or other function of reach properties related to travel time

Normal storage data

Storage no.	Length km*	Rel. delay time	Type	Slope percent
1	16.4	0.167	Natural	
2	20.0	0.203	Natural	
3	8.4	0.086	Natural	
4	8.4	0.086	Natural	
5	18.2	0.185	Natural	
6	14.4	0.147	Natural	
7	14.4	0.147	Natural	
8	25.8	0.262	Natural	
9	0.3	0.003	Natural	
10	13.4	0.136	Natural	
11	13.4	0.136	Natural	
12	13.9	0.141	Natural	
13	13.9	0.141	Natural	
14	5.1	0.052	Natural	
15	32.1	0.326	Natural	
16	5.1	0.052	Natural	
17	5.1	0.052	Natural	
18	13.9	0.141	Natural	
19	13.9	0.141	Natural	
20	4.9	0.050	Natural	
21	4.9	0.050	Natural	
22	24.9	0.253	Natural	
23	17.2	0.174	Natural	
24	17.2	0.174	Natural	
25	7.6	0.077	Natural	
26	20.5	0.208	Natural	
27	7.6	0.077	Natural	
28	7.6	0.077	Natural	
29	10.0	0.102	Natural	
30	10.0	0.102	Natural	
31	23.4	0.237	Natural	
32	0.6	0.006	Natural	
33	0.6	0.006	Natural	

* or other function of reach properties related to travel time

Input of parameters:
****

belyando
DESIGN Run
belyando: 72 hour 50 year Design Storm
Time increment = 4.00 hours

Constant loss model selected

Rainfall, mm, in time inc. following time shown

Time Incs	Catchment	Sub-Area A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
0	63.5	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64
1	11.6	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
2	4.2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
3	1.7	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
4	3.2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
5	6.4	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
6	29.6	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
7	41.9	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42
8	14.8	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
9	7.6	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
10	2.5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
11	5.2	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
12	18.5	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
13	23.2	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23
14	9.4	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
15	1.2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	1.2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17	0.7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Tot.	246.3	246	246	246	246	246	246	246	246	246	246	246	246	246	246	246	246
Pluvi. ref. no.		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Time Incs	Catchment	Sub-Area Q	R	S	T
0	63.5	64	64	64	64
1	11.6	12	12	12	12
2	4.2	4	4	4	4
3	1.7	2	2	2	2
4	3.2	3	3	3	3
5	6.4	6	6	6	6
6	29.6	30	30	30	30
7	41.9	42	42	42	42
8	14.8	15	15	15	15
9	7.6	8	8	8	8
10	2.5	2	2	2	2
11	5.2	5	5	5	5
12	18.5	18	18	18	18
13	23.2	23	23	23	23
14	9.4	9	9	9	9
15	1.2	1	1	1	1
16	1.2	1	1	1	1
17	0.7	1	1	1	1
Tot.	246.3	246	246	246	246
Pluvi. ref. no.		1	1	1	1

Rainfall-excess, mm, in time inc. following time shown

Time Incs	Catchment	Sub-Area A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
0	38.5	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39

1	1.6	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
2	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	19.6	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
7	31.9	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32
8	4.8	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
9	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	8.5	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
13	13.2	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
14	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tot.	117.9	118	118	118	118	118	118	118	118	118	118	118	118	118	118	118	118

Time Incs	Catchment	Sub-Area Q	R	S	T
0	38.5	39	39	39	39
1	1.6	2	2	2	2
2	0.0	0	0	0	0
3	0.0	0	0	0	0
4	0.0	0	0	0	0
5	0.0	0	0	0	0
6	19.6	20	20	20	20
7	31.9	32	32	32	32
8	4.8	5	5	5	5
9	0.0	0	0	0	0
10	0.0	0	0	0	0
11	0.0	0	0	0	0
12	8.5	8	8	8	8
13	13.2	13	13	13	13
14	0.0	0	0	0	0
15	0.0	0	0	0	0
16	0.0	0	0	0	0
17	0.0	0	0	0	0
Tot.	117.9	118	118	118	118

Routing results:
****
belyando
belyando: 72 hour 50 year Design Storm
DESIGN run no. 1

Parameters: kc = 130.00 m = 1.01

Loss parameters	Initial loss (mm)	Cont. loss (mm/h)
	15.00	2.50

*** Calculated hydrograph, outlet

	Hydrograph Calc.
Peak discharge,m³/s	804.8
Time to peak,h	104.
Volume,m³	6.66E+08
Time to centroid,h	164.
Lag (c.m. to c.m.),h	139.
Lag to peak,h	79.9

Belyando River RORB Result File

Hydrograph summary
****

Site Description
01 Calculated hydrograph, outlet

Inc	Time	Hyd0001
1	4.00	0.000
2	8.00	83.879
3	12.00	250.115
4	16.00	301.469
5	20.00	242.658
6	24.00	214.717
7	28.00	204.841
8	32.00	240.605
9	36.00	395.317
10	40.00	569.716
11	44.00	608.470
12	48.00	563.299
13	52.00	541.662
14	56.00	556.398
15	60.00	625.182
16	64.00	704.818
17	68.00	725.253
18	72.00	718.663
19	76.00	726.477
20	80.00	738.834
21	84.00	751.930
22	88.00	766.100
23	92.00	778.585
24	96.00	789.268
25	100.00	797.233
26	104.00	802.431
27	108.00	804.770
28	112.00	804.432
29	116.00	801.648
30	120.00	796.727
31	124.00	789.994
32	128.00	781.779
33	132.00	772.397
34	136.00	762.139
35	140.00	751.268
36	144.00	740.009
37	148.00	728.559
38	152.00	717.075
39	156.00	705.684
40	160.00	694.482
41	164.00	683.535
42	168.00	672.881
43	172.00	662.539
44	176.00	652.505
45	180.00	642.757
46	184.00	633.261
47	188.00	623.971
48	192.00	614.834
49	196.00	605.790
50	200.00	596.776
51	204.00	587.732
52	208.00	578.594
53	212.00	569.306
54	216.00	559.813
55	220.00	550.070
56	224.00	540.035
57	228.00	529.676
58	232.00	518.966
59	236.00	507.889
60	240.00	496.437
61	244.00	484.608
62	248.00	472.408
63	252.00	459.852
64	256.00	446.960

65	260.00	433.757
66	264.00	420.276
67	268.00	406.551
68	272.00	392.624
69	276.00	378.535
70	280.00	364.330
71	284.00	350.054
72	288.00	335.755
73	292.00	321.477
74	296.00	307.268
75	300.00	293.172
76	304.00	279.231
77	308.00	265.487
78	312.00	251.978
79	316.00	238.739
80	320.00	225.802
81	324.00	213.198
82	328.00	200.951
83	332.00	189.084
84	336.00	177.616
85	340.00	166.564
86	344.00	155.938
87	348.00	145.748
88	352.00	136.001
89	356.00	126.700
90	360.00	117.845
91	364.00	109.434
92	368.00	101.464
93	372.00	93.927
94	376.00	86.816
95	380.00	80.121
96	384.00	73.830
97	388.00	67.932
98	392.00	62.413
99	396.00	57.259
100	400.00	52.454
101	404.00	47.984
102	408.00	43.834
103	412.00	39.986
104	416.00	36.426
105	420.00	33.138
106	424.00	30.106
107	428.00	27.315
108	432.00	24.751
109	436.00	22.398
110	440.00	20.243
111	444.00	18.272
112	448.00	16.472
113	452.00	14.832
114	456.00	13.338
115	460.00	11.980
116	464.00	10.748
117	468.00	9.631
118	472.00	8.620
119	476.00	7.707
120	480.00	6.882
121	484.00	6.139
122	488.00	5.470
123	492.00	4.869
124	496.00	4.329
125	500.00	3.844
126	504.00	3.411
127	508.00	3.023
128	512.00	2.676
129	516.00	2.367
130	520.00	2.092
131	524.00	1.846
132	528.00	1.628
133	532.00	1.435
134	536.00	1.263
135	540.00	1.110
136	544.00	0.975

