HANCOCK COAL PTY LTD

Calibre Rail
Alpha Coal Project – Rail
Phase 1B

Detailed Floodplain Study
Diamond Creek / Myra Creek / Nibbereena Creek

HC-CRL-24100-RPT-0138
CJVP10007-REP-C-016

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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 Diamond Creek/Myra Creek/Nibbereena Creek floodplain system. The analysis provides recommendations of the cross-drainage infrastructure required to minimise impacts to existing flow-paths and to meet the conditions set in the Environmental Impact Study (EIS) and the Supplementary Environmental Impact Study (SEIS).

This Report 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 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 eventual 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 Project 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 (CVJP10007-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 (approximate 4000m wide corridor with a vertical accuracy of ±500mm) provided by HCIPL;
- 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 Diamond Creek, Myra Creek and Nibbereena Creek 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 three systems. More accurate LiDAR survey 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 is to provide detailed mapping of the pre- and post-development flood extents, inundation durations, flow velocities and afflux predictions for the Diamond, Myra and Nibbereena Creek system. A focus of this study is to assess the impacts that the proposed rail alignment would have on the landscape and surrounding properties.

5.1 Floodplain Location and Description

The combined Diamond Creek, Myra Creek and Nibbereena Creek systems have a catchment area of approximately 1,991km^2 and is a significant portion of the Suttor Sub-Basin (18,000km^2) in the Burdekin River Catchment. The terrain is predominantly very flat with significant low-land floodplains and the land-use is dominated by 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 ACP railway is illustrated in Figure 2.

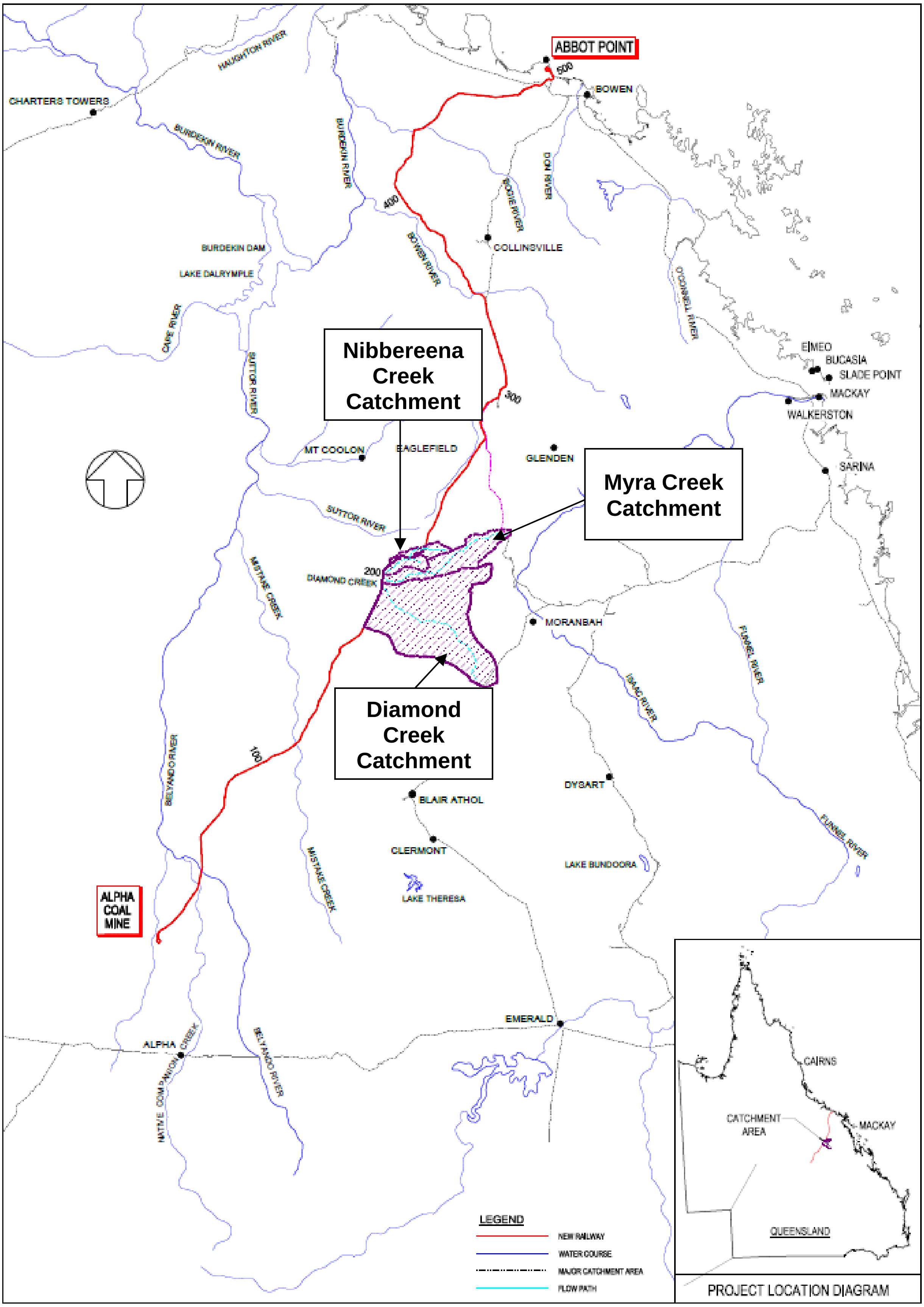


Figure 2: Catchment boundary and location

5.2 Diamond Creek

The catchment area for Diamond Creek at the proposed ACP rail alignment (Rail Chainage 195,301m) is approximately 1,470km^2. The catchment is undeveloped and consists of predominantly pastoral and agricultural land. The main low flow channel is poorly defined and has minimal capacity. Immediately upstream of the railway there is a complex interaction between the channel and floodplain flows.

5.3 Myra Creek

Myra Creek has a contributing catchment area of approximately 347.7km^2 at the proposed ACP rail alignment interface (Rail Chainage 197,873m). The catchment is predominantly undeveloped and consists of mostly pastoral land. The main channel is a well-defined flow-path but has minimal capacity. As such, during flood events, a complex interaction between the channel and floodplain flows occur.

The confluence of Diamond Creek and Myra Creek occurs approximately 4km downstream of the proposed ACP rail alignment.

5.4 Nibbereena Creek

Nibbereena Creek has a contributing catchment area of approximately 172.8km^2 at the proposed ACP rail alignment interface (Rail Chainage 200,515m). The catchment is predominantly undeveloped and consists of mostly pastoral land. The main channel is a well-defined flow-path but has minimal capacity. As such, during flood events, a complex interaction between the channel and floodplain flows occurs.

The confluence of Diamond Creek and Nibbereena Creek occurs approximately 7km downstream of the proposed ACP rail alignment.

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 has been incorporated into the modelling.

7.0 BANKABLE FEASIBILITY STUDY (BFS)

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 below.

Table 1: General drainage design criteria

Design Aspect	Design Criteria
Culvert Classification	Major culverts: culvert locations with a 50 years ARI design flow ≥ 50m^3/sec. Minor culverts: culvert locations with a 50 year ARI design flow < 50m^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.
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 TOF (embankments and guide banks) for 50 year ARI design flow.
Max Velocity	3.8m/s to enable to adopt 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 backwater	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 Tables 1 and 2) being modified to meet stakeholder requirements. Table 3 shows the modified drainage design criteria adopted for the Detailed Floodplain Modelling.

Table 3: SEIS Modified Drainage Design Criteria

Design Aspect	Design Criteria
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.
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 Tables 1 and 2.

9.0 DETAILED FLOODPLAIN ANALYSIS

9.1 Introduction

In order to assess the impacts that the proposed ACP rail alignment will have on the Diamond, Myra and Nibbereena Creek systems, a detailed floodplain analysis was conducted. 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 Diamond, Myra and Nibbereena Creeks estimated peak discharges for the 50 year ARI event respectively. No stream-gauge data was available for the systems and no calibration was undertaken.

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), 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:

Additional Survey

Additional LiDAR survey was obtained along the proposed rail alignment in a 600m wide corridor with a vertical accuracy of ±100mm.

9.1.1.3 RORB Analysis

The contributing catchment areas for Diamond, Myra and Logan Creek were delineated using the GIS based terrain analysis software, CatchmentSim. A visual check was performed against the BFS delineated catchments and SRTM contours to ensure the CatchmentSim delineation was accurate.

All the 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 these systems and exported into the rainfall-runoff routing program, RORB.

A summary of the catchment analysis for Diamond, Myra and Nibbereena Creeks are shown below in Tables 4, 5 and 6.

Table 4: Diamond Creek catchment properties

Item	Value
Catchment area	1470km^2
d_{av}	38.47km

Table 5: Myra Creek catchment properties

Item	Value
Catchment area	347.7km^2
d_{av}	44.13km

Table 6: Nibbereena Creek catchment properties

Item	Value
Catchment area	172.8km^2
d_{av}	19.26km

Parameters

RORB model parameters were initially set to those recommended by AR&R for Queensland. As no stream-gauge calibration was available for the Diamond, Myra and Nibbereena systems, if catchment characteristics showed similarities between adjacent calibrated catchments, these calibrated parameters were adopted.

Diamond, Myra and Nibbereena Creeks have similar catchment parameters to the neighbouring Mistake Creek catchment which has a stream-gauge that allowed for hydrologic calibration. The Detailed Floodplain Study conducted for the Mistake Creek (CJVP10007-REP-C-014 / HC-CRL-24100-RPT-0136) had calibrated RORB parameters as shown in Tables 7 and 8.

Table 7: Mistake Creek calibrated RORB parameters

Item	Value
k_c (calibrated)	150
m	0.847

Table 8: Mistake Creek calibrated losses

Event ARI (years)	Initial loss (mm)	Continuing loss (mm/hr)
100	25	2.5
50	25	2.5
20	30	2.5
10	30	2.5
5	35	2.5

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 and adopting the 'm' value from the Calibrated Mistake Creek Catchment, initial catchment parameters for Diamond, Myra and Nibbereena Creek were calculated and are shown in Tables 9, 10 and 11.

Table 9: Diamond Creek initial RORB parameters

Item	Value
k_c	37.05
m	0.847

Table 10: Myra Creek initial RORB parameters

Item	Value
k_c	42.50
m	0.847

Table 11: Nibbereena Creek initial RORB parameters

Item	Value
k_c	18.55
m	0.847

Calibration

No calibration was undertaken for Diamond, Myra and Nibbereena Creeks due to the absence of stream-gauge data.

Adopted parameters

The calibrated RORB parameter (m) for Mistake Creek was used for the Diamond, Myra and Nibbereena Creek models. The calibrated 'k_c' from Mistake Creek was unable to be adopted for these catchments as it was assessed that the predicted peak flows were unrealistic for the catchment characteristics. From previous floodplain calibrations it was observed that calibrated parameters lowered the predicted peak discharge when compared to the values produced when using the parameters suggested in equations 9.2 and 9.3. As such, it was conservative to use equations 9.2 and 9.3 (where appropriate) to estimate k_c to produce a more realistic representation of the catchment characteristics and predicted peak discharges.

Final adopted hydrologic parameters are shown in Tables 12, 13 and 14.

Table 12: Diamond Creek adopted RORB parameters

Item	Value
k_c	61.40
m	0.847

Table 13: Myra Creek adopted RORB parameters

Item	Value
k_c	42.50
m	0.847

Table 14: Nibbereena Creek adopted RORB parameters

Item	Value
k_c	18.55
m	0.847

Results

The results extracted from the hydrologic modelling for Diamond, Myra and Nibbereena Creek systems at the ACP rail interface are shown below. As Diamond Creek was the dominant catchment, peak storm durations have been adopted from Table 15 for Diamond, Myra and Nibbereena Creek.

Table 15: Peak storm durations

Event ARI (years)	Peak discharge storm duration (hours)
100	18
50	30
5	30

Table 16: Diamond Creek predicted peak discharges

Event ARI (years)	Peak predicted discharge (m^3/s)
100	1512.7
50	1199.4
5	385.4

Table 17: Myra Creek predicted peak discharges

Event ARI (years)	Peak predicted discharge (m^3/s)
100	542.3
50	442.9
5	181.5

Table 18: Nibbereena Creek predicted peak discharges

Event ARI (years)	Peak predicted discharge (m^3/s)
100	438.2
50	359.7
5	151.6

Full hydrographs have been extracted from the RORB model for the 5, 50 and 100 year ARI events are provided in Appendix A. The predicted peak discharges for all 3 systems were then used as inflows into the Diamond, Myra and Nibbereena Creek floodplain hydraulic model as described in Section 9.1.2.

9.1.2 Hydraulic Modelling

It had been identified during the BFS that the Diamond, Myra and Nibbereena systems had a complex floodplain interaction that occurred upstream of the proposed ACP rail alignment. An additional outcome from the Detailed Flood Study for Logan Creek/Brown Creek (CJVP10007-REP-C-012 / HC-CRL-24100-RPT-0131) was that additional inflows into the Diamond Creek system were required. A summary of the peak Logan Creek/Brown Creek inflows is shown below in Table 19.

Table 19: Logan Creek/Brown Creek peak inflows

Event ARI (years)	Peak predicted discharge (m^3/s)
100	613.8
50	410.4
5	22.9

In order to accurately assess this interaction, 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 complex floodplain interaction between the Diamond, Myra and Nibbereena Creek systems and be sufficiently downstream to reduce the effects of the downstream boundary. This resulted in a bathymetry of 1330 x 1175 cells at a grid cell size of 20m x 20m (model area of 625.1km^2). The final bathymetry used for the pre- and post-development rail cases is shown below in Figure 3.

A portion of the bathymetry along the proposed alignment has been based on a combination of LiDAR sources (BFS LiDAR survey and current alignment LiDAR survey) and covers a corridor upstream and downstream of the rail alignment (as per Figure 3). 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 data was split into upstream and downstream tiles. These tiles were then lowered independently by 3.5m upstream and 4.3m downstream. A variable interpreted transition was generated between the SRTM and LiDAR boundaries for both interfaces to provide a smoothed surface between the two data sets.

The preference was that the SRTM surface at Logan/Brown Creek Inflow was above the LiDAR data to ensure flows were able to flow parallel to the rail and pass over the LiDAR/SRTM interface. This resulted in some large differential surface elevations for the Diamond, Myra and Nibbereena Creek interface areas on the upstream side of the model bathymetry.

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.

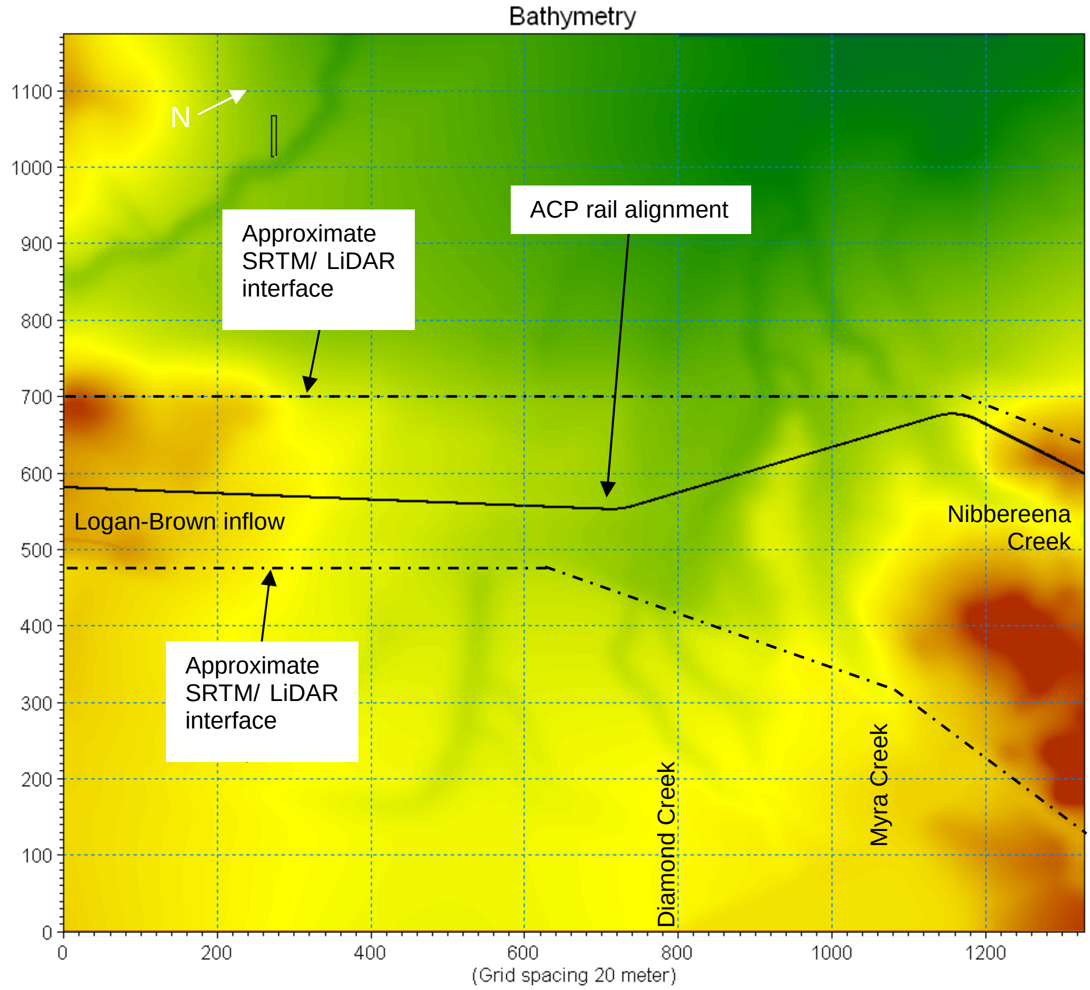


Figure 3: Hydraulic model extent

Boundary conditions

Logan/Brown, Diamond, Myra and Nibbereena Creek 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.