137	548.00	0.856
138	552.00	0.751
139	556.00	0.658
140	560.00	0.576
141	564.00	0.504
142	568.00	0.440
143	572.00	0.384
144	576.00	0.335
145	580.00	0.292
146	584.00	0.255
147	588.00	0.222
148	592.00	0.193
149	596.00	0.168
150	600.00	0.146
151	604.00	0.126
152	608.00	0.110
153	612.00	0.095
154	616.00	0.082
155	620.00	0.071
156	624.00	0.062
157	628.00	0.053
158	632.00	0.046
159	636.00	0.040
160	640.00	0.034
161	644.00	0.030
162	648.00	0.026
163	652.00	0.022
164	656.00	0.019
165	660.00	0.016
166	664.00	0.014
167	668.00	0.012
168	672.00	0.010
169	676.00	0.009
170	680.00	0.008
171	684.00	0.007
172	688.00	0.006
173	692.00	0.005
174	696.00	0.004
175	700.00	0.004
176	704.00	0.003
177	708.00	0.003
178	712.00	0.002
179	716.00	0.002
180	720.00	0.002
181	724.00	0.001
182	728.00	0.001
183	732.00	0.001
184	736.00	0.001
185	740.00	0.001
186	744.00	0.001
187	748.00	0.001
188	752.00	0.000
189	756.00	0.000
190	760.00	0.000
191	764.00	0.000
192	768.00	0.000
193	772.00	0.000
194	776.00	0.000
195	780.00	0.000
196	784.00	0.000
197	788.00	0.000
198	792.00	0.000
199	796.00	0.000
200	800.00	0.000
201	804.00	0.000
202	808.00	0.000
203	812.00	0.000
204	816.00	0.000
205	820.00	0.000
206	824.00	0.000
207	828.00	0.000
208	832.00	0.000

209	836.00	0.000
210	840.00	0.000
211	844.00	0.000
212	848.00	0.000
213	852.00	0.000
214	856.00	0.000
215	860.00	0.000
216	864.00	0.000
217	868.00	0.000
218	872.00	0.000
219	876.00	0.000
220	880.00	0.000
221	884.00	0.000
222	888.00	0.000
223	892.00	0.000
224	896.00	0.000
225	900.00	0.000
226	904.00	0.000
227	908.00	0.000
228	912.00	0.000
229	916.00	0.000
230	920.00	0.000
231	924.00	0.000
232	928.00	0.000
233	932.00	0.000
234	936.00	0.000
235	940.00	0.000
236	944.00	0.000
237	948.00	0.000
238	952.00	0.000
239	956.00	0.000
240	960.00	0.000
241	964.00	0.000
242	968.00	0.000
243	972.00	0.000
244	976.00	0.000
245	980.00	0.000
246	984.00	0.000
247	988.00	0.000
248	992.00	0.000
249	996.00	0.000
250	1000.00	0.000
251	1004.00	0.000
252	1008.00	0.000
253	1012.00	0.000
254	1016.00	0.000
255	1020.00	0.000
256	1024.00	0.000
257	1028.00	0.000
258	1032.00	0.000
259	1036.00	0.000
260	1040.00	0.000
261	1044.00	0.000
262	1048.00	0.000
263	1052.00	0.000
264	1056.00	0.000
265	1060.00	0.000
266	1064.00	0.000
267	1068.00	0.000
268	1072.00	0.000
269	1076.00	0.000
270	1080.00	0.000
271	1084.00	0.000
272	1088.00	0.000
273	1092.00	0.000
274	1096.00	0.000
275	1100.00	0.000
276	1104.00	0.000
277	1108.00	0.000
278	1112.00	0.000
279	1116.00	0.000
280	1120.00	0.000

281	1124.00	0.000
282	1128.00	0.000
283	1132.00	0.000
284	1136.00	0.000
285	1140.00	0.000
286	1144.00	0.000
287	1148.00	0.000
288	1152.00	0.000
289	1156.00	0.000
290	1160.00	0.000
291	1164.00	0.000
292	1168.00	0.000
293	1172.00	0.000
294	1176.00	0.000
295	1180.00	0.000
296	1184.00	0.000
297	1188.00	0.000
298	1192.00	0.000
299	1196.00	0.000
300	1200.00	0.000
301	1204.00	0.000

Native Companion Creek RORB Result File

```
 RORBWin Output File
 *******************

 Program version 6.15 (last updated 30th March 2010)
 Copyright Monash University and Sinclair Knight Merz

 Date run: 12 Sep 2011 15:43

 Vector file       : \\calibre.network\PROJECTS\CEJV\BRI\Projects\PRO-Projects\2011
\CARP11064 HCPL Alpha FEED\06 Engineering\6.4 Hydrology\Native companion creek\RORB
modelling\Native companion creek.catg
 Storm file        : S:\PRO-Projects\2011\CARP11064 HCPL Alpha FEED\06 Engineering
\6.4 Hydrology\Native companion creek\RORB modelling\Native companion creek_
72h50y.stm
 Output information: Flows & all input data


 Data checks:
 ************
 Next data to be read & checked:

 Catchment name & reach type flag
 Control vector & storage data
 Code no.  33     7.0 Location read as
 Code no.  41     7.0 Location read as outlet
 Sub-area areas
 Impervious flag
 Initial storm data
 Rainfall burst times
 Pluviograph 1
 Sub-area rainfalls

 Data check completed



 Data:
 ****

 native companion


 Time data, in increments from initial time
 native companion: 72 hour 50 year Design Storm
 Time increment (hours)=  4.00

                   Start   Finish
 Rainfall times:     0       18


 End of hyeto/hydrographs:   18
 Duration of calculations:  120



 Pluviograph data (time in incs, rainfall in mm, in
                   increment following time shown)

         1:Temporal pattern (% of depth
   Time     1
     0    25.8
     1     4.7
     2     1.7
     3     0.7
     4     1.3
     5     2.6
     6    12.0
     7    17.0
     8     6.0
     9     3.1
    10     1.0
    11     2.1
```

12	7.5
13	9.4
14	3.8
15	0.5
16	0.5
17	0.3
Total	100.0

DESIGN run control vector

Step	Code	Description
1	1	Add sub-area 'A' inflow & route thru normal storage 1
2	3	Store hydrograph from step 1; reset hydrograph to zero
3	1	Add sub-area 'B' inflow & route thru normal storage 2
4	4	Add h-graph ex step 2 to h-graph ex step 3
5	5	Route hydrograph thru normal storage 3
6	2	Add sub-area 'C' inflow & route thru normal storage 4
7	3	Store hydrograph from step 6; reset hydrograph to zero
8	1	Add sub-area 'D' inflow & route thru normal storage 5
9	4	Add h-graph ex step 7 to h-graph ex step 8
10	5	Route hydrograph thru normal storage 6
11	2	Add sub-area 'E' inflow & route thru normal storage 7
12	3	Store hydrograph from step 11; reset hydrograph to zero
13	1	Add sub-area 'F' inflow & route thru normal storage 8
14	4	Add h-graph ex step 12 to h-graph ex step 13
15	5	Route hydrograph thru normal storage 9
16	2	Add sub-area 'G' inflow & route thru normal storage 10
17	3	Store hydrograph from step 16; reset hydrograph to zero
18	1	Add sub-area 'H' inflow & route thru normal storage 11
19	4	Add h-graph ex step 17 to h-graph ex step 18
20	5	Route hydrograph thru normal storage 12
21	2	Add sub-area 'I' inflow & route thru normal storage 13
22	3	Store hydrograph from step 21; reset hydrograph to zero
23	1	Add sub-area 'J' inflow & route thru normal storage 14
24	5	Route hydrograph thru normal storage 15
25	2	Add sub-area 'K' inflow & route thru normal storage 16
26	5	Route hydrograph thru normal storage 17
27	2	Add sub-area 'L' inflow & route thru normal storage 18
28	5	Route hydrograph thru normal storage 19
29	2	Add sub-area 'M' inflow & route thru normal storage 20
30	5	Route hydrograph thru normal storage 21
31	2	Add sub-area 'N' inflow & route thru normal storage 22
32	4	Add h-graph ex step 22 to h-graph ex step 31
33	7.0	Print hydrograph,
34	5	Route hydrograph thru normal storage 23
35	2	Add sub-area 'O' inflow & route thru normal storage 24
36	3	Store hydrograph from step 35; reset hydrograph to zero
37	1	Add sub-area 'P' inflow & route thru normal storage 25
38	4	Add h-graph ex step 36 to h-graph ex step 37
39	5	Route hydrograph thru normal storage 26
40	2	Add sub-area 'Q' inflow & route thru normal storage 27
41	7.0	Print hydrograph, outlet
42	0	**********End of control vector**********

Sub-area data

Sub-area	Area km²	Dist. km*
A	1.06E+02	2.75E+02
B	1.49E+02	2.75E+02
C	3.13E+02	2.44E+02
D	4.68E+02	2.50E+02
E	3.71E+02	2.08E+02
F	3.67E+02	2.20E+02
G	7.59E+02	1.52E+02
H	9.65E+01	1.23E+02

I	1.61E+01	1.12E+02
J	3.01E+02	2.26E+02
K	3.52E+02	1.91E+02
L	3.24E+02	1.65E+02
M	3.12E+02	1.41E+02
N	1.51E+02	1.19E+02
O	3.48E+02	9.18E+01
P	1.03E+02	8.27E+01
Q	5.90E+02	3.67E+01

Total 5.125E+03

For whole catchment ; Av. Dist., km* = 168.35
For interstation area 1; Av. Dist., km* = 168.35; ISA Factor = 1.000

* or other function of reach properties related to travel time

Normal storage data

Storage no.	Length km*	Rel. delay time	Type	Slope percent
1	12.8	0.076	Natural	
2	13.2	0.079	Natural	
3	18.3	0.109	Natural	
4	18.3	0.109	Natural	
5	24.3	0.144	Natural	
6	17.5	0.104	Natural	
7	17.5	0.104	Natural	
8	29.8	0.177	Natural	
9	38.8	0.230	Natural	
10	38.8	0.230	Natural	
11	9.4	0.056	Natural	
12	1.4	0.009	Natural	
13	1.4	0.009	Natural	
14	18.8	0.111	Natural	
15	16.5	0.098	Natural	
16	16.5	0.098	Natural	
17	9.6	0.057	Natural	
18	9.6	0.057	Natural	
19	13.9	0.083	Natural	
20	13.9	0.083	Natural	
21	8.4	0.050	Natural	
22	8.4	0.050	Natural	
23	18.5	0.110	Natural	
24	18.5	0.110	Natural	
25	9.4	0.056	Natural	
26	36.7	0.218	Natural	
27	36.7	0.218	Natural	

* or other function of reach properties related to travel time

Input of parameters:
****

native companion
DESIGN Run
native companion: 72 hour 50 year Design Storm
Time increment = 4.00 hours

Constant loss model selected

Rainfall, mm, in time inc. following time shown

Time Incs	Catch ment	Sub-Area A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
0	63.5	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64

1	11.6	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
2	4.2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
3	1.7	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
4	3.2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
5	6.4	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
6	29.6	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
7	41.9	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42
8	14.8	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
9	7.6	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
10	2.5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
11	5.2	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
12	18.5	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
13	23.2	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23
14	9.4	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
15	1.2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	1.2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17	0.7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Tot.	246.3	246	246	246	246	246	246	246	246	246	246	246	246	246	246	246	246
Pluvi. ref. no.		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Time Incs	Catch ment	Sub-Area Q
0	63.5	64
1	11.6	12
2	4.2	4
3	1.7	2
4	3.2	3
5	6.4	6
6	29.6	30
7	41.9	42
8	14.8	15
9	7.6	8
10	2.5	2
11	5.2	5
12	18.5	18
13	23.2	23
14	9.4	9
15	1.2	1
16	1.2	1
17	0.7	1
Tot.	246.3	246
Pluvi. ref. no.		1

Rainfall-excess, mm, in time inc. following time shown

Time Incs	Catch ment	Sub-Area A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
0	38.5	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39
1	1.6	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
2	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	19.6	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
7	31.9	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32
8	4.8	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
9	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	8.5	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
13	13.2	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
14	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

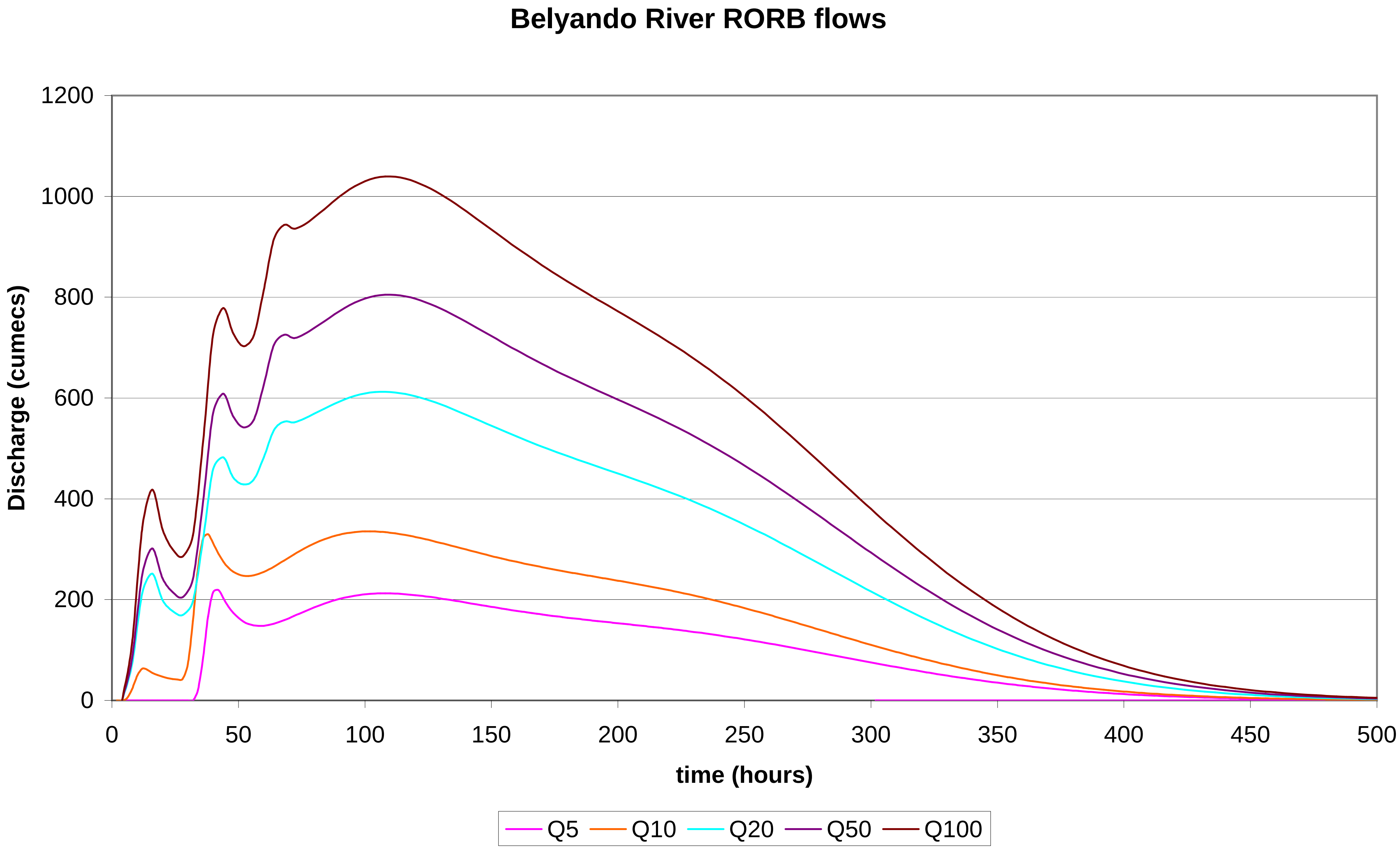
```
 17   0.0          0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0

Tot.117.9        118 118 118 118 118 118 118 118 118 118 118 118 118 118 118 118

Time              Sub-
     Catch        Area
Incs ment         Q

  0  38.5         39
  1   1.6          2
  2   0.0          0
  3   0.0          0
  4   0.0          0
  5   0.0          0
  6  19.6         20
  7  31.9         32
  8   4.8          5
  9   0.0          0
 10   0.0          0
 11   0.0          0
 12   8.5          8
 13  13.2         13
 14   0.0          0
 15   0.0          0
 16   0.0          0
 17   0.0          0

Tot.117.9        118


Routing results:
****************
native companion
native companion: 72 hour 50 year Design Storm
DESIGN run no.  1


Parameters:  kc =   130.00    m = 1.01

Loss parameters     Initial loss (mm)   Cont. loss (mm/h)
                          15.00               2.50



*** Calculated hydrograph,

                          Hydrograph
                         Calc.
Peak discharge,m³/s     1096.
Time to peak,h           60.0
Volume,m³            4.81E+08
Time to centroid,h       96.1
Lag (c.m. to c.m.),h     71.9
Lag to peak,h            35.9



*** Calculated hydrograph,  outlet

                          Hydrograph
                         Calc.
Peak discharge,m³/s     814.5
Time to peak,h           152.
Volume,m³            6.03E+08
Time to centroid,h       164.
Lag (c.m. to c.m.),h     140.
Lag to peak,h            128.


Hydrograph summary
******************
```