Due to the differential levels at the SRTM/ LiDAR interface upstream of the proposed railway, point source inflows were initially used to input inflow hydrographs into the model. After initial simulations, it was determined that impacts from the proposed railway extended up to the inflow locations for Diamond Creek. To more accurately represent the flow conditions at this location, a Mike11 model was constructed using an upstream cross section (duplicated 4 times and projected upstream at the average stream slope) and then coupled in to the 2D domain at the SRTM/ LiDAR interface. The coupled location is shown below in Figure 4. Although impacts have not been covered to their full extent in the 2D model, this approach is considered appropriate to determine the relative impacts of the proposed railway and to assess if impacts are below those specified in the EIS and SEIS.

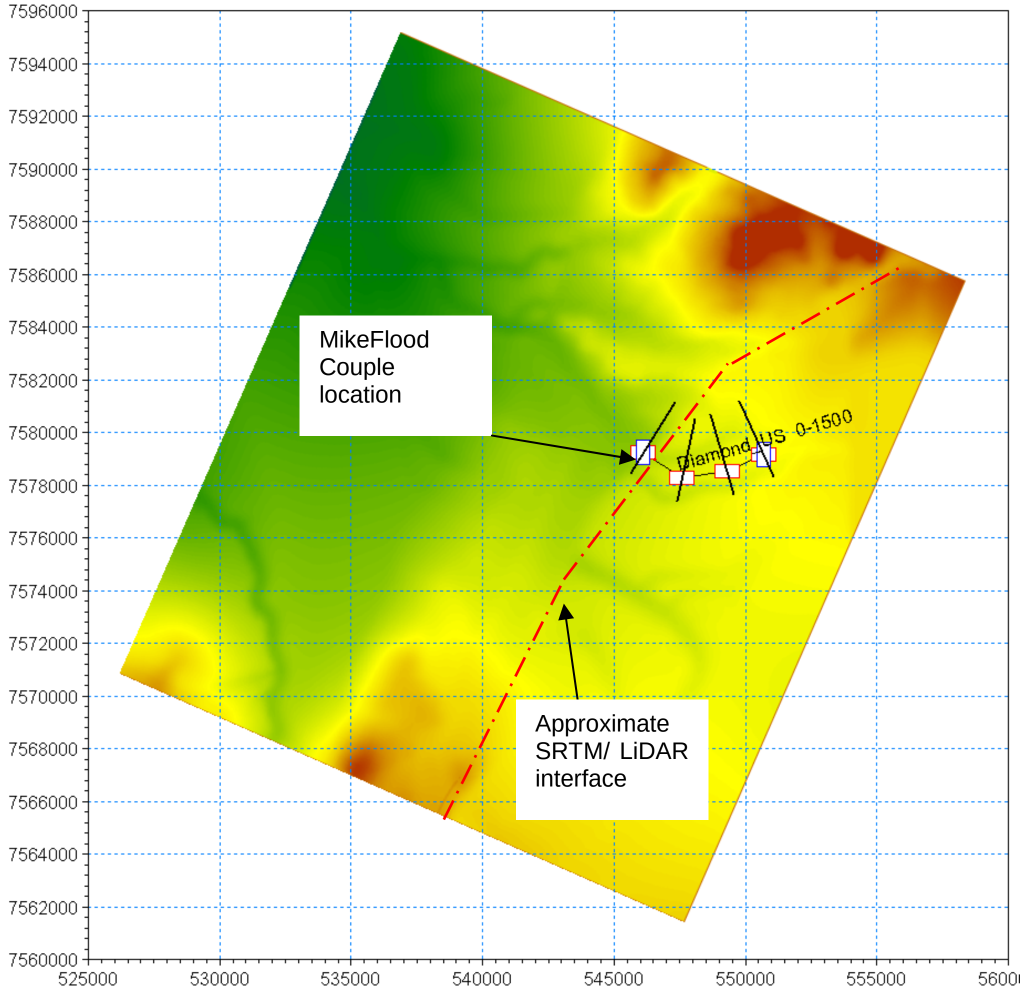


Figure 4: Diamond Creek Mike11 couple inflow location

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 Diamond, Myra and Nibbereena Creek systems have two distinct types of roughness: a relatively smooth and well defined flow-path 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 an initial approach 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.

After Landholder feedback was received on several neighbouring floodplain systems it was identified that a more accurate representation of the two separate roughness areas was to assign a channel roughness to the main stream flow-path only (delineated by contour maps) and set a roughness value equivalent to a floodplain for the remaining model domain. The adopted values are shown in Figure 5. The selection of roughness values was subject to sensitivity testing as outlined in Section 9.1.3.

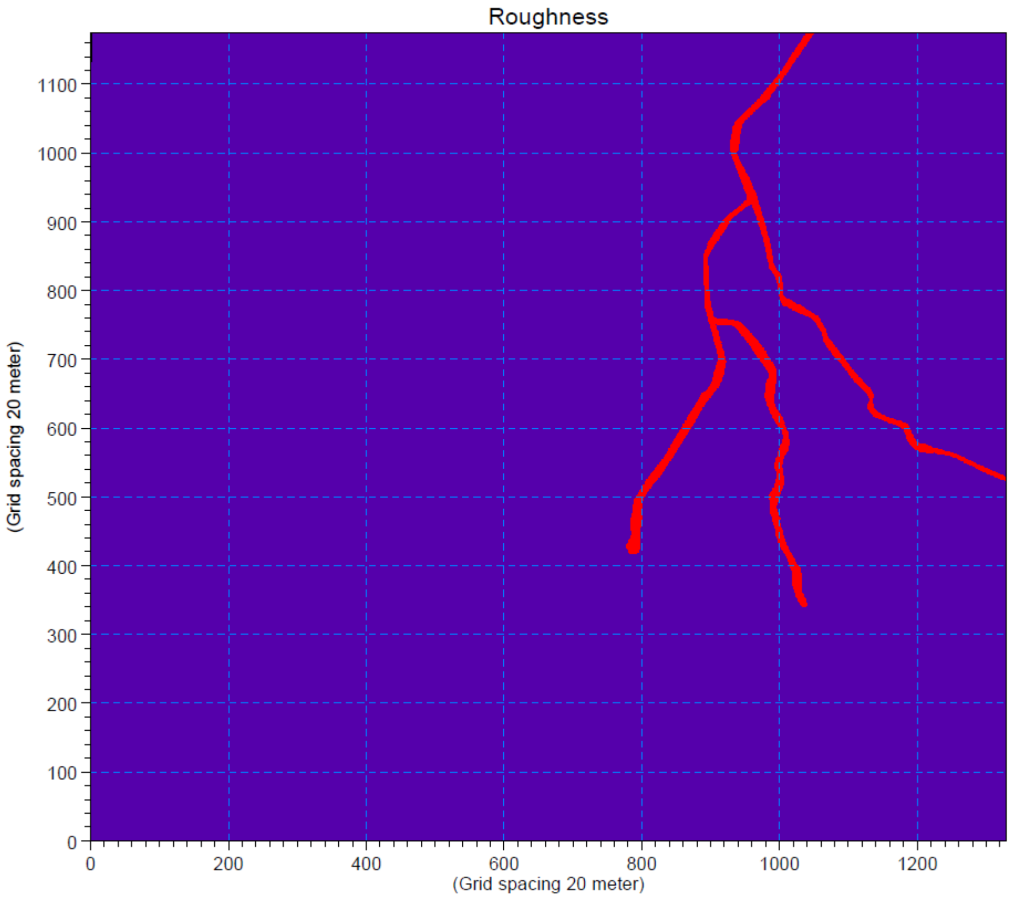


Figure 5: Manning's roughness

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 6.

In order to maintain inundation extents post-development and as specified in the SEIS, floodplain relief culverts are proposed for the Diamond, Myra and Nibbereena Creek system at 50m 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 250m within the model.

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

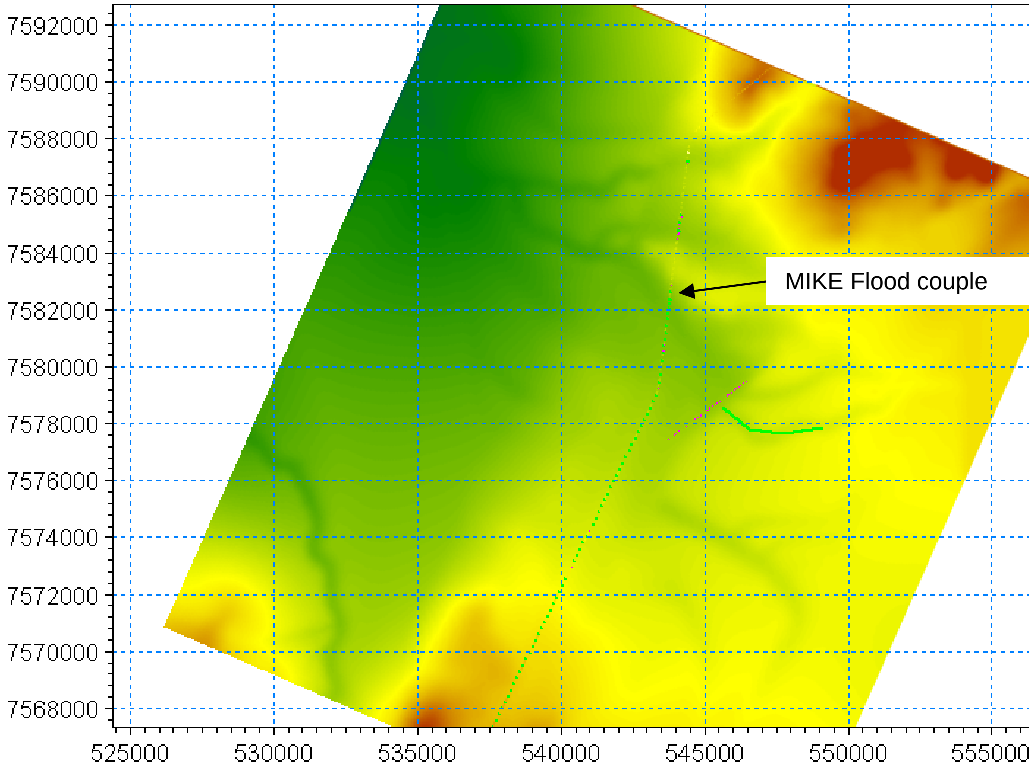


Figure 6: MIKE Flood couple locations

In addition to the floodplain relief culverts, the BFS proposed a single bridge span of 180m for Diamond Creek, 38/ 2400mm CSP culverts for Myra Creek and 54/ 2700mm CSP culverts for Nibbereena Creek. 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 7.

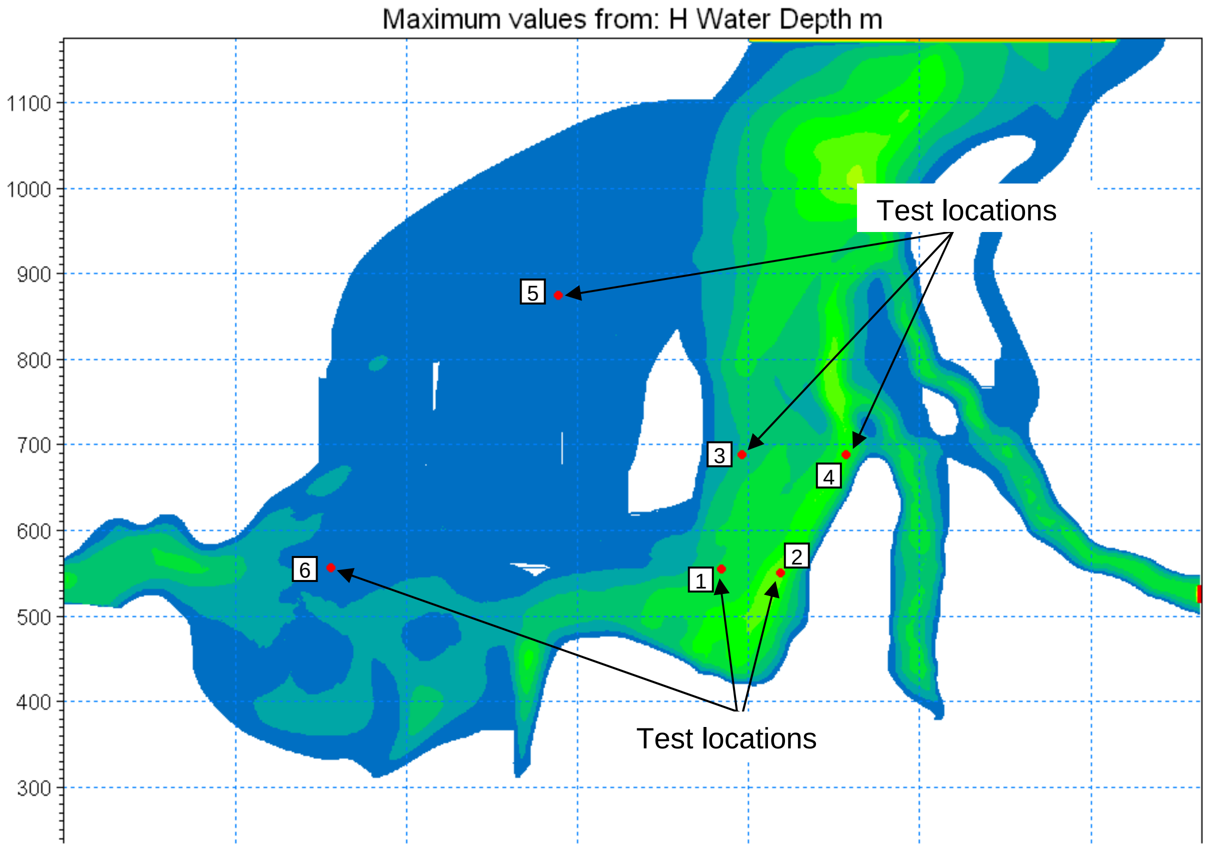


Figure 7: Sensitivity testing locations

Six 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 7. The sensitivity of the Manning's 'M' value is shown below in Table 20.

Table 20: Manning's 'M' value sensitivity (depth)

Location	Adopted value (m)	+30% value	Change (m)	-30% value	Change (m)
1	1.315	1.114	-0.201	1.608	0.293
2	2.176	1.034	-0.209	2.477	0.301
3	0.884	0.340	-0.165	1.125	0.241
4	1.678	1.039	-0.180	1.940	0.262
5	0.134	0.092	-0.012	0.148	0.014
6	0.245	0.186	-0.039	0.307	0.062

The Manning's value has an impact ranging from -210mm to +310mm on the predicted water surface level. This has an equivalent inundation extent impact of -4% and +7.5%, which is a relatively minor impact on the predicted extents.

At the same testing locations, the peak velocities were also extracted. From Table 21 it can be seen that there is an equivalent change in velocity as per the change in Manning's percentage. However the flow velocity change is small and remains in the same order of magnitude as the adopted existing case.

Table 21: Manning's 'M' value sensitivity (velocity)

Location	Adopted value (m/s)	+30% value	Change (%)	-30% value	Change (%)
1	0.283	0.334	18.0	0.227	-19.8
2	0.875	1.034	18.2	0.690	-21.1
3	0.305	0.340	11.5	0.255	-16.4
4	0.852	1.039	21.9	0.642	-24.6
5	0.075	0.092	22.7	0.056	-25.3
6	0.160	0.186	16.3	0.129	-19.4

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 Table 22.

Table 22: Inflow hydrograph sensitivity

Location	Adopted value (m)	+30% value	Change (m)	-30% value	Change (m)
1	1.315	1.528	0.213	1.060	-0.255
2	2.176	2.397	0.221	1.904	-0.272
3	0.884	1.059	0.175	0.674	-0.210
4	1.678	0.874	0.196	1.438	-0.240
5	0.134	0.173	0.039	0.093	-0.041
6	0.245	0.292	0.047	0.192	-0.053

The inflow values have an impact ranging from -280mm to +250mm on the predicted water surface level. This has an equivalent inundation extent impact of -7.1% and +6.5%, which is a relatively minor impact on the predicted extents.