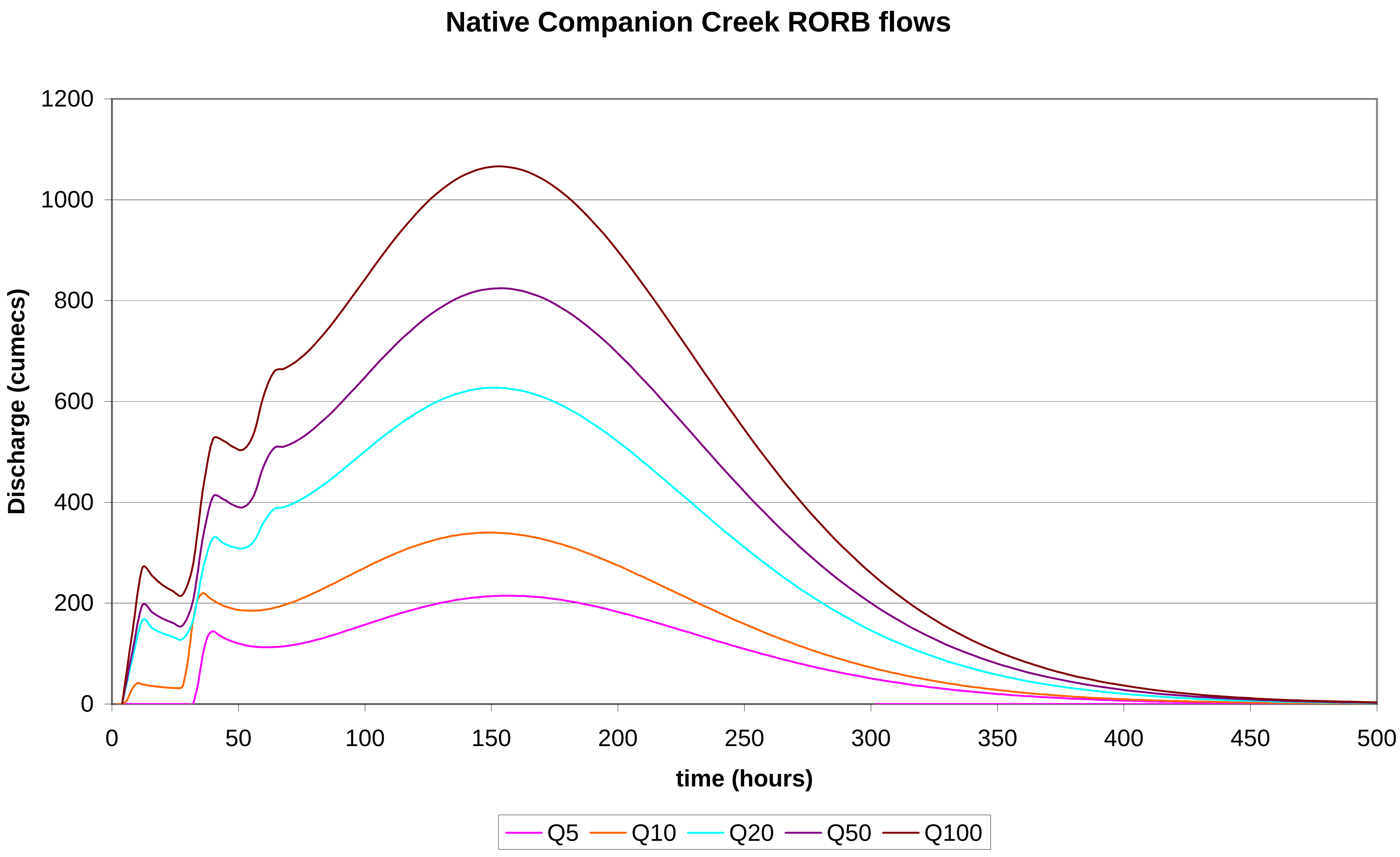
Native Companion Creek RORB Result File

Site	Description
01	Calculated hydrograph,
02	Calculated hydrograph, outlet

Inc	Time	Hyd0001	Hyd0002
1	4.00	0.00	0.000
2	8.00	196.51	100.476
3	12.00	431.05	193.651
4	16.00	464.74	180.385
5	20.00	426.94	168.001
6	24.00	394.24	159.620
7	28.00	385.57	154.384
8	32.00	473.96	201.986
9	36.00	742.57	328.159
10	40.00	960.94	406.586
11	44.00	987.44	401.090
12	48.00	940.57	390.077
13	52.00	903.25	385.439
14	56.00	927.01	407.441
15	60.00	1026.39	464.875
16	64.00	1096.40	499.524
17	68.00	1085.20	502.437
18	72.00	1053.61	510.308
19	76.00	1028.60	522.019
20	80.00	1009.79	536.743
21	84.00	989.58	553.816
22	88.00	969.15	572.666
23	92.00	947.07	592.781
24	96.00	923.27	613.696
25	100.00	897.55	634.981
26	104.00	869.93	656.246
27	108.00	840.48	677.132
28	112.00	809.41	697.320
29	116.00	776.94	716.523
30	120.00	743.35	734.488
31	124.00	708.94	750.999
32	128.00	674.01	765.867
33	132.00	638.87	778.939
34	136.00	603.79	790.088
35	140.00	569.04	799.217
36	144.00	534.86	806.256
37	148.00	501.45	811.161
38	152.00	469.01	813.910
39	156.00	437.67	814.507
40	160.00	407.56	812.974
41	164.00	378.77	809.356
42	168.00	351.35	803.712
43	172.00	325.35	796.121
44	176.00	300.78	786.675
45	180.00	277.65	775.476
46	184.00	255.92	762.640
47	188.00	235.59	748.291
48	192.00	216.59	732.557
49	196.00	198.90	715.574
50	200.00	182.44	697.479
51	204.00	167.17	678.410
52	208.00	153.02	658.507
53	212.00	139.94	637.906
54	216.00	127.85	616.740
55	220.00	116.71	595.138
56	224.00	106.44	573.223
57	228.00	96.99	551.114
58	232.00	88.31	528.922
59	236.00	80.34	506.748
60	240.00	73.04	484.689
61	244.00	66.34	462.833
62	248.00	60.22	441.259
63	252.00	54.61	420.038
64	256.00	49.50	399.233
65	260.00	44.83	378.900
66	264.00	40.57	359.087

67	268.00	36.69	339.835
68	272.00	33.16	321.176
69	276.00	29.94	303.139
70	280.00	27.02	285.745
71	284.00	24.37	269.008
72	288.00	21.97	252.940
73	292.00	19.79	237.546
74	296.00	17.81	222.826
75	300.00	16.02	208.779
76	304.00	14.40	195.399
77	308.00	12.94	182.676
78	312.00	11.62	170.599
79	316.00	10.43	159.153
80	320.00	9.36	148.324
81	324.00	8.39	138.093
82	328.00	7.51	128.441
83	332.00	6.73	119.350
84	336.00	6.02	110.798
85	340.00	5.39	102.763
86	344.00	4.82	95.225
87	348.00	4.30	88.162
88	352.00	3.84	81.552
89	356.00	3.43	75.373
90	360.00	3.06	69.604
91	364.00	2.73	64.224
92	368.00	2.44	59.211
93	372.00	2.17	54.547
94	376.00	1.93	50.211
95	380.00	1.72	46.184
96	384.00	1.53	42.448
97	388.00	1.36	38.985
98	392.00	1.21	35.779
99	396.00	1.08	32.812
100	400.00	0.96	30.071
101	404.00	0.85	27.539
102	408.00	0.75	25.203
103	412.00	0.67	23.050
104	416.00	0.59	21.066
105	420.00	0.53	19.241
106	424.00	0.47	17.563
107	428.00	0.41	16.020
108	432.00	0.37	14.604
109	436.00	0.32	13.305
110	440.00	0.29	12.114
111	444.00	0.25	11.023
112	448.00	0.23	10.024
113	452.00	0.20	9.110
114	456.00	0.18	8.275
115	460.00	0.16	7.512
116	464.00	0.14	6.816
117	468.00	0.12	6.181
118	472.00	0.11	5.601
119	476.00	0.09	5.074
120	480.00	0.08	4.593
121	484.00	0.07	4.156