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 Table 23.

Table 23: Downstream boundary sensitivity

Location	Adopted value (m)	+30% value	Change (m)	-30% value	Change (m)
1	1.315	1.315	0.0	1.315	0.0
2	2.176	2.176	0.0	2.176	0.0
3	0.884	0.884	0.0	0.884	0.0
4	1.678	1.678	0.0	1.678	0.0
5	0.134	0.134	0.0	0.134	0.0
6	0.245	0.245	0.0	0.245	0.0

The downstream boundary level has no predicted impacted on the predicted water surface levels at areas near the proposed railway alignment.

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.

Conservative values for all variables have been adopted as part of this study. It is considered that the outcomes of the study are adequate without hydraulic model calibration and are conservative in nature.

9.2 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. This resulted in a significant increase in the cross-drainage infrastructure.

The following additional cross-drainage structures are proposed to meet the EIS, SEIS and stakeholder requirements for the system. For Diamond Creek, an additional 200/ 2700mm and 60/ 1500mm diameter supplementary CSPs are recommended in order to minimise the impacts of the railway. Myra Creek required an additional 158/ 2700mm diameter supplementary CSPs instead of the BFS proposed structures. Nibbereena Creek required an additional 21/ 2700mm diameter supplementary CSPs. The approximate location of the above structures are shown in Figure 8.

Floodplain relief culverts are required at 50m spacing across the floodplains between Logan-Brown inflows, Diamond Creek, Myra Creek and Nibbereena Creek.

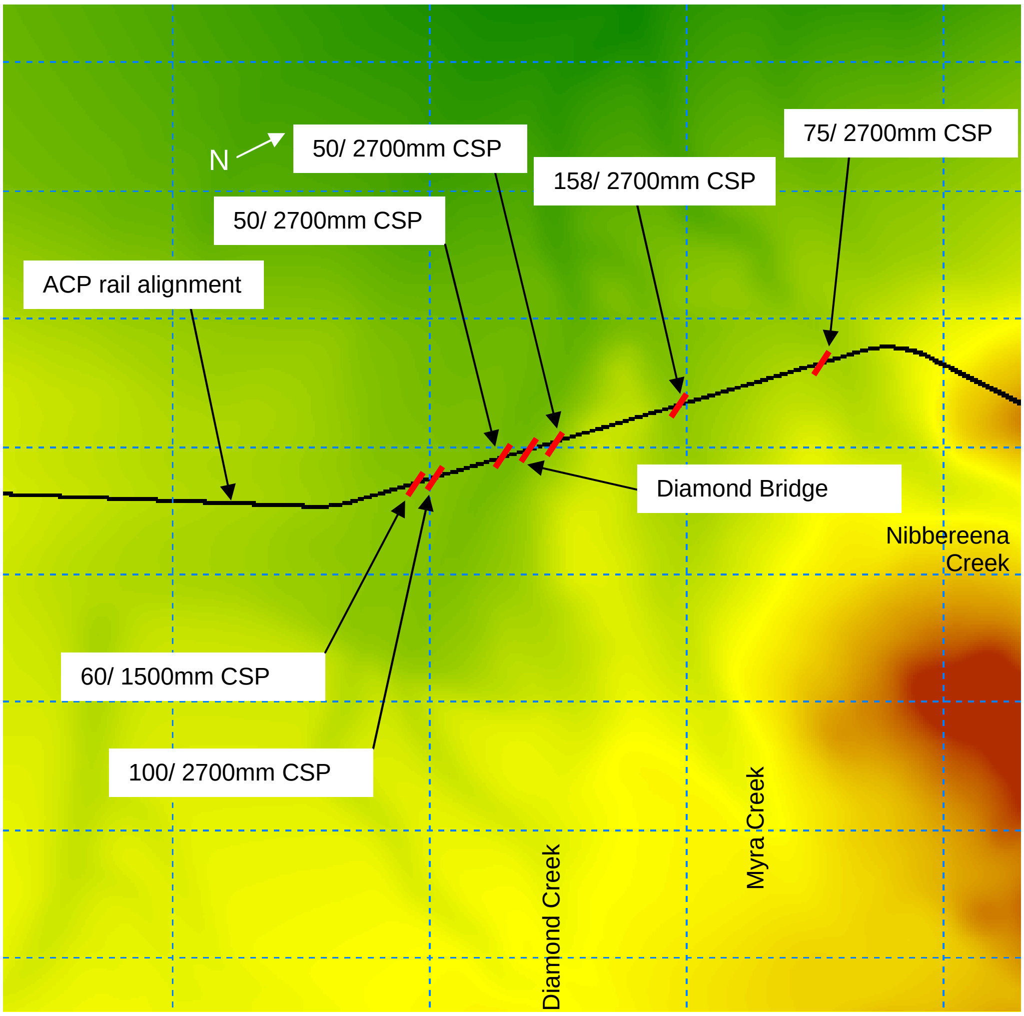


Figure 8: Proposed structure locations

9.3 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 Diamond/Myra/Nibbereena Creek floodplain system.

Feedback from Landholders though 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 B.

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 24.

Table 24: 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 decrease of 6.9% 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.
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 B 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 B 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 25.

Table 25: Change in inundation extents

Event ARI (years)	% change in "wet" cells	Change in area (ha)
5	-7.0	-908
50	-6.9	-1549

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 B.

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.

It should be noted that the predicted impacts from the proposed railway extend up to the upstream model boundary for Diamond Creek and as such, the current model cannot be used to demonstrate the entire impacted area. An attempt was made to match the SRTM surface to the LiDAR however large irregularities between adjacent SRTM tiles meant that the area around Diamond Creek was unusable. In order to undertake further modelling, additional detailed survey data would be required further upstream from the proposed railway alignment. However, the maximum relative impact is less than 200mm at the upstream boundary during the design event. As this level is below the threshold for impacts under the SEIS conditions, the model extent is considered adequate for the purposes of this Detailed Floodplain Study.

10.0 CONCLUSION

Detailed hydrologic and hydraulic modelling has been completed for Diamond, Myra and Nibbereena Creeks 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 Diamond, Myra and Nibbereena Creek are shown below in Tables 26 to 29. Alternative drainage structures may be utilised providing equivalent hydraulic performance is maintained or improved.

Table 26: Diamond Creek

Item	Value
Proposed cross-drainage infrastructure.	1/ 180m bridge, 200/ 2700mm and 60/ 1500mm diameter supplementary CSPs.

Table 27: Myra Creek

Item	Value
Proposed cross-drainage infrastructure.	158/ 2700mm diameter CSPs.

Table 28: Nibbereena Creek

Item	Value
Proposed cross-drainage infrastructure.	75/ 2700mm diameter supplementary CSPs.

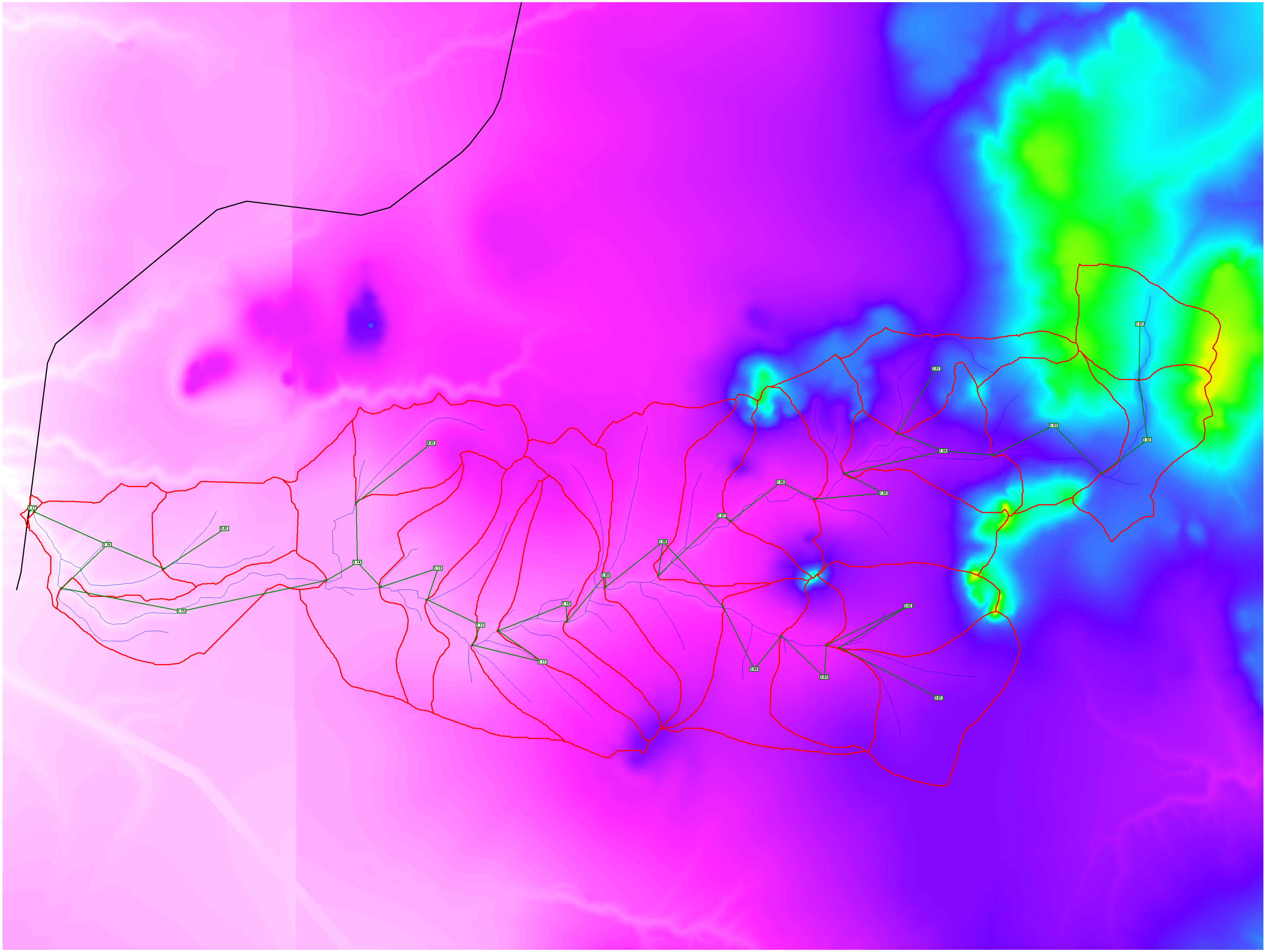
Table 29: Floodplain relief culverts

Item	Value
Proposed cross-drainage infrastructure.	900mm diameter CSPs at 50m in the floodplains.

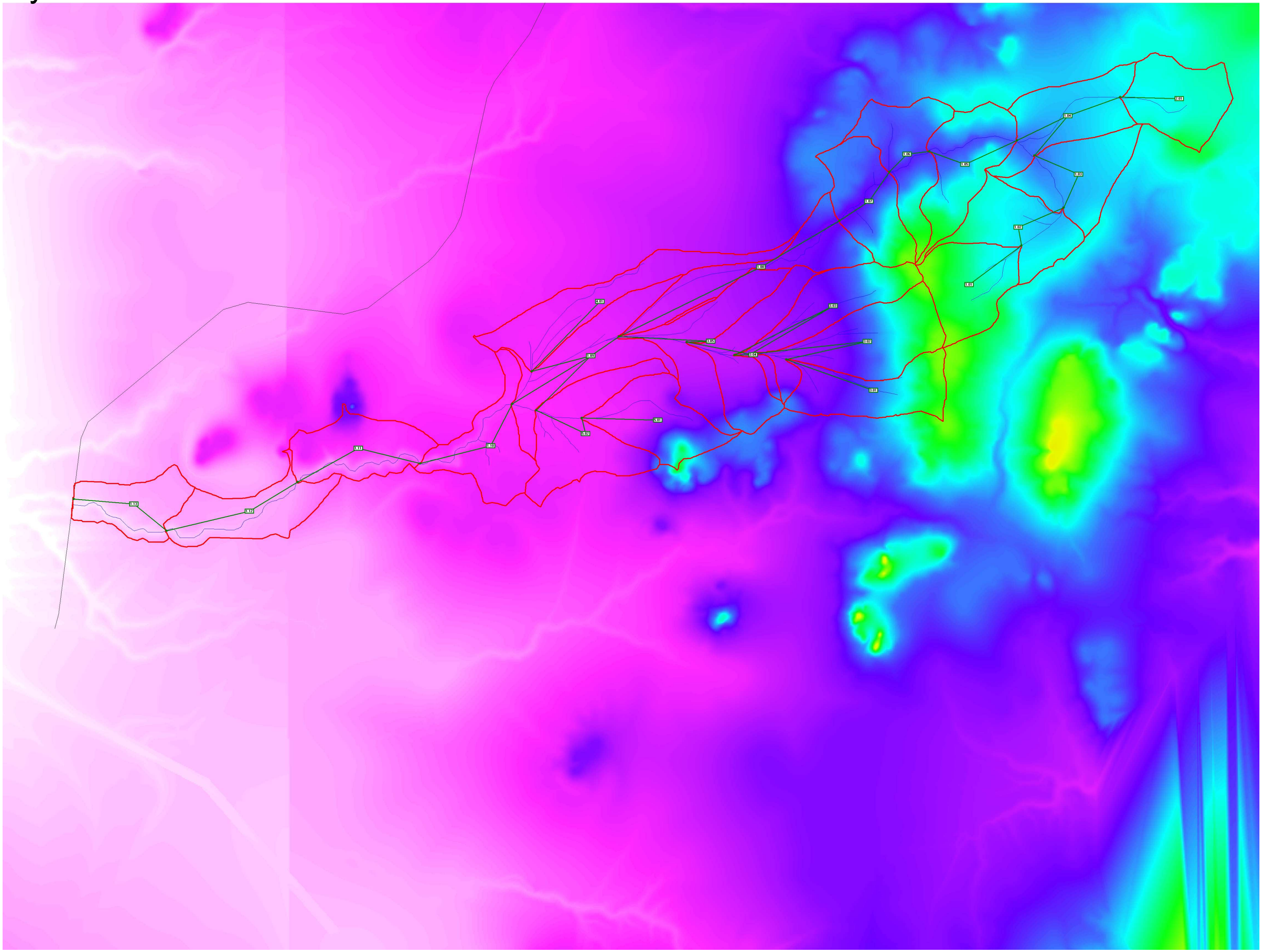
The findings can be further optimised when further hydraulic analysis is undertaken during the Detailed Design phase of the project.

APPENDIX A
RORB PARAMETERS AND RESULTS

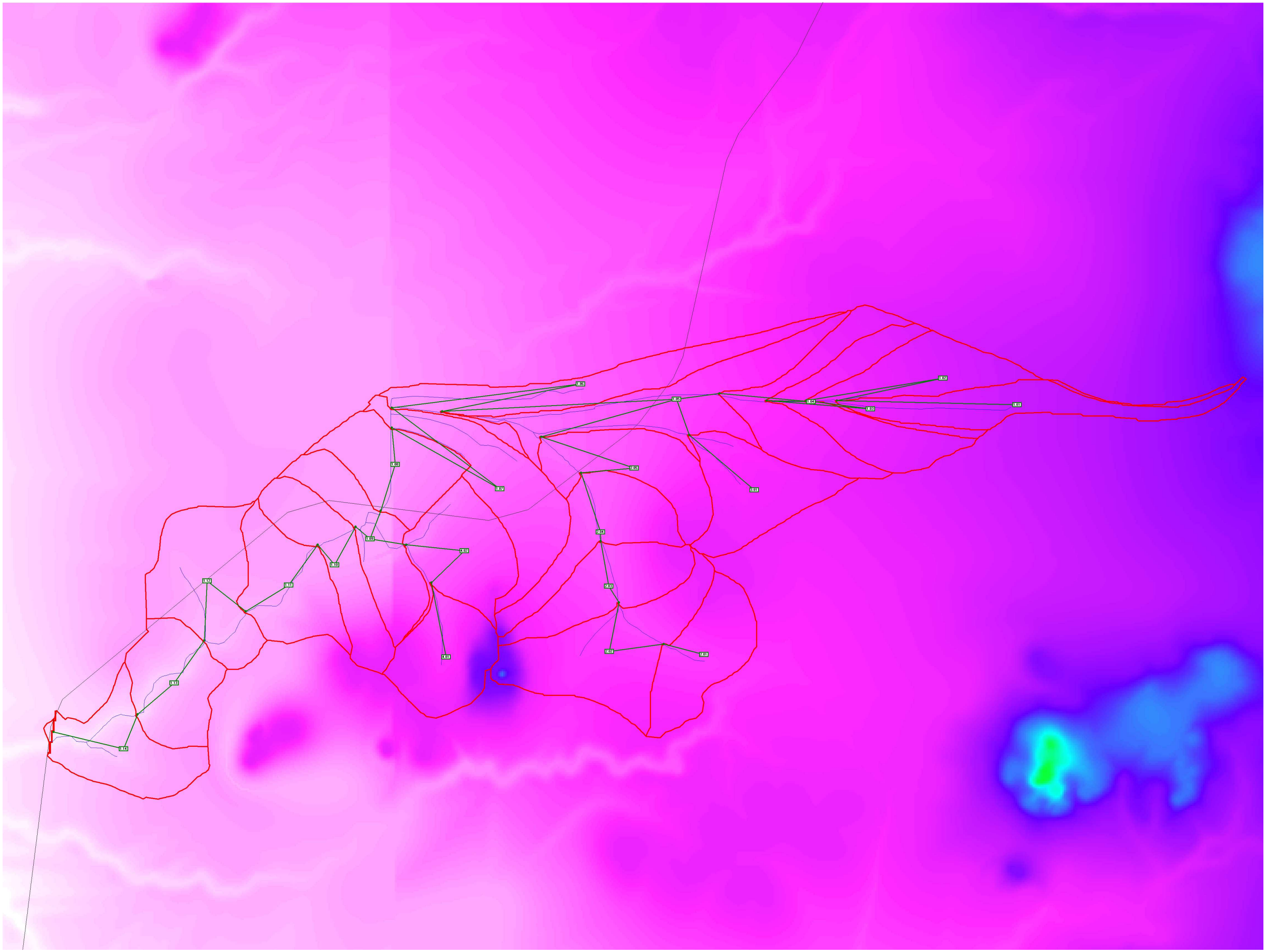
Diamond Creek Catchment Deliniation



Myra Creek Catchment Deliniation



Nibbereena Creek Catchment Deliniation



Kc and m parameters - Diamond creek

Diamond Creek
ARR Book 5

Catchment area	1470	km^2	
d_{av}	38.47	km	(from RORB model)
K_c (Weeks, QLD)	41.99		

adjusted K_c	37.05119	
m	0.847	for 0.6<m<1.2

LHS	RHS (goal seek to LHS by changing m)
0.963119	0.963119

RORB manual	**Iteration1**	
K_c	61.39806	
Q_p	1147	m^3/s
m_1	0.85	

Kc and m parameters - Myra creek

Myra Creek

ARR Book 5

Catchment area	347.7	km^2	
d_{av}	44.13	km	(from RORB model)
K_c (Weeks, QLD)	19.56		

adjusted K_c	21.34484	
m	1.0088	for 0.6<m<1.2

LHS	RHS (goal seek to LHS by changing m)
0.483681	0.483681

RORB manual	**Iteration1**	
K_c	26.96383	
Q_p	500	m^3/s
m_1	0.876	

Kc and m parameters - Nibbereena creek

Nibbereena Creek
ARR Book 5

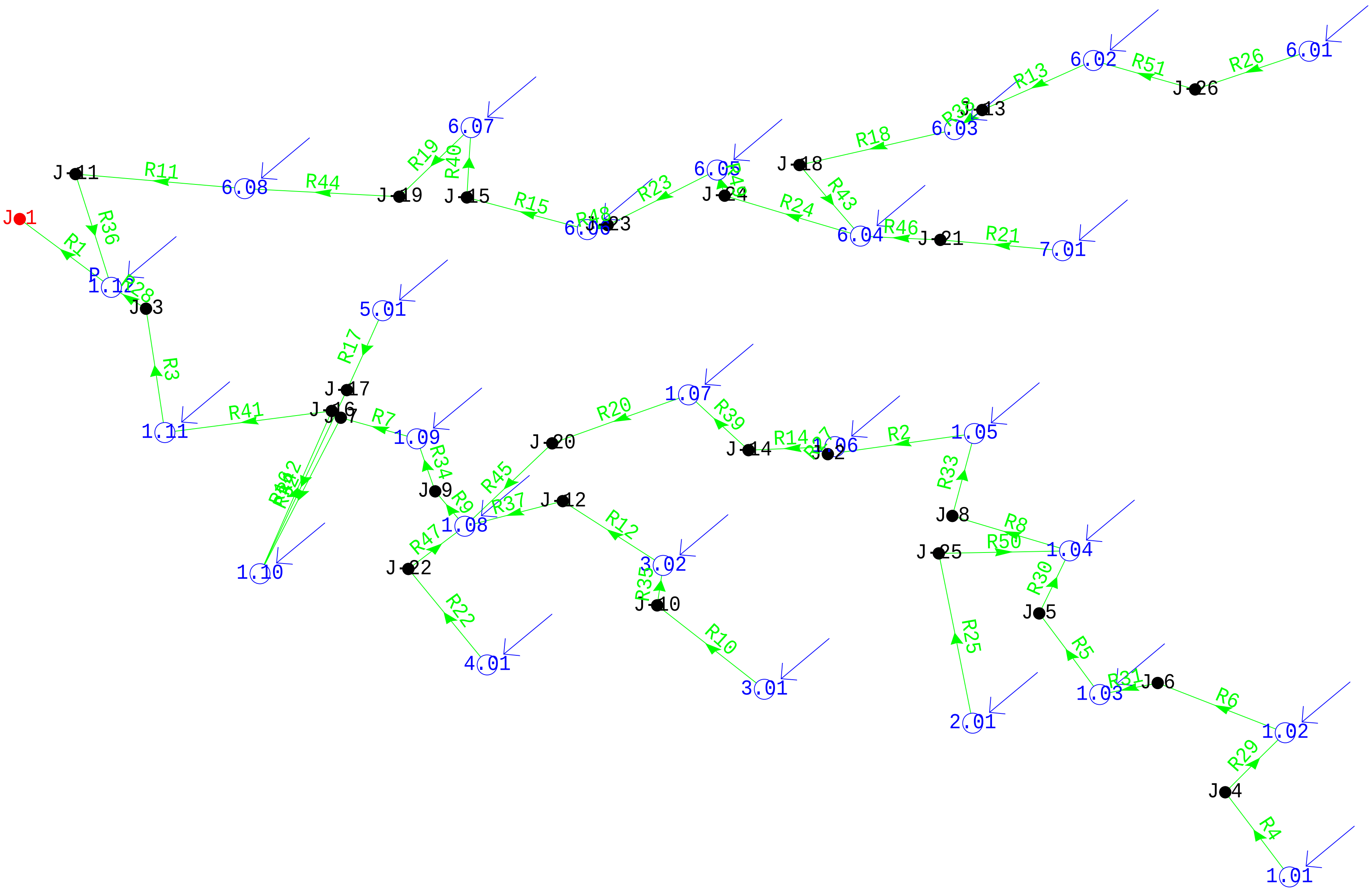
Catchment area	172.8	km^2	
d_{av}	19.26	km	(from RORB model)
K_c (Weeks, QLD)	13.50		

adjusted K_c	18.54967	
m	0.847	for 0.6<m<1.2

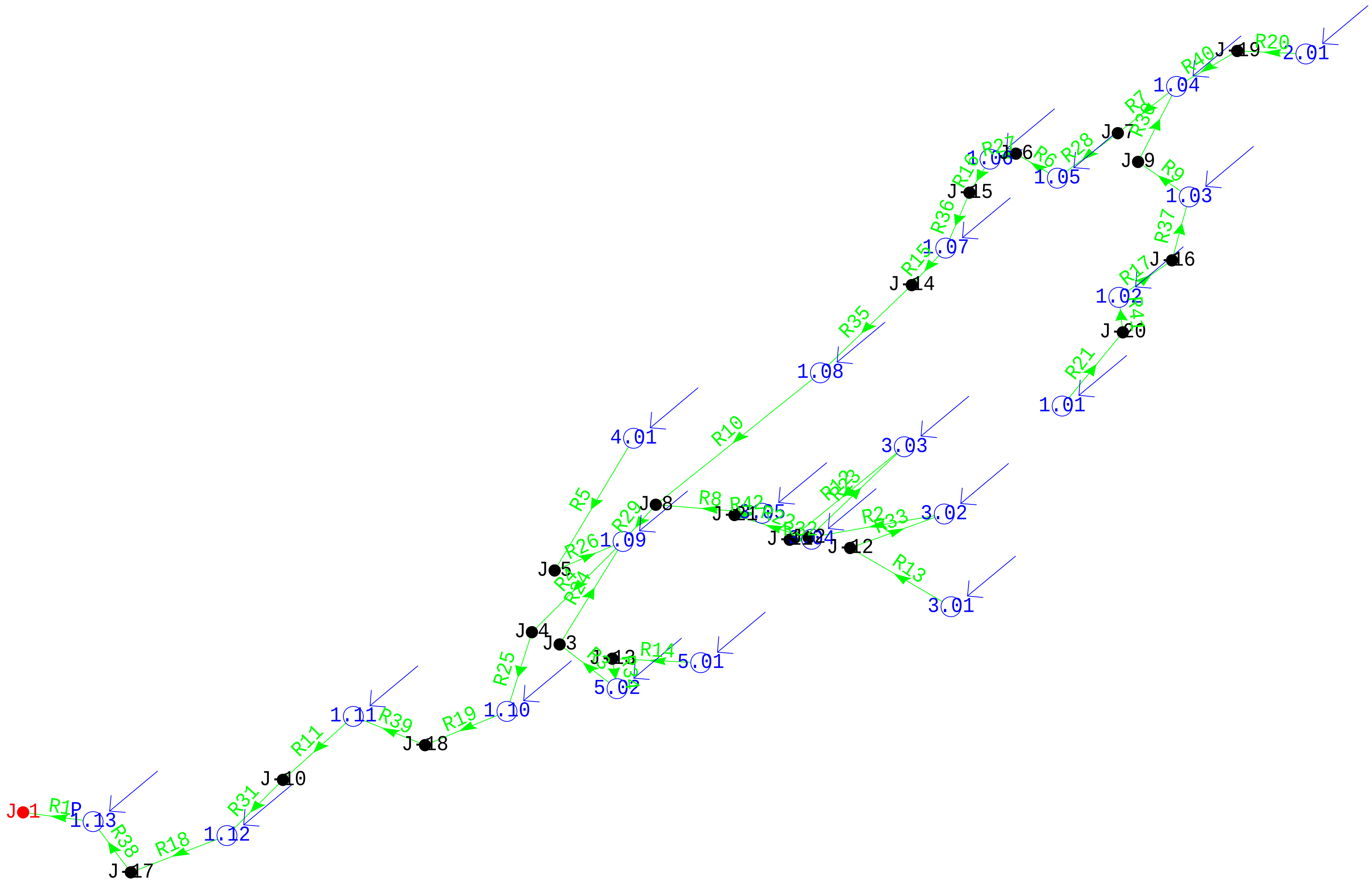
LHS	RHS (goal seek to LHS by changing m)
0.963119	0.963119

RORB manual	**Iteration1**	
K_c	19.00864	
Q_p	500	m^3/s
m_1	0.876	

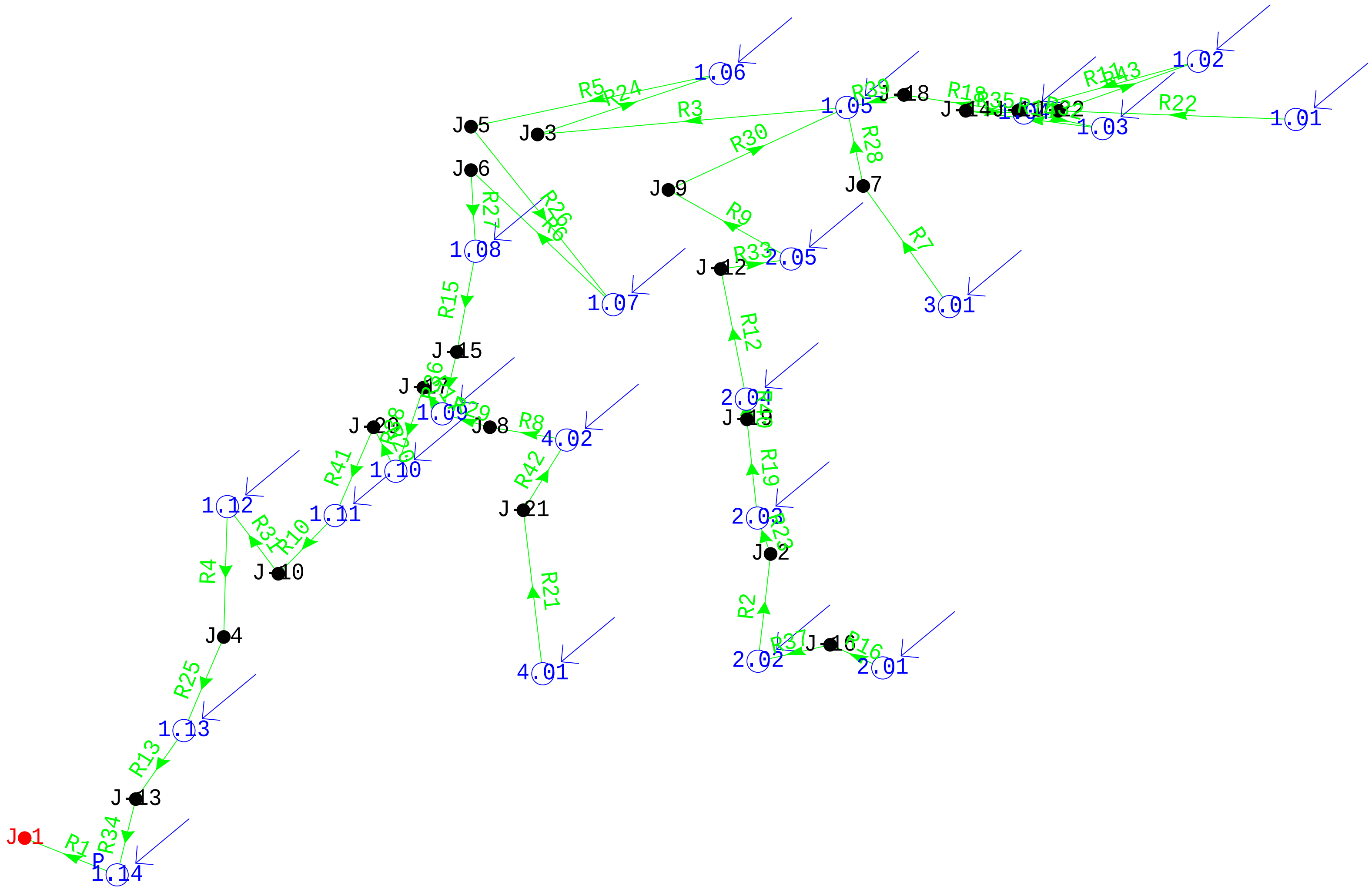
Diamond Creek RORB



Myra Creek RORB



Nibbereena Creek RORB



Diamond Creek_30h50y

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

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

 Date run: 11 Oct 2011 20:34

 Vector file       : S:\PRO-Projects\2011\CARP11064 HCPL Alpha FEED\06
Engineering\6.4 Hydrology\Diamond Creek\RORB\Diamond Creek.catg
 Storm file        : S:\PRO-Projects\2011\CARP11064 HCPL Alpha FEED\06
Engineering\6.4 Hydrology\Piebald Creek\RORB\Diamond Creek_30h50y.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.  63     7.0 Location read as  Subcatchment: 1.12
 Sub-area areas
 Impervious flag
 Initial storm data
 Rainfall burst times
 Pluviograph 1
 Sub-area rainfalls

 Data check completed



 Data:
 ****

 Diamond Creek


 Time data, in increments from initial time
 Diamond Creek: 30 hour 50 year Design Storm
 Time increment (hours)=  2.00