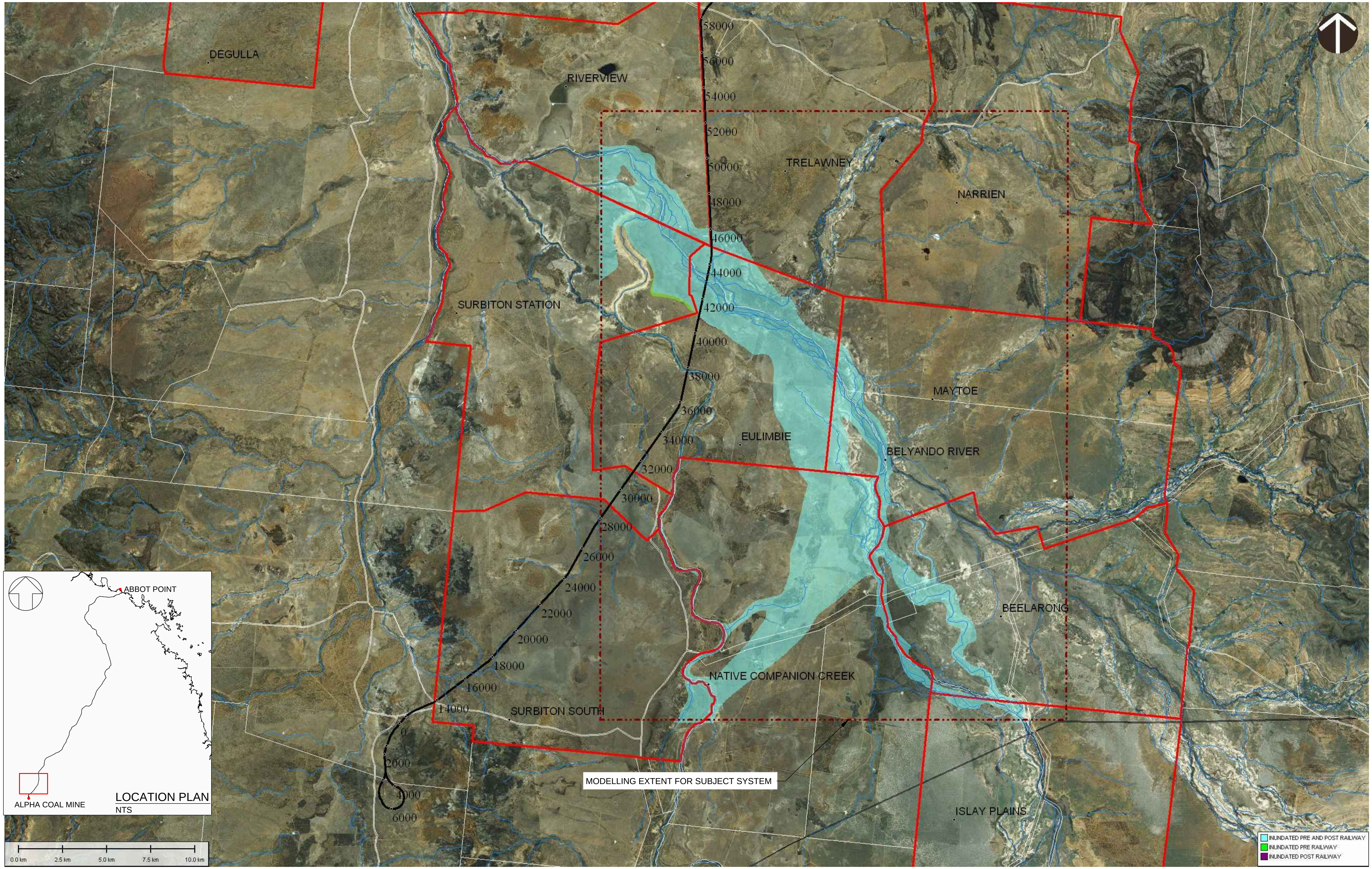

Belyando River RORB flows
Discharge (cumecs)
time (hours)
0
200
400
600
800
1000
1200
0
50
100
150
200
250
300
350
400
450
500
Q5
Q10
Q20
Q50
Q100


Native Companion Creek RORB flows
Discharge (cumecs)
1200
1000
800
600
400
200
0
0
50
100
150
200
250
300
350
400
450
500
time (hours)
Q5
Q10
Q20
Q50
Q100

APPENDIX C
FLOOD MAPS

NOT TO BE SCALED

NOT TO BE SCALED



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C	DES	03.11.11	RE-ISSUED FOR INFORMATION	TLB	
B	DES	07.10.11	RE-ISSUED FOR INFORMATION	TLB	
A	DES	03.10.11	ISSUED FOR INFORMATION	TLB	

REVISIONS

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DRAWN	D. SMITH	03.10.11
DRAFTING CHECK		
DESIGNER		
ENG. APPROVED		
ENG. MANAGER		
PROJECT MANAGER		
CLIENT APPROVED		