                  Start   Finish
 Rainfall times:     0       15


 End of hyeto/hydrographs:   15
 Duration of calculations:  100



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

         1:Temporal pattern (% of depth
   Time     1
     0     1.9
     1    25.3
     2     4.2
     3     5.1
     4     1.1
     5     3.6
     6     1.5
     7     2.3
     8     2.9
     9     9.3
    10     7.5
```

11	16.1
12	12.0
13	6.4
14	0.8
Total	100.0

DESIGN run control vector

Step	Code	Description
1	1	Add sub-area 'A' inflow & route thru normal storage 1
2	5	Route hydrograph thru normal storage 2
3	2	Add sub-area 'B' inflow & route thru normal storage 3
4	5	Route hydrograph thru normal storage 4
5	2	Add sub-area 'C' inflow & route thru normal storage 5
6	5	Route hydrograph thru normal storage 6
7	3	Store hydrograph from step 6; reset hydrograph to zero
8	1	Add sub-area 'D' inflow & route thru normal storage 7
9	5	Route hydrograph thru normal storage 8
10	4	Add h-graph ex step 7 to h-graph ex step 9
11	2	Add sub-area 'E' inflow & route thru normal storage 9
12	5	Route hydrograph thru normal storage 10
13	2	Add sub-area 'F' inflow & route thru normal storage 11
14	5	Route hydrograph thru normal storage 12
15	2	Add sub-area 'G' inflow & route thru normal storage 13
16	5	Route hydrograph thru normal storage 14
17	2	Add sub-area 'H' inflow & route thru normal storage 15
18	5	Route hydrograph thru normal storage 16
19	3	Store hydrograph from step 18; reset hydrograph to zero
20	1	Add sub-area 'I' inflow & route thru normal storage 17
21	5	Route hydrograph thru normal storage 18
22	2	Add sub-area 'J' inflow & route thru normal storage 19
23	5	Route hydrograph thru normal storage 20
24	4	Add h-graph ex step 19 to h-graph ex step 23
25	3	Store hydrograph from step 24; reset hydrograph to zero
26	1	Add sub-area 'K' inflow & route thru normal storage 21
27	5	Route hydrograph thru normal storage 22
28	4	Add h-graph ex step 25 to h-graph ex step 27
29	2	Add sub-area 'L' inflow & route thru normal storage 23
30	5	Route hydrograph thru normal storage 24
31	2	Add sub-area 'M' inflow & route thru normal storage 25
32	5	Route hydrograph thru normal storage 26
33	3	Store hydrograph from step 32; reset hydrograph to zero
34	1	Add sub-area 'N' inflow & route thru normal storage 27
35	5	Route hydrograph thru normal storage 28
36	4	Add h-graph ex step 33 to h-graph ex step 35
37	2	Add sub-area 'O' inflow & route thru normal storage 29
38	5	Route hydrograph thru normal storage 30
39	2	Add sub-area 'P' inflow & route thru normal storage 31
40	5	Route hydrograph thru normal storage 32
41	3	Store hydrograph from step 40; reset hydrograph to zero
42	1	Add sub-area 'Q' inflow & route thru normal storage 33
43	5	Route hydrograph thru normal storage 34
44	2	Add sub-area 'R' inflow & route thru normal storage 35
45	5	Route hydrograph thru normal storage 36
46	2	Add sub-area 'S' inflow & route thru normal storage 37
47	5	Route hydrograph thru normal storage 38
48	3	Store hydrograph from step 47; reset hydrograph to zero
49	1	Add sub-area 'T' inflow & route thru normal storage 39
50	5	Route hydrograph thru normal storage 40
51	4	Add h-graph ex step 48 to h-graph ex step 50
52	2	Add sub-area 'U' inflow & route thru normal storage 41
53	5	Route hydrograph thru normal storage 42
54	2	Add sub-area 'V' inflow & route thru normal storage 43
55	5	Route hydrograph thru normal storage 44

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56	2	Add sub-area 'W' inflow & route thru normal storage 45
57	5	Route hydrograph thru normal storage 46
58	2	Add sub-area 'X' inflow & route thru normal storage 47
59	5	Route hydrograph thru normal storage 48
60	2	Add sub-area 'Y' inflow & route thru normal storage 49
61	5	Route hydrograph thru normal storage 50
62	4	Add h-graph ex step 41 to h-graph ex step 61
63	7.0	Print hydrograph, Subcatchment: 1.12
64	2	Add sub-area 'Z' inflow & route thru normal storage 51
65	0	**********End of control vector**********

Sub-area data

Sub-area	Area km²	Dist. km*
A	6.79E+01	7.56E+01
B	6.25E+01	6.44E+01
C	6.35E+01	5.71E+01
D	5.00E+01	6.55E+01
E	6.02E+01	4.98E+01
F	6.99E+01	4.25E+01
G	5.28E+01	3.75E+01
H	5.05E+01	3.19E+01
I	5.88E+01	4.64E+01
J	5.46E+01	3.27E+01
K	5.02E+01	3.56E+01
L	5.99E+01	2.53E+01
M	6.04E+01	2.03E+01
N	5.25E+01	2.48E+01
O	5.26E+01	1.77E+01
P	6.92E+01	1.21E+01
Q	5.00E+01	6.83E+01
R	5.32E+01	5.57E+01
S	5.16E+01	4.67E+01
T	5.04E+01	4.72E+01
U	5.01E+01	4.01E+01
V	5.01E+01	3.53E+01
W	5.28E+01	2.90E+01
X	5.12E+01	2.43E+01
Y	5.86E+01	1.50E+01
Z	6.66E+01	3.40E+00

Total 1.470E+03

For whole catchment ; Av. Dist., km* = 38.47
For interstation area 1; Av. Dist., km* = 38.47; 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	7.5	0.194	Natural	
2	3.8	0.098	Natural	
3	3.8	0.098	Natural	
4	3.5	0.092	Natural	
5	3.5	0.092	Natural	
6	3.7	0.097	Natural	
7	12.0	0.311	Natural	
8	3.7	0.097	Natural	
9	3.7	0.097	Natural	
10	3.5	0.092	Natural	
11	3.5	0.092	Natural	

12	1.5	0.040	Natural
13	1.5	0.040	Natural
14	4.0	0.104	Natural
15	4.0	0.104	Natural
16	2.6	0.069	Natural
17	9.0	0.233	Natural
18	4.8	0.124	Natural
19	4.8	0.124	Natural
20	2.6	0.069	Natural
21	7.6	0.199	Natural
22	2.6	0.069	Natural
23	2.6	0.069	Natural
24	2.4	0.062	Natural
25	2.4	0.062	Natural
26	0.2	0.006	Natural
27	6.9	0.180	Natural
28	0.2	0.006	Natural
29	0.2	0.006	Natural
30	5.3	0.138	Natural
31	5.3	0.138	Natural
32	3.4	0.089	Natural
33	8.3	0.215	Natural
34	4.3	0.112	Natural
35	4.3	0.112	Natural
36	4.6	0.120	Natural
37	4.6	0.120	Natural
38	2.0	0.052	Natural
39	5.1	0.132	Natural
40	2.0	0.052	Natural
41	2.0	0.052	Natural
42	2.8	0.072	Natural
43	2.8	0.072	Natural
44	3.5	0.091	Natural
45	3.5	0.091	Natural
46	1.2	0.031	Natural
47	1.2	0.031	Natural
48	8.2	0.212	Natural
49	8.2	0.212	Natural
50	3.4	0.089	Natural
51	3.4	0.089	Natural

* or other function of reach properties related to travel time

Input of parameters:
****

Diamond Creek
DESIGN Run
Diamond Creek: 30 hour 50 year Design Storm
Time increment = 2.00 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	3.9	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
1	52.6	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53
2	8.7	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9

Diamond Creek_30h50y

3	10.6	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
4	2.3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
5	7.5	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
6	3.1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
7	4.8	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
8	6.0	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
9	19.3	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19
10	15.6	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
11	33.4	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33
12	24.9	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
13	13.3	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
14	1.7	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Tot.	207.7	208	208	208	208	208	208	208	208	208	208	208	208	208	208	208	208
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	U	V	W	X	Y	Z
0	3.9	4	4	4	4	4	4	4	4	4	4
1	52.6	53	53	53	53	53	53	53	53	53	53
2	8.7	9	9	9	9	9	9	9	9	9	9
3	10.6	11	11	11	11	11	11	11	11	11	11
4	2.3	2	2	2	2	2	2	2	2	2	2
5	7.5	7	7	7	7	7	7	7	7	7	7
6	3.1	3	3	3	3	3	3	3	3	3	3
7	4.8	5	5	5	5	5	5	5	5	5	5
8	6.0	6	6	6	6	6	6	6	6	6	6
9	19.3	19	19	19	19	19	19	19	19	19	19
10	15.6	16	16	16	16	16	16	16	16	16	16
11	33.4	33	33	33	33	33	33	33	33	33	33
12	24.9	25	25	25	25	25	25	25	25	25	25
13	13.3	13	13	13	13	13	13	13	13	13	13
14	1.7	2	2	2	2	2	2	2	2	2	2
Tot.	207.7	208	208	208	208	208	208	208	208	208	208
Pluvi. ref. no.		1	1	1	1	1	1	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	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	26.5	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
2	3.7	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4

Diamond Creek_30h50y

3	5.6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
4	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	2.5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
6	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	1.0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	14.3	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
10	10.6	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
11	28.4	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
12	19.9	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
13	8.3	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
14	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tot.	120.9	121	121	121	121	121	121	121	121	121	121	121	121	121	121	121	121

Time Incs	Catch ment	Sub-Area Q	R	S	T	U	V	W	X	Y	Z
0	0.0	0	0	0	0	0	0	0	0	0	0
1	26.5	26	26	26	26	26	26	26	26	26	26
2	3.7	4	4	4	4	4	4	4	4	4	4
3	5.6	6	6	6	6	6	6	6	6	6	6
4	0.0	0	0	0	0	0	0	0	0	0	0
5	2.5	2	2	2	2	2	2	2	2	2	2
6	0.0	0	0	0	0	0	0	0	0	0	0
7	0.0	0	0	0	0	0	0	0	0	0	0
8	1.0	1	1	1	1	1	1	1	1	1	1
9	14.3	14	14	14	14	14	14	14	14	14	14
10	10.6	11	11	11	11	11	11	11	11	11	11
11	28.4	28	28	28	28	28	28	28	28	28	28
12	19.9	20	20	20	20	20	20	20	20	20	20
13	8.3	8	8	8	8	8	8	8	8	8	8
14	0.0	0	0	0	0	0	0	0	0	0	0
Tot.	120.9	121	121	121	121	121	121	121	121	121	121

Routing results:
****
Diamond Creek
Diamond Creek: 30 hour 50 year Design Storm
DESIGN run no. 1

Parameters: kc = 61.40 m = 0.85

Loss parameters	Initial loss (mm)	Cont. loss (mm/h)
	25.00	2.50

*** Calculated hydrograph, Subcatchment: 1.12

	Diamond Creek_30h50y Hydrograph Calc.
Peak discharge,m³/s	1199.
Time to peak,h	36.0
Volume,m³	1.70E+08
Time to centroid,h	44.2
Lag (c.m. to c.m.),h	27.2
Lag to peak,h	19.0

Hydrograph summary
****

Site Description
01 Calculated hydrograph,   Subcatchment: 1.12

Inc	Time	Hyd0001
1	2.00	0.00
2	4.00	0.00
3	6.00	15.74
4	8.00	77.19
5	10.00	156.49
6	12.00	217.51
7	14.00	261.96
8	16.00	294.71
9	18.00	318.77
10	20.00	336.32
11	22.00	371.41
12	24.00	445.89
13	26.00	573.11
14	28.00	764.86
15	30.00	967.70
16	32.00	1106.87
17	34.00	1173.79
18	36.00	1197.69
19	38.00	1199.49
20	40.00	1183.28
21	42.00	1149.57
22	44.00	1099.79
23	46.00	1037.51
24	48.00	967.37
25	50.00	893.65
26	52.00	819.53
27	54.00	747.05
28	56.00	677.41
29	58.00	611.31
30	60.00	549.19
31	62.00	491.34
32	64.00	437.95
33	66.00	389.11
34	68.00	344.80
35	70.00	304.89
36	72.00	269.17
37	74.00	237.37
38	76.00	209.20
39	78.00	184.32
40	80.00	162.42
41	82.00	143.16
42	84.00	126.27
43	86.00	111.46
44	88.00	98.48
45	90.00	87.11
46	92.00	77.15
47	94.00	68.42
48	96.00	60.76
49	98.00	54.03
50	100.00	48.12
51	102.00	42.92

52	104.00	38.34
53	106.00	34.31
54	108.00	30.74
55	110.00	27.59
56	112.00	24.80
57	114.00	22.32
58	116.00	20.13
59	118.00	18.17
60	120.00	16.43
61	122.00	14.88
62	124.00	13.49
63	126.00	12.25
64	128.00	11.13
65	130.00	10.14
66	132.00	9.24
67	134.00	8.43
68	136.00	7.71
69	138.00	7.05
70	140.00	6.46
71	142.00	5.92
72	144.00	5.44
73	146.00	5.00
74	148.00	4.60
75	150.00	4.24
76	152.00	3.91
77	154.00	3.61
78	156.00	3.33
79	158.00	3.08
80	160.00	2.85
81	162.00	2.64
82	164.00	2.45
83	166.00	2.27
84	168.00	2.11
85	170.00	1.96
86	172.00	1.83
87	174.00	1.70
88	176.00	1.59
89	178.00	1.48
90	180.00	1.38
91	182.00	1.29
92	184.00	1.21
93	186.00	1.13
94	188.00	1.06
95	190.00	0.99
96	192.00	0.93
97	194.00	0.87
98	196.00	0.82
99	198.00	0.77
100	200.00	0.72
101	202.00	0.68

Myra Creek RORB Result File

```
                              Myra Creek_30h50y
 RORBWin Output File
 *******************

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

 Date run: 12 Oct 2011 10:38

 Vector file       : S:\PRO-Projects\2011\CARP11064 HCPL Alpha FEED\06
Engineering\6.4 Hydrology\Myra Creek\RORB\Myra Creek.catg
 Storm file        : S:\PRO-Projects\2011\CARP11064 HCPL Alpha FEED\06
Engineering\6.4 Hydrology\Piebald Creek\RORB\Myra Creek_30h50y.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  Subcatchment: 1.13
 Sub-area areas
 Impervious flag
 Initial storm data
 Rainfall burst times
 Pluviograph 1
 Sub-area rainfalls

 Data check completed



 Data:
 ****

 Myra Creek


 Time data, in increments from initial time
 Myra Creek: 30 hour 50 year Design Storm
 Time increment (hours)=  2.00

                  Start   Finish
 Rainfall times:     0       15


 End of hyeto/hydrographs:   15
 Duration of calculations:  100



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

         1:Temporal pattern (% of depth
   Time     1
     0     1.9
     1    25.3
     2     4.2
     3     5.1
     4     1.1
     5     3.6
     6     1.5
     7     2.3
     8     2.9
     9     9.3
    10     7.5
```

11	16.1
12	12.0
13	6.4
14	0.8
Total	100.0

DESIGN run control vector

Step	Code	Description
1	1	Add sub-area 'A' inflow & route thru normal storage 1
2	5	Route hydrograph thru normal storage 2
3	2	Add sub-area 'B' inflow & route thru normal storage 3
4	5	Route hydrograph thru normal storage 4
5	2	Add sub-area 'C' inflow & route thru normal storage 5
6	5	Route hydrograph thru normal storage 6
7	3	Store hydrograph from step 6; reset hydrograph to zero
8	1	Add sub-area 'D' inflow & route thru normal storage 7
9	5	Route hydrograph thru normal storage 8
10	4	Add h-graph ex step 7 to h-graph ex step 9
11	2	Add sub-area 'E' inflow & route thru normal storage 9
12	5	Route hydrograph thru normal storage 10
13	2	Add sub-area 'F' inflow & route thru normal storage 11
14	5	Route hydrograph thru normal storage 12
15	2	Add sub-area 'G' inflow & route thru normal storage 13
16	5	Route hydrograph thru normal storage 14
17	2	Add sub-area 'H' inflow & route thru normal storage 15
18	5	Route hydrograph thru normal storage 16
19	2	Add sub-area 'I' inflow & route thru normal storage 17
20	3	Store hydrograph from step 19; reset hydrograph to zero
21	1	Add sub-area 'J' inflow & route thru normal storage 18
22	5	Route hydrograph thru normal storage 19
23	2	Add sub-area 'K' inflow & route thru normal storage 20
24	5	Route hydrograph thru normal storage 21
25	2	Add sub-area 'L' inflow & route thru normal storage 22
26	5	Route hydrograph thru normal storage 23
27	2	Add sub-area 'M' inflow & route thru normal storage 24
28	5	Route hydrograph thru normal storage 25
29	2	Add sub-area 'N' inflow & route thru normal storage 26
30	4	Add h-graph ex step 20 to h-graph ex step 29
31	5	Route hydrograph thru normal storage 27
32	3	Store hydrograph from step 31; reset hydrograph to zero
33	1	Add sub-area 'O' inflow & route thru normal storage 28
34	5	Route hydrograph thru normal storage 29
35	2	Add sub-area 'P' inflow & route thru normal storage 30
36	5	Route hydrograph thru normal storage 31
37	4	Add h-graph ex step 32 to h-graph ex step 36
38	3	Store hydrograph from step 37; reset hydrograph to zero
39	1	Add sub-area 'Q' inflow & route thru normal storage 32
40	5	Route hydrograph thru normal storage 33
41	4	Add h-graph ex step 38 to h-graph ex step 40
42	2	Add sub-area 'R' inflow & route thru normal storage 34
43	5	Route hydrograph thru normal storage 35
44	2	Add sub-area 'S' inflow & route thru normal storage 36
45	5	Route hydrograph thru normal storage 37
46	2	Add sub-area 'T' inflow & route thru normal storage 38
47	5	Route hydrograph thru normal storage 39
48	2	Add sub-area 'U' inflow & route thru normal storage 40
49	5	Route hydrograph thru normal storage 41
50	7.0	Print hydrograph, Subcatchment: 1.13
51	2	Add sub-area 'V' inflow & route thru normal storage 42
52	0	**********End of control vector**********

Myra Creek_30h50y

Sub-area data

Sub-area	Area km²	Dist. km*
A	1.50E+01	7.14E+01
B	1.51E+01	6.68E+01
C	1.58E+01	6.39E+01
D	1.50E+01	6.59E+01
E	1.60E+01	6.17E+01
F	1.61E+01	5.83E+01
G	1.51E+01	5.43E+01
H	1.51E+01	5.08E+01
I	1.55E+01	4.25E+01
J	1.51E+01	4.79E+01
K	2.01E+01	4.29E+01
L	1.52E+01	4.17E+01
M	1.50E+01	4.05E+01
N	1.58E+01	3.80E+01
O	1.51E+01	4.29E+01
P	1.96E+01	3.75E+01
Q	1.76E+01	4.50E+01
R	1.84E+01	3.33E+01
S	1.50E+01	2.67E+01
T	1.52E+01	1.89E+01
U	1.50E+01	1.03E+01
V	1.18E+01	3.00E+00

Total 3.477E+02

For whole catchment ; Av. Dist., km* = 44.13
For interstation area 1; Av. Dist., km* = 44.13; 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	3.3	0.075	Natural	
2	1.3	0.030	Natural	
3	1.3	0.030	Natural	
4	1.5	0.035	Natural	
5	1.5	0.035	Natural	
6	0.7	0.015	Natural	
7	3.5	0.079	Natural	
8	0.7	0.015	Natural	
9	0.7	0.015	Natural	
10	2.7	0.061	Natural	
11	2.7	0.061	Natural	
12	1.3	0.030	Natural	
13	1.3	0.030	Natural	
14	2.2	0.050	Natural	
15	2.2	0.050	Natural	
16	6.1	0.138	Natural	
17	6.1	0.138	Natural	
18	4.1	0.093	Natural	
19	0.8	0.019	Natural	
20	0.8	0.019	Natural	
21	0.4	0.009	Natural	
22	0.4	0.009	Natural	
23	0.9	0.020	Natural	
24	0.9	0.020	Natural	
25	1.6	0.036	Natural	
26	1.6	0.036	Natural	
27	3.0	0.069	Natural	
28	4.3	0.097	Natural	

29	1.1	0.025	Natural
30	1.1	0.025	Natural
31	3.0	0.069	Natural
32	8.6	0.195	Natural
33	3.0	0.069	Natural
34	3.0	0.069	Natural
35	3.6	0.081	Natural
36	3.6	0.081	Natural
37	4.3	0.097	Natural
38	4.3	0.097	Natural
39	4.3	0.097	Natural
40	4.3	0.097	Natural
41	3.0	0.068	Natural
42	3.0	0.068	Natural

* or other function of reach properties related to travel time

Input of parameters:
****

Myra Creek
DESIGN Run
Myra Creek: 30 hour 50 year Design Storm
Time increment = 2.00 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	4.1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
1	54.5	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55
2	9.0	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
3	11.0	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
4	2.4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
5	7.8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
6	3.2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
7	5.0	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
8	6.2	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
9	20.0	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
10	16.2	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
11	34.7	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
12	25.9	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
13	13.8	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
14	1.7	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Tot.	215.5	215	215	215	215	215	215	215	215	215	215	215	215	215	215	215	

Myra Creek_30h50y

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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	U	V
0	4.1	4	4	4	4	4	4
1	54.5	55	55	55	55	55	55
2	9.0	9	9	9	9	9	9
3	11.0	11	11	11	11	11	11
4	2.4	2	2	2	2	2	2
5	7.8	8	8	8	8	8	8
6	3.2	3	3	3	3	3	3
7	5.0	5	5	5	5	5	5
8	6.2	6	6	6	6	6	6
9	20.0	20	20	20	20	20	20
10	16.2	16	16	16	16	16	16
11	34.7	35	35	35	35	35	35
12	25.9	26	26	26	26	26	26
13	13.8	14	14	14	14	14	14
14	1.7	2	2	2	2	2	2
Tot.	215.5	215	215	215	215	215	215
Pluvi. ref. no.		1	1	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	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	28.6	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29
2	4.0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
3	6.0	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
4	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	2.8	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	1.2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	15.0	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
10	11.2	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
11	29.7	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
12	20.9	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
13	8.8	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
14	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tot.	128.2	128	128	128	128	128	128	128	128	128	128	128	128	128	128	128	

Myra Creek_30h50y

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Time Incs	Catchment	Sub-Area Q	R	S	T	U	V
0	0.0	0	0	0	0	0	0
1	28.6	29	29	29	29	29	29
2	4.0	4	4	4	4	4	4
3	6.0	6	6	6	6	6	6
4	0.0	0	0	0	0	0	0
5	2.8	3	3	3	3	3	3
6	0.0	0	0	0	0	0	0
7	0.0	0	0	0	0	0	0
8	1.2	1	1	1	1	1	1
9	15.0	15	15	15	15	15	15
10	11.2	11	11	11	11	11	11
11	29.7	30	30	30	30	30	30
12	20.9	21	21	21	21	21	21
13	8.8	9	9	9	9	9	9
14	0.0	0	0	0	0	0	0
Tot.	128.2	128	128	128	128	128	128

Routing results:
****
Myra Creek
Myra Creek: 30 hour 50 year Design Storm
DESIGN run no. 1

Parameters: kc = 42.50 m = 0.85

Loss parameters	Initial loss (mm)	Cont. loss (mm/h)
	25.00	2.50

*** Calculated hydrograph, Subcatchment: 1.13

	Hydrograph Calc.
Peak discharge, m^3/s	443.0
Time to peak,h	38.0
Volume, m^3	4.28E+07
Time to centroid,h	36.7
Lag (c.m. to c.m.),h	19.8
Lag to peak,h	21.1

Hydrograph summary
****

Site	Description
01	Calculated hydrograph, Subcatchment: 1.13

Inc	Time	Hyd0001
1	2.00	0.000
2	4.00	0.000
3	6.00	5.631
4	8.00	21.129
5	10.00	33.269
6	12.00	41.527
7	14.00	57.880
8	16.00	86.361
9	18.00	122.007

10	20.00	152.687
11	22.00	175.666
12	24.00	192.477
13	26.00	209.314
14	28.00	235.925
15	30.00	265.909
16	32.00	298.768
17	34.00	345.546
18	36.00	400.421
19	38.00	439.517
20	40.00	442.952
21	42.00	412.161
22	44.00	362.424
23	46.00	308.547
24	48.00	258.116
25	50.00	213.257
26	52.00	174.090
27	54.00	140.457
28	56.00	112.186
29	58.00	88.956
30	60.00	70.238
31	62.00	55.376
32	64.00	43.691
33	66.00	34.554
34	68.00	27.424
35	70.00	21.860
36	72.00	17.509
37	74.00	14.096
38	76.00	11.408
39	78.00	9.282
40	80.00	7.591
41	82.00	6.241
42	84.00	5.156
43	86.00	4.281
44	88.00	3.571
45	90.00	2.992
46	92.00	2.518
47	94.00	2.128
48	96.00	1.806
49	98.00	1.538
50	100.00	1.315
51	102.00	1.129
52	104.00	0.972
53	106.00	0.840
54	108.00	0.728
55	110.00	0.633
56	112.00	0.551
57	114.00	0.482
58	116.00	0.423
59	118.00	0.371
60	120.00	0.327
61	122.00	0.289
62	124.00	0.256
63	126.00	0.227
64	128.00	0.202
65	130.00	0.180
66	132.00	0.161
67	134.00	0.144
68	136.00	0.129
69	138.00	0.116
70	140.00	0.104
71	142.00	0.094
72	144.00	0.085
73	146.00	0.076
74	148.00	0.069
75	150.00	0.063
76	152.00	0.057
77	154.00	0.052

78	156.00	0.047
79	158.00	0.043
80	160.00	0.039
81	162.00	0.036
82	164.00	0.033
83	166.00	0.030
84	168.00	0.028
85	170.00	0.025
86	172.00	0.023
87	174.00	0.021
88	176.00	0.020
89	178.00	0.018
90	180.00	0.017
91	182.00	0.016
92	184.00	0.014
93	186.00	0.013
94	188.00	0.012
95	190.00	0.011
96	192.00	0.011
97	194.00	0.010
98	196.00	0.009
99	198.00	0.009
100	200.00	0.008
101	202.00	0.007

Nibereena Creek RORB Result File

```
                             Nibereena Creek_30h50y
 RORBWin Output File
 *******************

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

 Date run: 12 Oct 2011 12:14

 Vector file       : S:\PRO-Projects\2011\CARP11064 HCPL Alpha FEED\06
Engineering\6.4 Hydrology\Nibbereena Creek\RORB\Nibereena Creek.catg
 Storm file        : S:\PRO-Projects\2011\CARP11064 HCPL Alpha FEED\06
Engineering\6.4 Hydrology\Piebald Creek\RORB\Nibereena Creek_30h50y.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.  49     7.0 Location read as  Subcatchment: 1.14
 Sub-area areas
 Impervious flag
 Initial storm data
 Rainfall burst times
 Pluviograph 1
 Sub-area rainfalls

 Data check completed



 Data:
 ****

 Nibereena Creek


 Time data, in increments from initial time
 Nibereena Creek: 30 hour 50 year Design Storm
 Time increment (hours)=  2.00

                  Start   Finish
 Rainfall times:     0       15


 End of hyeto/hydrographs:   15
 Duration of calculations:  100



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

         1:Temporal pattern (% of depth
   Time     1
     0     1.9
     1    25.3
     2     4.2
     3     5.1
     4     1.1
     5     3.6
     6     1.5
     7     2.3
     8     2.9
     9     9.3
    10     7.5
```

Nibereena Creek_30h50y