calibre

HANCOCK COAL PTY LTD

ALPHA COAL PROJECT
RAIL ALIGNMENT - MINE TO ABBOT POINT
FLOOD INUNDATION
BELYANDO RIVER / NATIVE COMPANION CREEK - Q5

SHEET SIZE A1

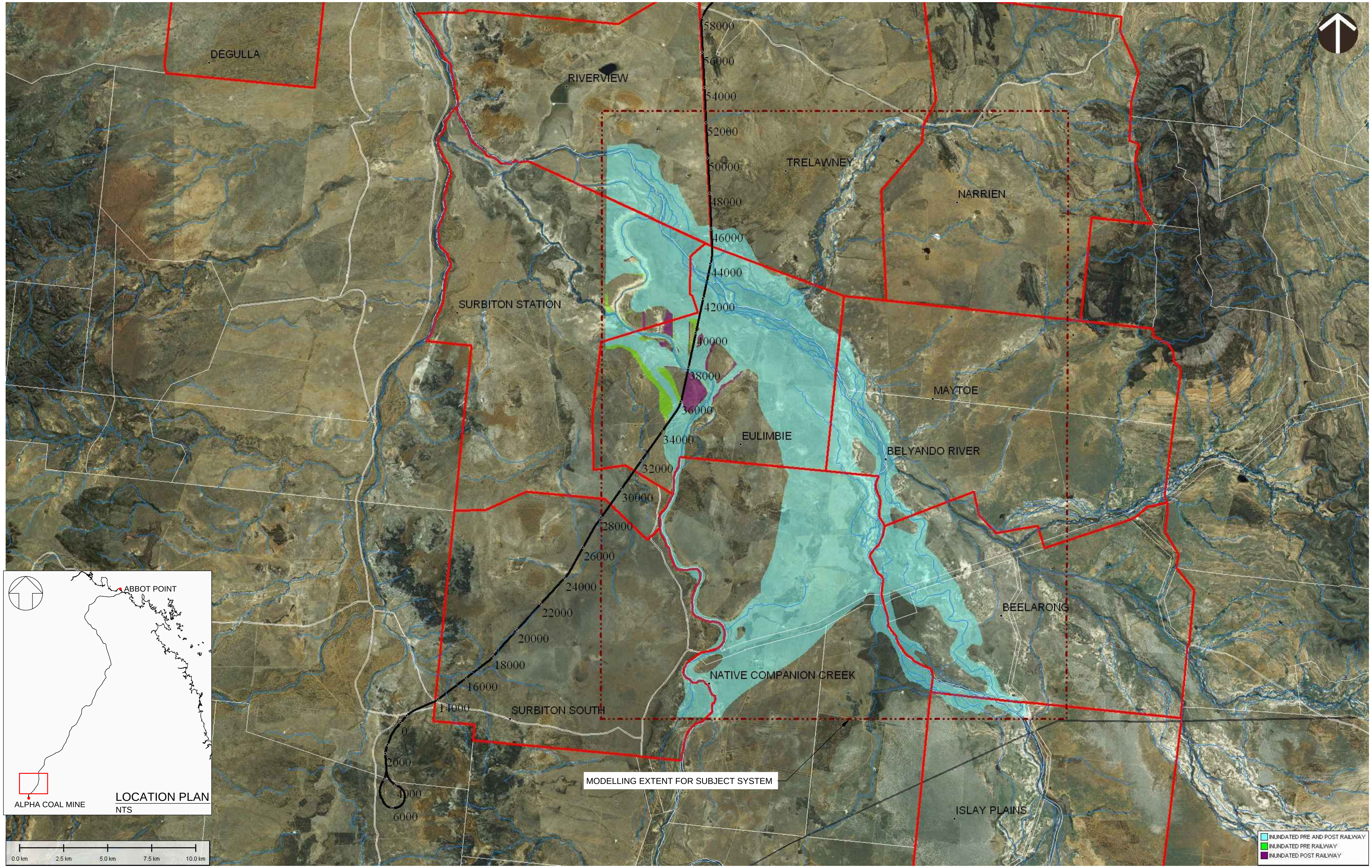
PN No CJVP10007

SCALE NTS

CALIBRE DRAWING No. CJVP10007-DWG-G-610

HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0542

REV D



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D	DES	15.11.11	RE-ISSUED FOR INFORMATION	TLB	
C	DES	03.11.11	RE-ISSUED FOR INFORMATION	TLB	
B	DES	07.10.11	RE-ISSUED FOR INFORMATION	TLB	
A	DES	03.10.11	ISSUED FOR INFORMATION	TLB	

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ENG. APPROVED		
ENG. MANAGER		
PROJECT MANAGER		
CLIENT APPROVED		

HANCOCK COAL PTY LTD

ALPHA COAL PROJECT
RAIL ALIGNMENT - MINE TO ABBOT POINT
FLOOD INUNDATION
BELYANDO RIVER / NATIVE COMPANION CREEK - Q50

SHEET SIZE A1
PN No CJVP10007
SCALE NTS

CALIBRE DRAWING No. CJVP10007-DWG-G-611
HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0543
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NOT TO BE SCALED

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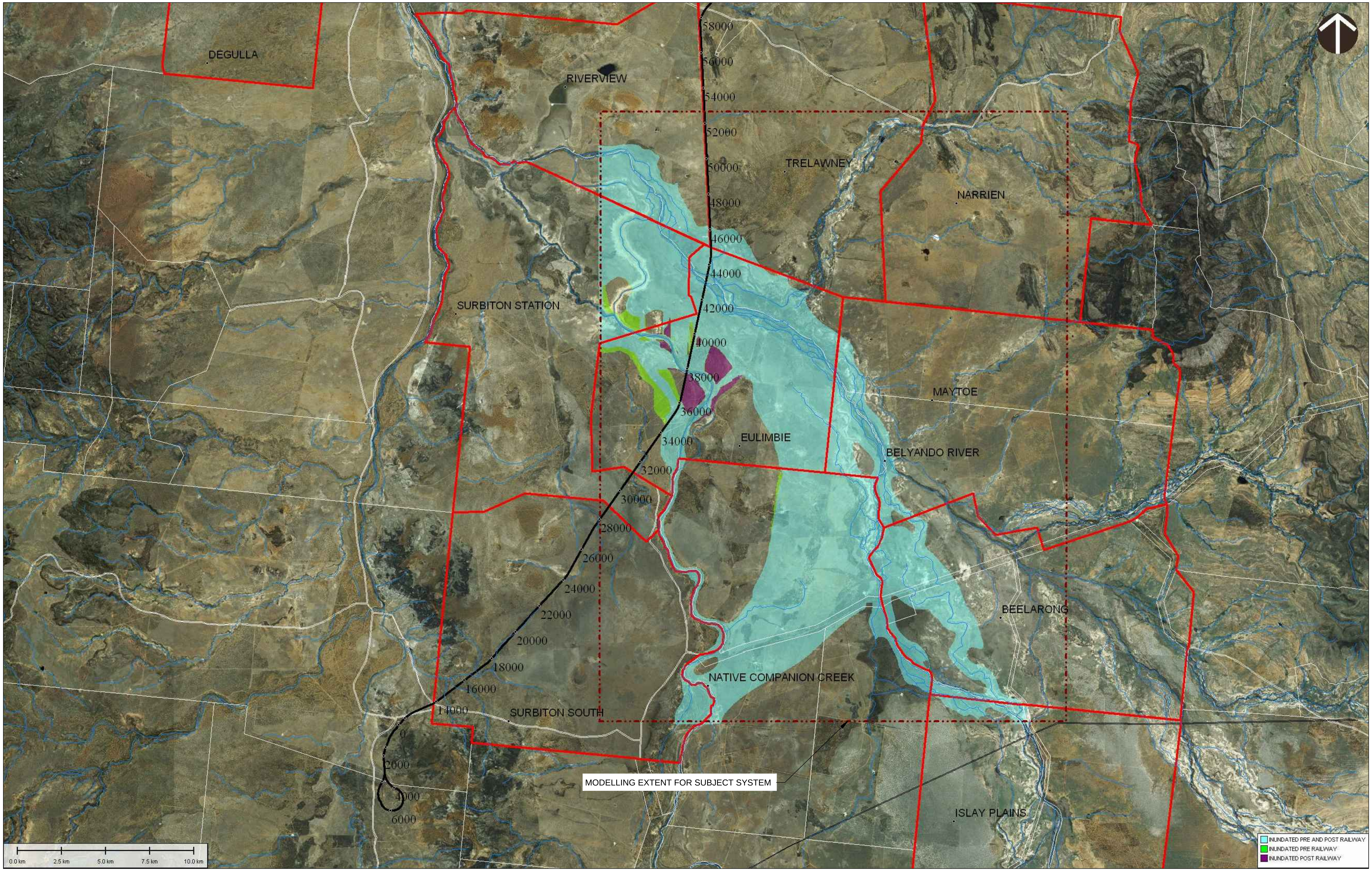

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REV	BY	DATE	DESCRIPTION	CKD	APP

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ENG. MANAGER		
PROJECT MANAGER		
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HANCOCK COAL PTY LTD