```
  11    16.1
  12    12.0
  13     6.4
  14     0.8

 Total 100.0
```

DESIGN run control vector

```
Step  Code            Description
  1    1     Add sub-area 'A' inflow & route thru normal storage    1
  2    5     Route hydrograph thru normal storage    2
  3    2     Add sub-area 'B' inflow & route thru normal storage    3
  4    5     Route hydrograph thru normal storage    4
  5    2     Add sub-area 'C' inflow & route thru normal storage    5
  6    5     Route hydrograph thru normal storage    6
  7    2     Add sub-area 'D' inflow & route thru normal storage    7
  8    5     Route hydrograph thru normal storage    8
  9    2     Add sub-area 'E' inflow & route thru normal storage    9
 10    5     Route hydrograph thru normal storage   10
 11    3     Store hydrograph from step   10; reset hydrograph to zero
 12    1     Add sub-area 'F' inflow & route thru normal storage   11
 13    5     Route hydrograph thru normal storage   12
 14    2     Add sub-area 'G' inflow & route thru normal storage   13
 15    5     Route hydrograph thru normal storage   14
 16    2     Add sub-area 'H' inflow & route thru normal storage   15
 17    5     Route hydrograph thru normal storage   16
 18    2     Add sub-area 'I' inflow & route thru normal storage   17
 19    5     Route hydrograph thru normal storage   18
 20    4     Add h-graph ex step   11 to h-graph ex step   19
 21    3     Store hydrograph from step   20; reset hydrograph to zero
 22    1     Add sub-area 'J' inflow & route thru normal storage   19
 23    5     Route hydrograph thru normal storage   20
 24    4     Add h-graph ex step   21 to h-graph ex step   23
 25    2     Add sub-area 'K' inflow & route thru normal storage   21
 26    5     Route hydrograph thru normal storage   22
 27    2     Add sub-area 'L' inflow & route thru normal storage   23
 28    5     Route hydrograph thru normal storage   24
 29    2     Add sub-area 'M' inflow & route thru normal storage   25
 30    5     Route hydrograph thru normal storage   26
 31    2     Add sub-area 'N' inflow & route thru normal storage   27
 32    5     Route hydrograph thru normal storage   28
 33    3     Store hydrograph from step   32; reset hydrograph to zero
 34    1     Add sub-area 'O' inflow & route thru normal storage   29
 35    5     Route hydrograph thru normal storage   30
 36    2     Add sub-area 'P' inflow & route thru normal storage   31
 37    5     Route hydrograph thru normal storage   32
 38    4     Add h-graph ex step   33 to h-graph ex step   37
 39    2     Add sub-area 'Q' inflow & route thru normal storage   33
 40    5     Route hydrograph thru normal storage   34
 41    2     Add sub-area 'R' inflow & route thru normal storage   35
 42    5     Route hydrograph thru normal storage   36
 43    2     Add sub-area 'S' inflow & route thru normal storage   37
 44    5     Route hydrograph thru normal storage   38
 45    2     Add sub-area 'T' inflow & route thru normal storage   39
 46    5     Route hydrograph thru normal storage   40
 47    2     Add sub-area 'U' inflow & route thru normal storage   41
 48    5     Route hydrograph thru normal storage   42
 49    7.0   Print hydrograph,  Subcatchment: 1.14
 50    2     Add sub-area 'V' inflow & route thru normal storage   43
 51    0     **********End of control vector**********
```

Sub-area data

Nibereena Creek_30h50y

Sub-area	Area km²	Dist. km*
A	7.05E+00	3.12E+01
B	1.17E+01	2.79E+01
C	7.03E+00	2.61E+01
D	7.18E+00	2.42E+01
E	7.45E+00	2.24E+01
F	7.00E+00	3.11E+01
G	7.23E+00	2.44E+01
H	7.16E+00	2.35E+01
I	7.03E+00	2.23E+01
J	7.90E+00	2.46E+01
K	9.98E+00	2.08E+01
L	9.18E+00	1.93E+01
M	9.10E+00	1.83E+01
N	7.05E+00	1.68E+01
O	7.01E+00	1.93E+01
P	7.72E+00	1.63E+01
Q	7.04E+00	1.50E+01
R	7.02E+00	1.36E+01
S	7.33E+00	1.10E+01
T	9.75E+00	8.19E+00
U	7.18E+00	5.36E+00
V	7.71E+00	1.74E+00

Total 1.728E+02

For whole catchment ; Av. Dist., km* = 19.26
For interstation area 1; Av. Dist., km* = 19.26; 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	2.3	0.122	Natural	
2	0.9	0.047	Natural	
3	0.9	0.047	Natural	
4	0.9	0.046	Natural	
5	0.9	0.046	Natural	
6	1.0	0.053	Natural	
7	1.0	0.053	Natural	
8	0.8	0.040	Natural	
9	0.8	0.040	Natural	
10	0.8	0.043	Natural	
11	6.2	0.323	Natural	
12	0.4	0.022	Natural	
13	0.4	0.022	Natural	
14	0.6	0.029	Natural	
15	0.6	0.029	Natural	
16	0.6	0.033	Natural	
17	0.6	0.033	Natural	
18	0.8	0.043	Natural	
19	3.0	0.154	Natural	
20	0.8	0.043	Natural	
21	0.8	0.043	Natural	
22	0.7	0.037	Natural	
23	0.7	0.037	Natural	
24	0.3	0.014	Natural	
25	0.3	0.014	Natural	
26	1.2	0.062	Natural	
27	1.2	0.062	Natural	
28	0.6	0.033	Natural	
29	2.4	0.122	Natural	

30	0.6	0.034	Natural
31	0.6	0.034	Natural
32	0.6	0.033	Natural
33	0.6	0.033	Natural
34	0.8	0.040	Natural
35	0.8	0.040	Natural
36	1.8	0.095	Natural
37	1.8	0.095	Natural
38	1.0	0.050	Natural
39	1.0	0.050	Natural
40	1.9	0.097	Natural
41	1.9	0.097	Natural
42	1.7	0.090	Natural
43	1.7	0.090	Natural

* or other function of reach properties related to travel time

Input of parameters:
****

Nibereena Creek
DESIGN Run
Nibereena Creek: 30 hour 50 year Design Storm
Time increment = 2.00 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	4.2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
1	55.5	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56
2	9.2	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
3	11.2	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
4	2.4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
5	7.9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
6	3.3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
7	5.0	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
8	6.4	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
9	20.4	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
10	16.5	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
11	35.3	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
12	26.3	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
13	14.0	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
14	1.8	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Tot.	219.4	219	219	219	219	219	219	219	219	219	219	219	219	219	219	219	

Nibereena Creek_30h50y
219

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	U	V
0	4.2	4	4	4	4	4	4