ALPHA COAL PROJECT
RAIL ALIGNMENT - MINE TO ABBOT POINT
FLOOD INUNDATION
BELYANDO RIVER / NATIVE COMPANION CREEK - Q100

SHEET SIZE A1

PN No CJVP10007

SCALE NTS

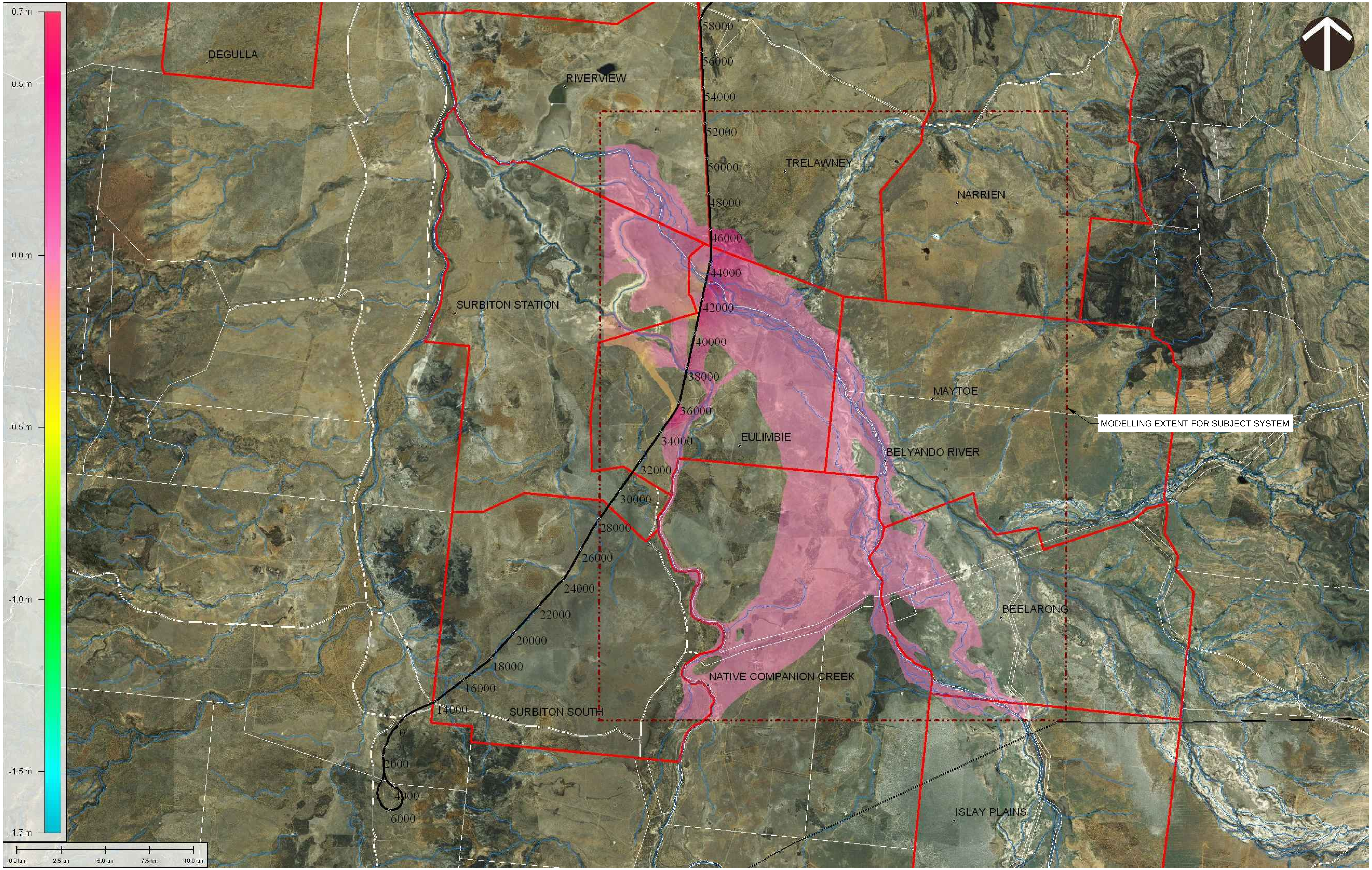
CALIBRE DRAWING No. CJVP10007-DWG-G-640

HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0572

REV C

NOT TO BE SCALED

NOT TO BE SCALED



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MASTER COPY

DRAWN	D. SMITH	07.10.11
DRAFTING CHECK		
DESIGNER		
ENG. APPROVED		
ENG. MANAGER		
PROJECT MANAGER		
CLIENT APPROVED		

calibre

HANCOCK COAL PTY LTD

ALPHA COAL PROJECT
RAIL ALIGNMENT - MINE TO ABBOT POINT
AFFLUX
BELYANDO RIVER / NATIVE COMPANION CREEK - Q50

SHEET SIZE A1
PN No CJVP10007
SCALE NTS

CALIBRE DRAWING No. CJVP10007-DWG-G-720
HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0652
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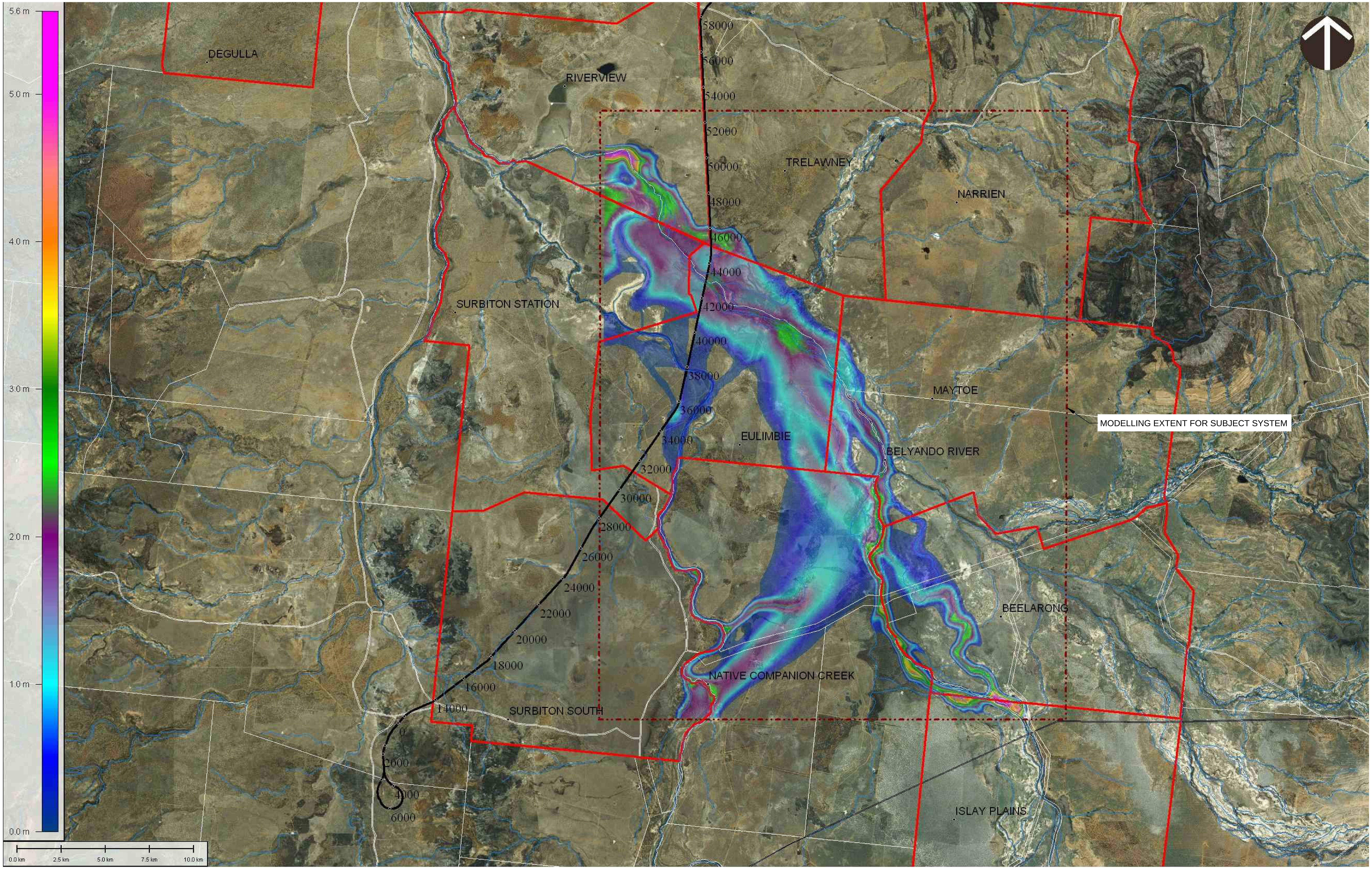
NOT TO BE SCALED



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REVISIONS

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A	DES	07.10.11	ISSUED FOR INFORMATION	TLB	

REVISIONS

REV	BY	DATE	DESCRIPTION	CKD	APP

MASTER COPY

DRAWN	D. SMITH	07.10.11
DRAFTING CHECK		
DESIGNER		
ENG. APPROVED		
ENG. MANAGER		
PROJECT MANAGER		
CLIENT APPROVED		

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HANCOCK COAL PTY LTD

ALPHA COAL PROJECT
RAIL ALIGNMENT - MINE TO ABBOT POINT
DEPTH
BELYANDO RIVER / NATIVE COMPANION CREEK - Q50

SHEET SIZE A1

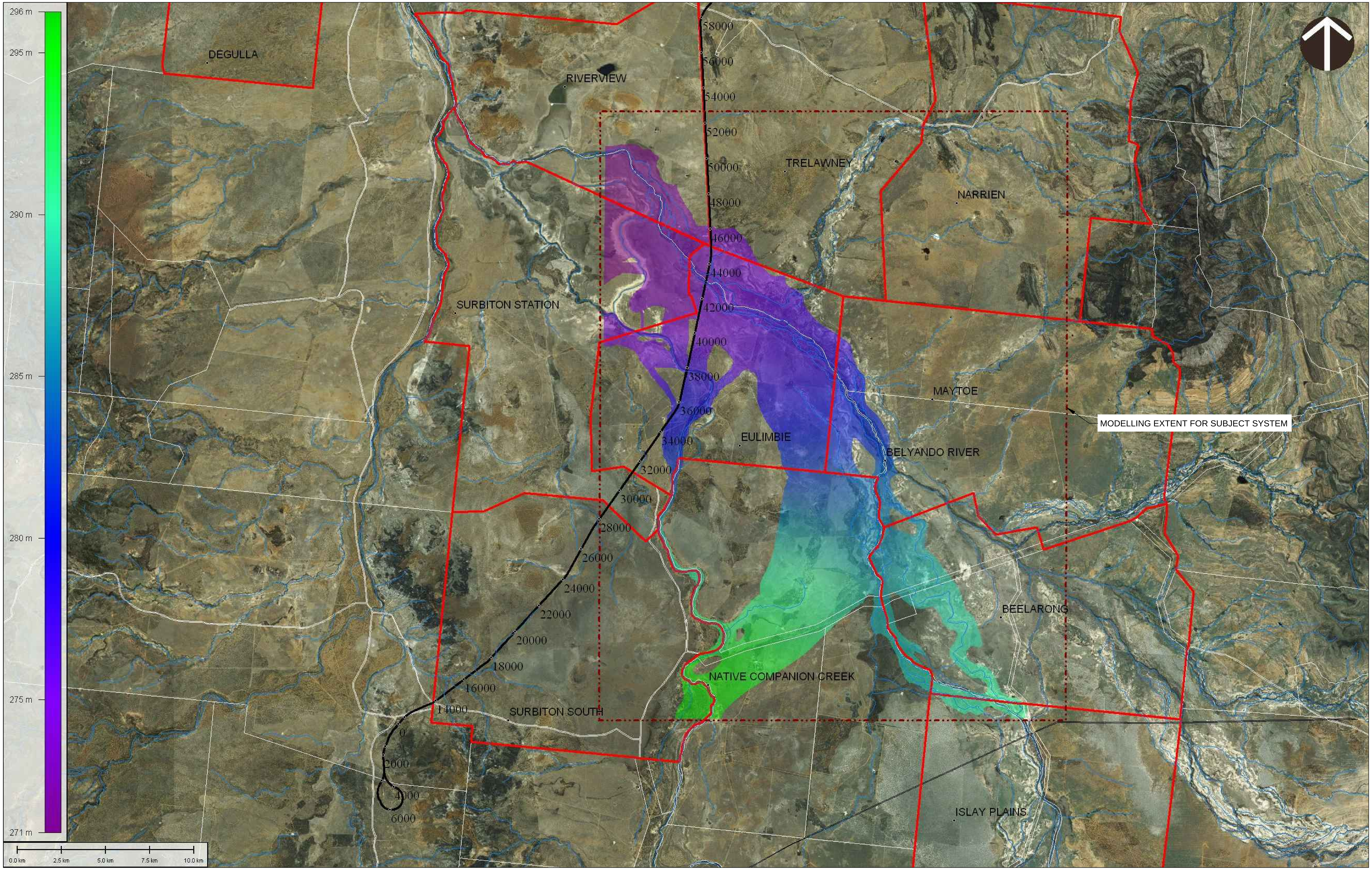
PN No CJVP10007

SCALE NTS

CALIBRE DRAWING No. CJVP10007-DWG-G-721

HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0653

REV C



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REV	BY	DATE	DESCRIPTION	CKD	APP
C	DES	15.11.11	RE-ISSUED FOR INFORMATION	TLB	
B	DES	03.11.11	RE-ISSUED FOR INFORMATION	TLB	
A	DES	07.10.11	ISSUED FOR INFORMATION	TLB	

DRAWN	D. SMITH	07.10.11
DRAFTING CHECK		
DESIGNER		
ENG. APPROVED		
ENG. MANAGER		
PROJECT MANAGER		
CLIENT APPROVED		

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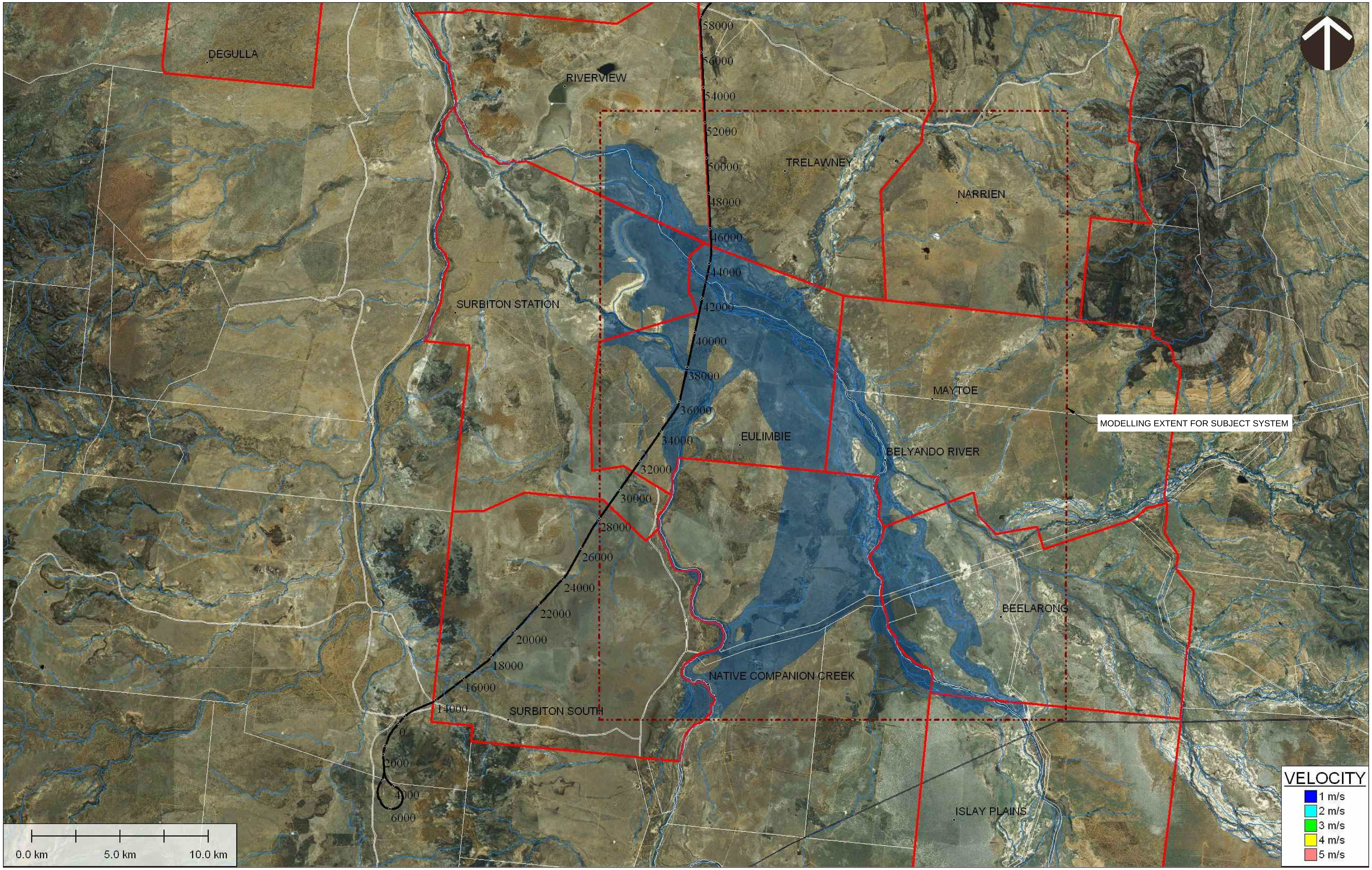
HANCOCK COAL PTY LTD

ALPHA COAL PROJECT
RAIL ALIGNMENT - MINE TO ABBOT POINT
SURFACE ELEVATION
BELYANDO RIVER / NATIVE COMPANION CREEK - Q50

SHEET SIZE A1
PN No CJVP10007
SCALE NTS

CALIBRE DRAWING No. CJVP10007-DWG-G-722
HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0654
REV C



REV	BY	DATE	DESCRIPTION	CKD	APP
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A	DES	07.10.11	ISSUED FOR INFORMATION	TLB	

REFERENCES

REVISIONS

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DRAWN	D. SMITH	07.10.11
DRAFTING CHECK		
DESIGNER		
ENG. APPROVED		
ENG. MANAGER		
PROJECT MANAGER		
CLIENT APPROVED		

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HANCOCK COAL PTY LTD

ALPHA COAL PROJECT
RAIL ALIGNMENT - MINE TO ABBOT POINT
VELOCITY
BELYANDO RIVER / NATIVE COMPANION CREEK - Q50

SHEET SIZE A1

PN No CJVP10007

SCALE NTS

CALIBRE DRAWING No. CJVP10007-DWG-G-723

HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0655

REV C