1	55.5	56	56	56	56	56	56
2	9.2	9	9	9	9	9	9
3	11.2	11	11	11	11	11	11
4	2.4	2	2	2	2	2	2
5	7.9	8	8	8	8	8	8
6	3.3	3	3	3	3	3	3
7	5.0	5	5	5	5	5	5
8	6.4	6	6	6	6	6	6
9	20.4	20	20	20	20	20	20
10	16.5	16	16	16	16	16	16
11	35.3	35	35	35	35	35	35
12	26.3	26	26	26	26	26	26
13	14.0	14	14	14	14	14	14
14	1.8	2	2	2	2	2	2
Tot.	219.4	219	219	219	219	219	219
Pluvi. ref. no.		1	1	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	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	29.7	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
2	4.2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
3	6.2	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
4	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	2.9	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	1.4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	15.4	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
10	11.5	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
11	30.3	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
12	21.3	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
13	9.0	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
14	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tot.	132.0	132	132	132	132	132	132	132	132	132	132	132	132	132	132	132	

Nibereena Creek RORB Result File

Nibereena Creek_30h50y

132

Time Incs	Catchment	Sub-Area Q	R	S	T	U	V
0	0.0	0	0	0	0	0	0
1	29.7	30	30	30	30	30	30
2	4.2	4	4	4	4	4	4
3	6.2	6	6	6	6	6	6
4	0.0	0	0	0	0	0	0
5	2.9	3	3	3	3	3	3
6	0.0	0	0	0	0	0	0
7	0.0	0	0	0	0	0	0
8	1.4	1	1	1	1	1	1
9	15.4	15	15	15	15	15	15
10	11.5	11	11	11	11	11	11
11	30.3	30	30	30	30	30	30
12	21.3	21	21	21	21	21	21
13	9.0	9	9	9	9	9	9
14	0.0	0	0	0	0	0	0
Tot.	132.0	132	132	132	132	132	132

Routing results:
****
Nibereena Creek
Nibereena Creek: 30 hour 50 year Design Storm
DESIGN run no. 1

Parameters: kc = 18.55 m = 0.85

Loss parameters	Initial loss (mm)	Cont. loss (mm/h)
	25.00	2.50

*** Calculated hydrograph, Subcatchment: 1.14

	Hydrograph Calc.
Peak discharge,m³/s	359.8
Time to peak,h	30.0
Volume,m³	2.15E+07
Time to centroid,h	26.3
Lag (c.m. to c.m.),h	9.47
Lag to peak,h	13.2

Hydrograph summary
****

Site	Description
01	Calculated hydrograph, Subcatchment: 1.14

Inc	Time	Hyd0001
1	2.00	0.000
2	4.00	0.000
3	6.00	10.271
4	8.00	42.291
5	10.00	82.161
6	12.00	129.423
7	14.00	169.772
8	16.00	167.158
9	18.00	126.880

10	20.00	83.636
11	22.00	63.500
12	24.00	68.712
13	26.00	103.895
14	28.00	184.198
15	30.00	288.187
16	32.00	359.766
17	34.00	359.402
18	36.00	287.043
19	38.00	189.892
20	40.00	111.708
21	42.00	61.686
22	44.00	34.303
23	46.00	20.111
24	48.00	12.567
25	50.00	8.271
26	52.00	5.647
27	54.00	3.976
28	56.00	2.864
29	58.00	2.104
30	60.00	1.574
31	62.00	1.198
32	64.00	0.925
33	66.00	0.723
34	68.00	0.571
35	70.00	0.456
36	72.00	0.366
37	74.00	0.297
38	76.00	0.243
39	78.00	0.200
40	80.00	0.165
41	82.00	0.138
42	84.00	0.115
43	86.00	0.097
44	88.00	0.082
45	90.00	0.069
46	92.00	0.059
47	94.00	0.051
48	96.00	0.044
49	98.00	0.038
50	100.00	0.032
51	102.00	0.028
52	104.00	0.025
53	106.00	0.021
54	108.00	0.019
55	110.00	0.016
56	112.00	0.014
57	114.00	0.013
58	116.00	0.011
59	118.00	0.010
60	120.00	0.009
61	122.00	0.008
62	124.00	0.007
63	126.00	0.006
64	128.00	0.006
65	130.00	0.005
66	132.00	0.005
67	134.00	0.004
68	136.00	0.004
69	138.00	0.003
70	140.00	0.003
71	142.00	0.003
72	144.00	0.003
73	146.00	0.002
74	148.00	0.002
75	150.00	0.002
76	152.00	0.002
77	154.00	0.002

78	156.00	0.001
79	158.00	0.001
80	160.00	0.001
81	162.00	0.001
82	164.00	0.001
83	166.00	0.001
84	168.00	0.001
85	170.00	0.001
86	172.00	0.001
87	174.00	0.001
88	176.00	0.001
89	178.00	0.001
90	180.00	0.001
91	182.00	0.001
92	184.00	0.000
93	186.00	0.000
94	188.00	0.000
95	190.00	0.000
96	192.00	0.000
97	194.00	0.000
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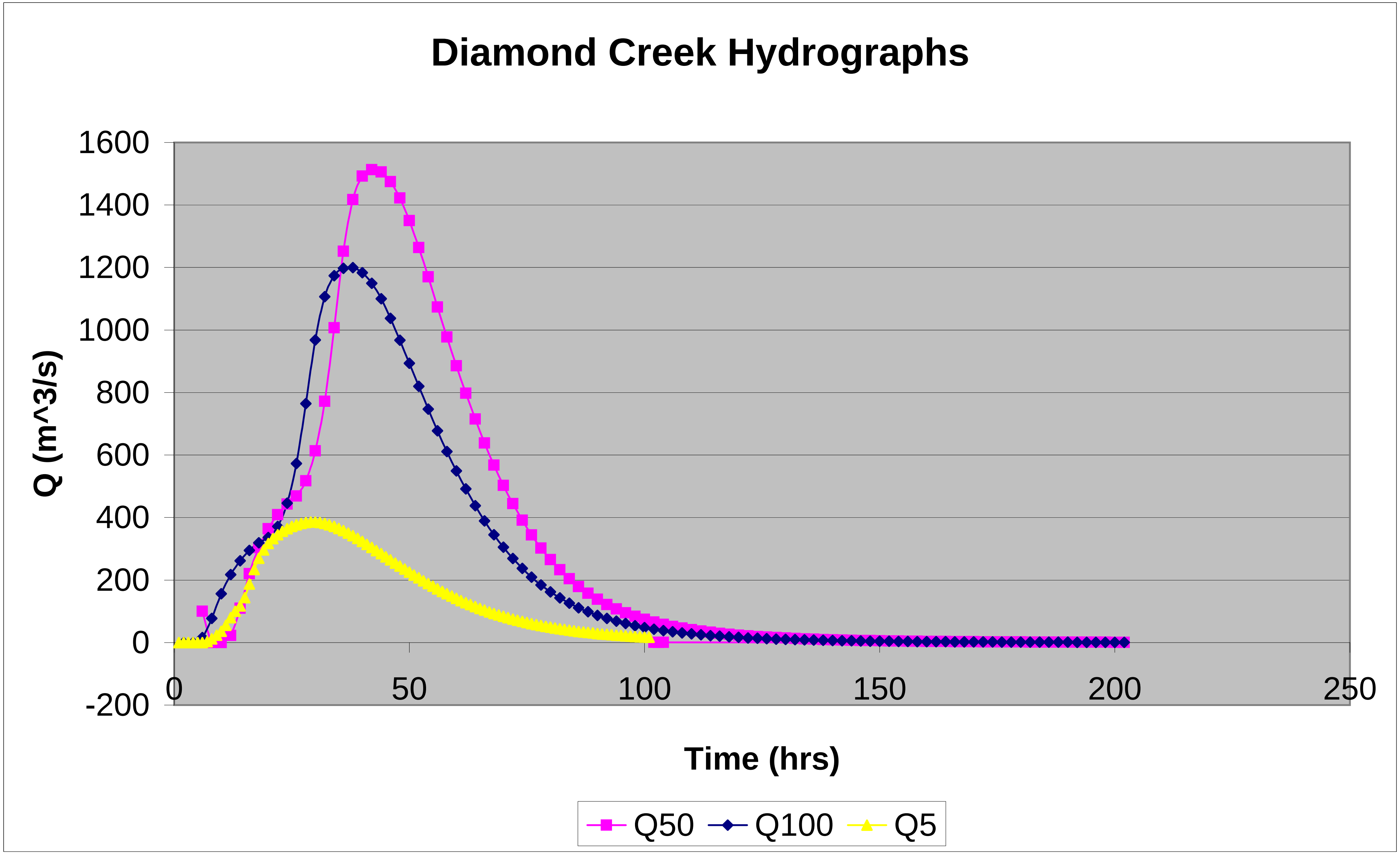
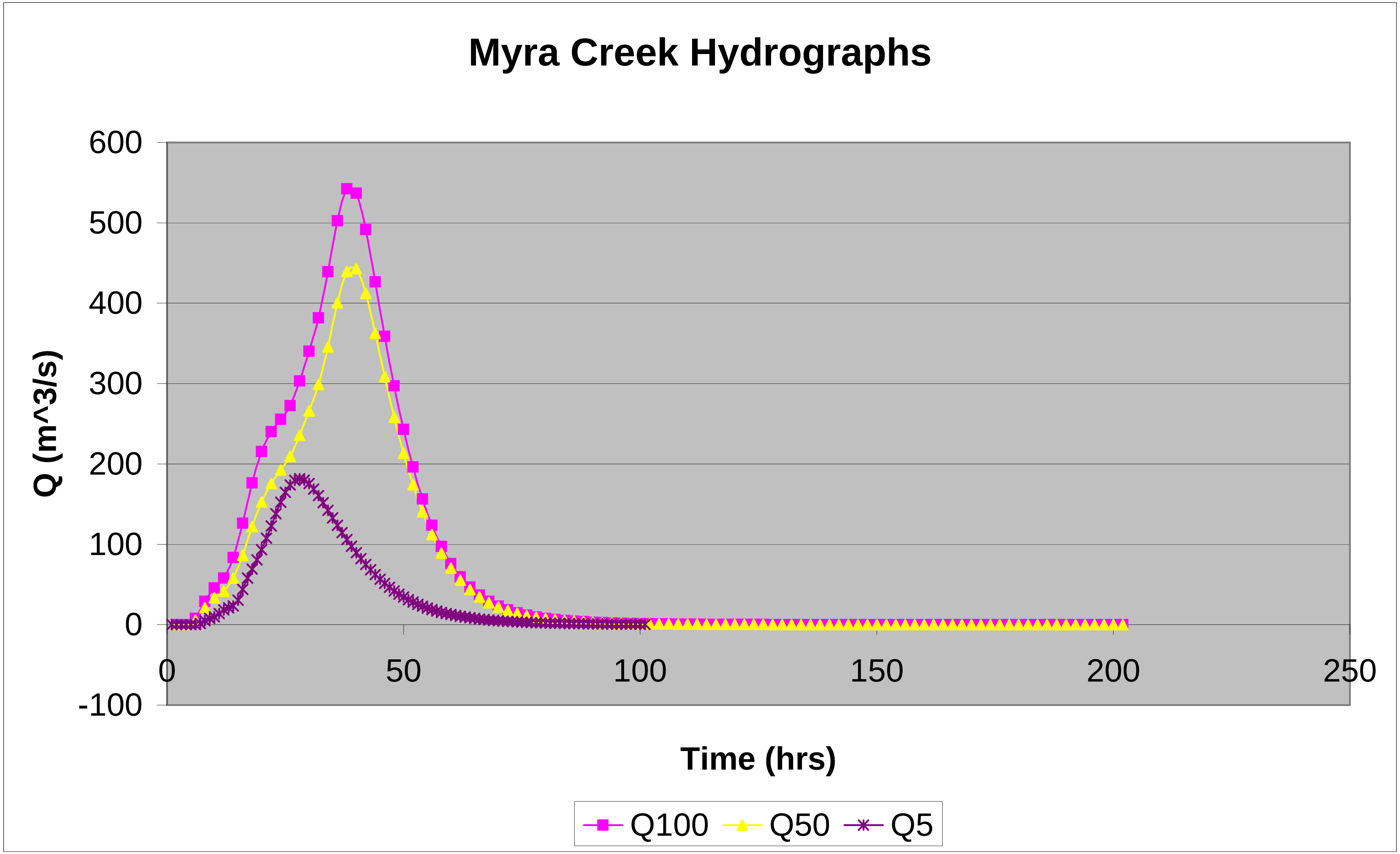
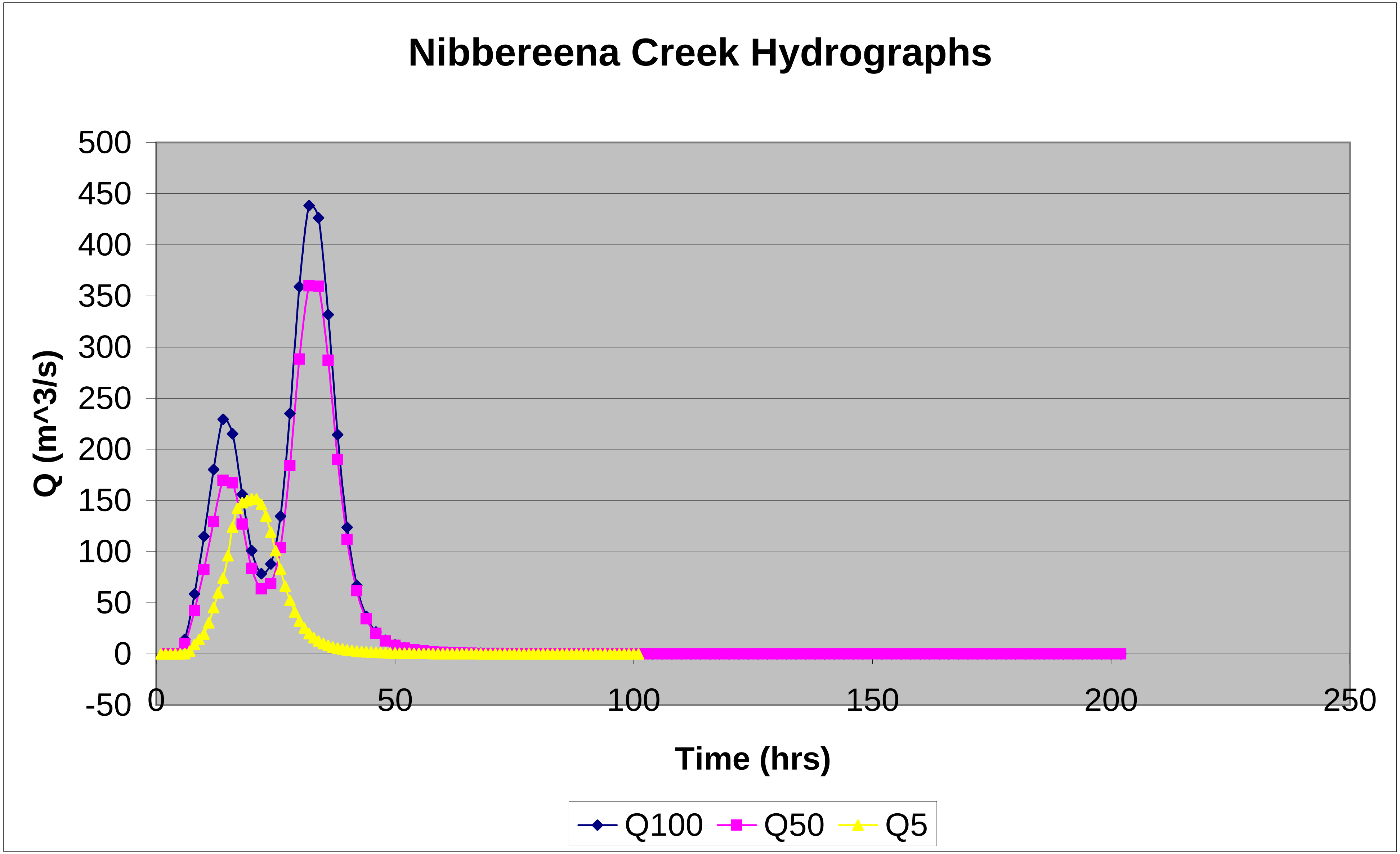
99	198.00	0.000
100	200.00	0.000
101	202.00	0.000



Diamond Creek Hydrographs
Q (m^3/s)
1600
1400
1200
1000
800
600
400
200
0
-200
0
50
100
150
200
250
Time (hrs)
Q50
Q100
Q5



Myra Creek Hydrographs
Q (m^3/s)
600
500
400
300
200
100
0
-100
0
50
100
150
200
250
Time (hrs)
Q100
Q50
Q5

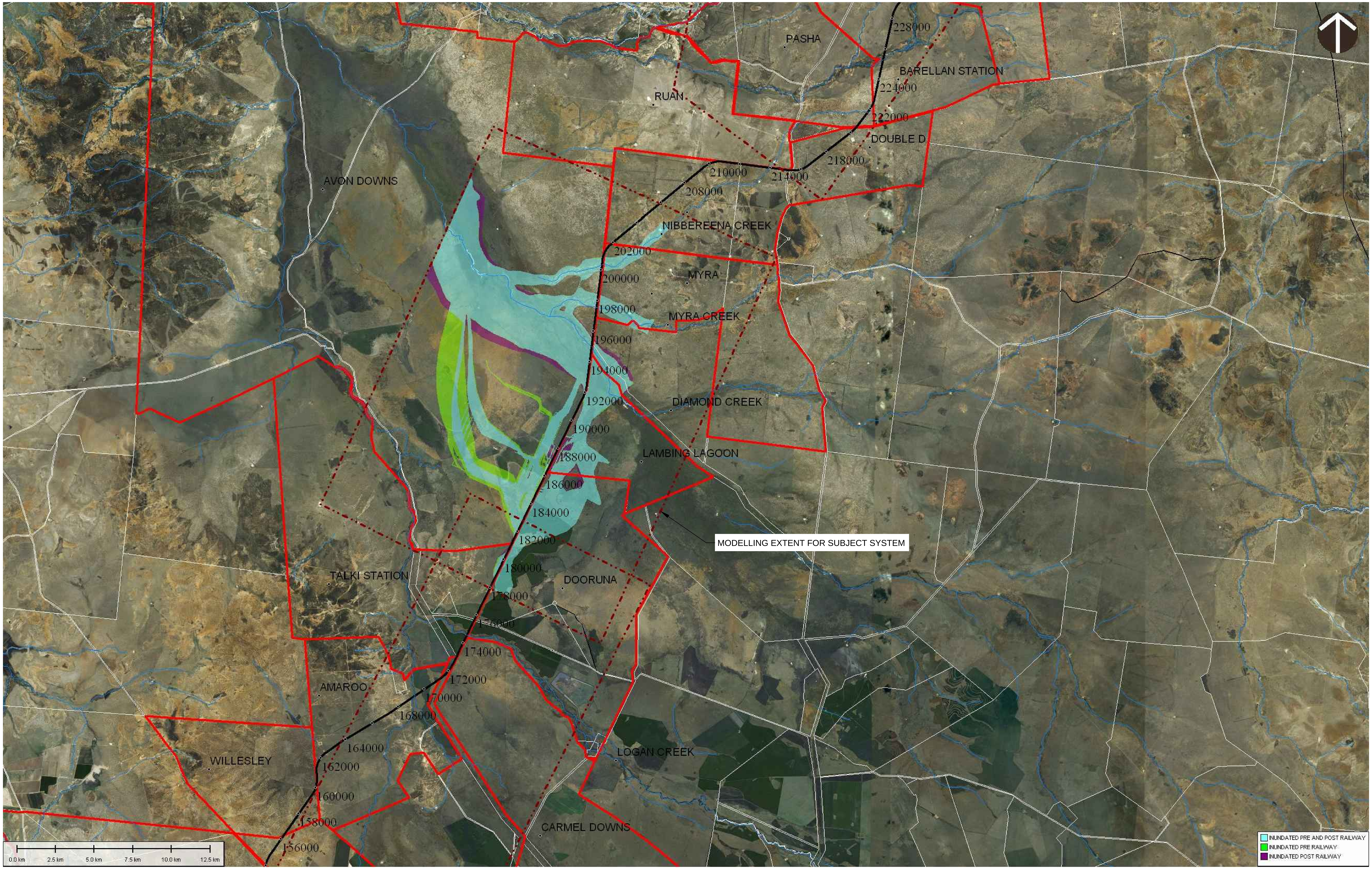


Nibbereena Creek Hydrographs
Q (m^3/s)
500
450
400
350
300
250
200
150
100
50
0
-50
0
50
100
150
200
250
Time (hrs)
Q100
Q50
Q5

APPENDIX B
FLOOD MAPS

NOT TO BE SCALED

NOT TO BE SCALED



REFERENCES

REVISIONS

REV	BY	DATE	DESCRIPTION	CKD	APP
B	DES	17.11.11	RE-ISSUED FOR INFORMATION	TLB	
A	DES	16.11.11	ISSUED FOR INFORMATION	TLB	

REVISIONS

REV	BY	DATE	DESCRIPTION	CKD	APP

MASTER COPY

DRAWN	D. SMITH	16.11.11
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
DIAMOND CREEK / MYRA CREEK - Q5

SHEET SIZE A1

PN No CJVP10007

SCALE NTS

CALIBRE DRAWING No. CJVP10007-DWG-G-643

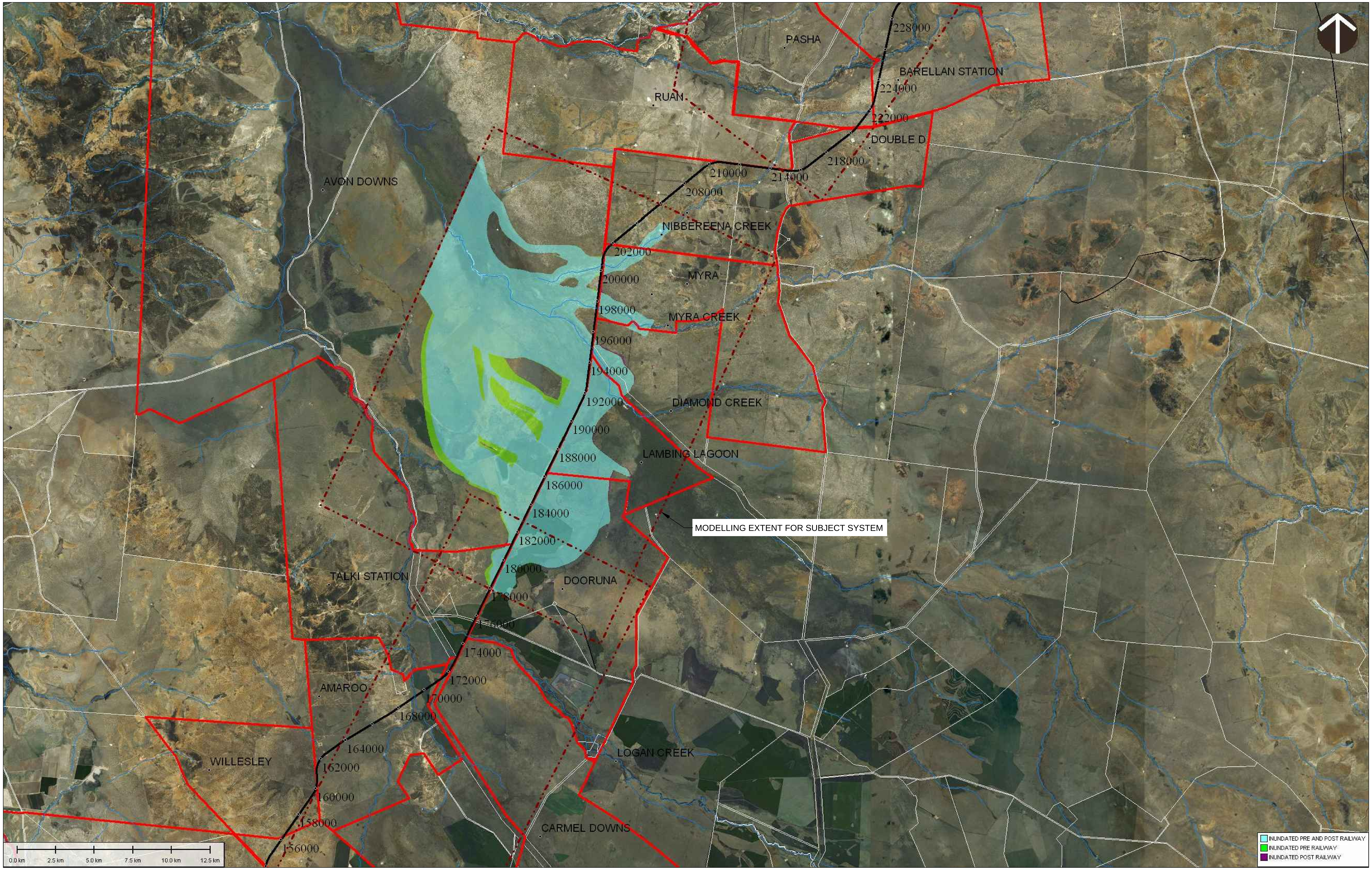
HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0575

REV B

NOT TO BE SCALED

NOT TO BE SCALED

MASTER COPY



REV	BY	DATE	DESCRIPTION	CKD	APP
B	DES	17.11.11	RE-ISSUED FOR INFORMATION	TLB	
A	DES	15.11.11	ISSUED FOR INFORMATION	TLB	

REFERENCES

REVISIONS

DRAWN	D. SMITH	15.11.11
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
DIAMOND CREEK / MYRA CREEK - Q50

SHEET SIZE A1

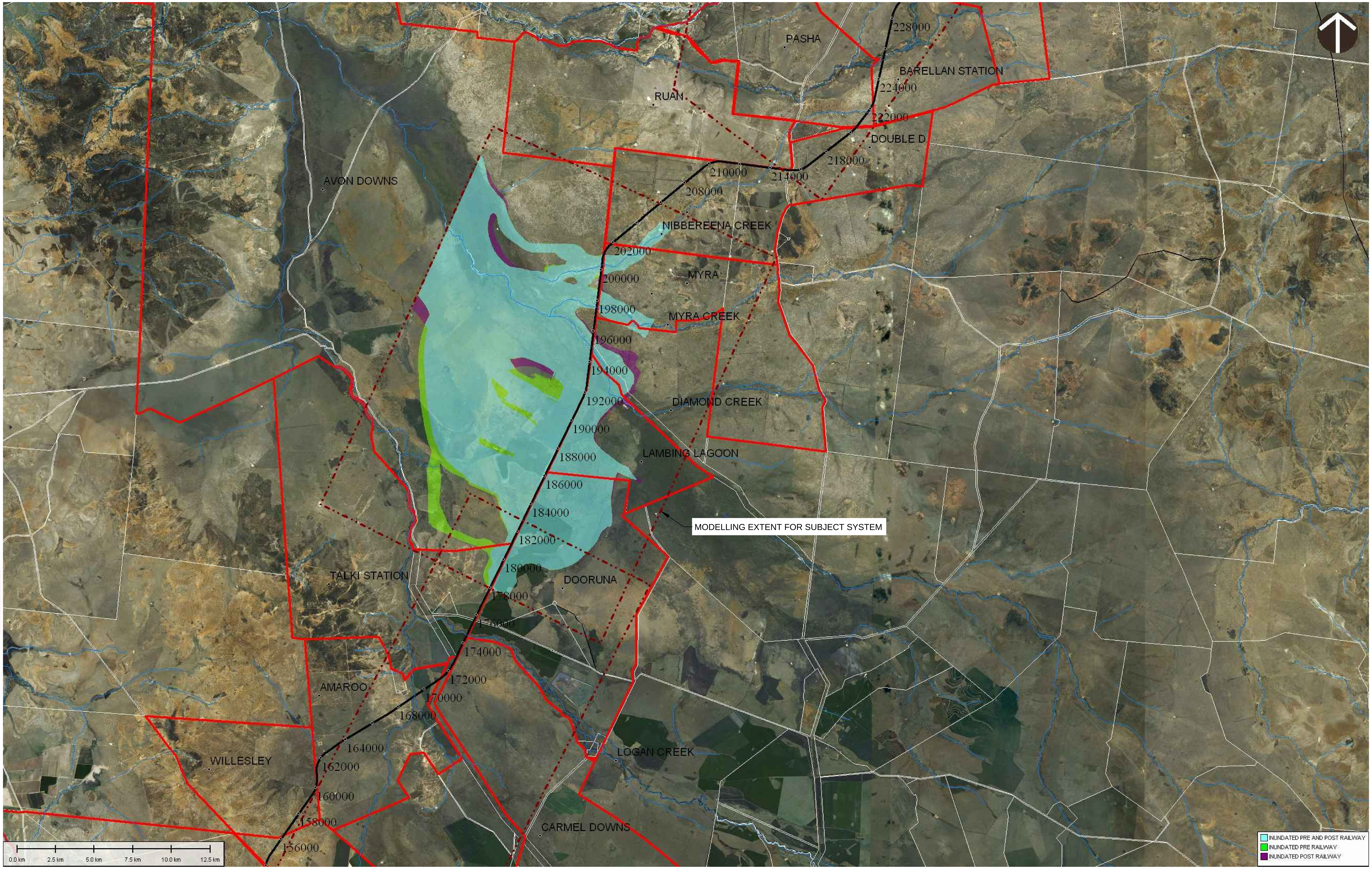
PN No CJVP10007

SCALE NTS

CALIBRE DRAWING No. CJVP10007-DWG-G-644

HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0576

REV B



REV	BY	DATE	DESCRIPTION	CKD	APP
B	DES	17.11.11	RE-ISSUED FOR INFORMATION	TLB	
A	DES	15.11.11	ISSUED FOR INFORMATION	TLB	

REFERENCES

REVISIONS

DRAWN	D. SMITH	15.11.11
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
DIAMOND CREEK / MYRA CREEK - Q100

SHEET SIZE A1

PN No CJVP10007

SCALE NTS

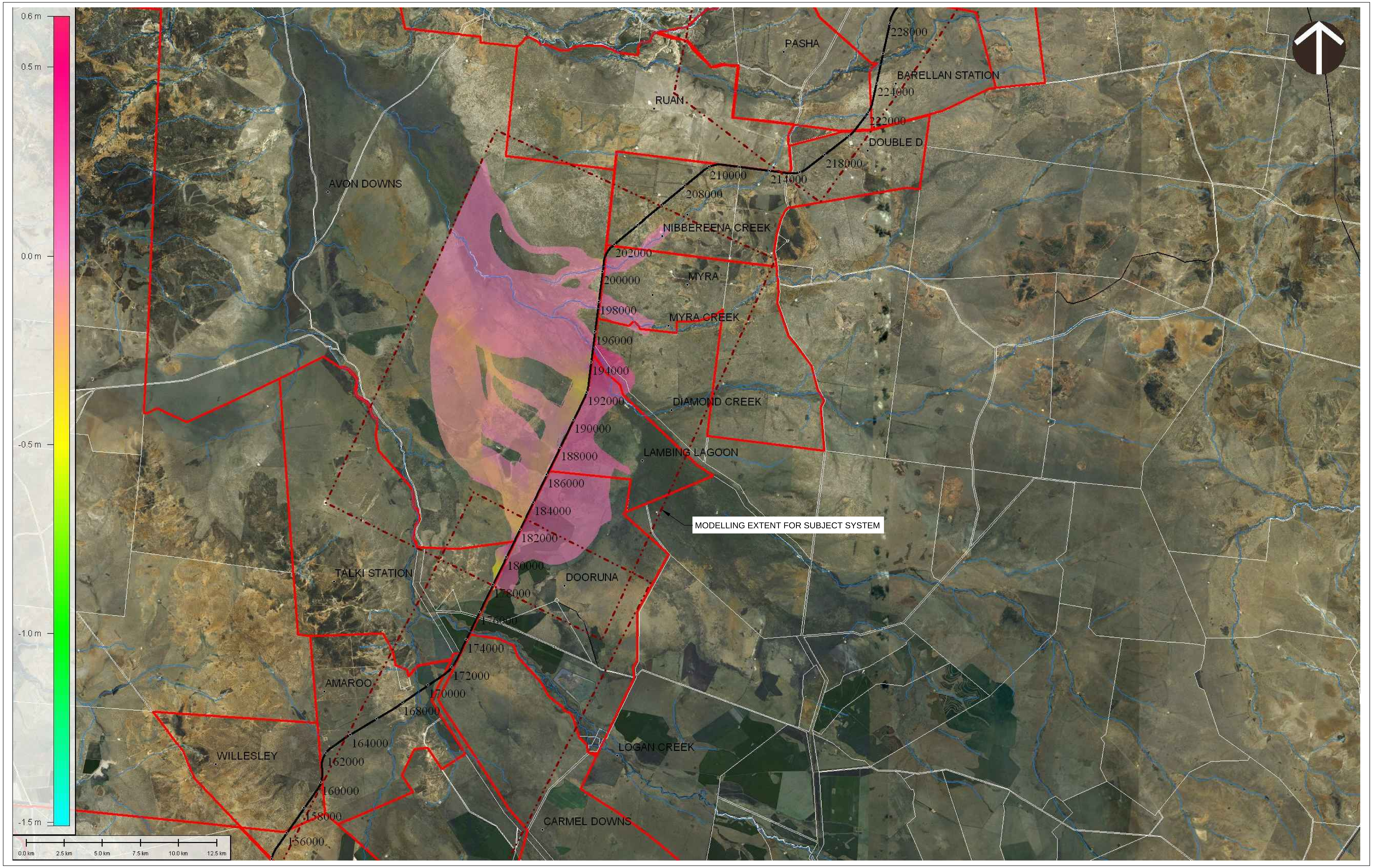
CALIBRE DRAWING No. CJVP10007-DWG-G-645

HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0577

REV B

NOT TO BE SCALED

NOT TO BE SCALED



REFERENCES

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ALPHA COAL PROJECT
RAIL ALIGNMENT - MINE TO ABBOT POINT
AFFLUX
DIAMOND CREEK / MYRA CREEK - Q50

SHEET SIZE A1

PN No CJVP10007

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HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0656

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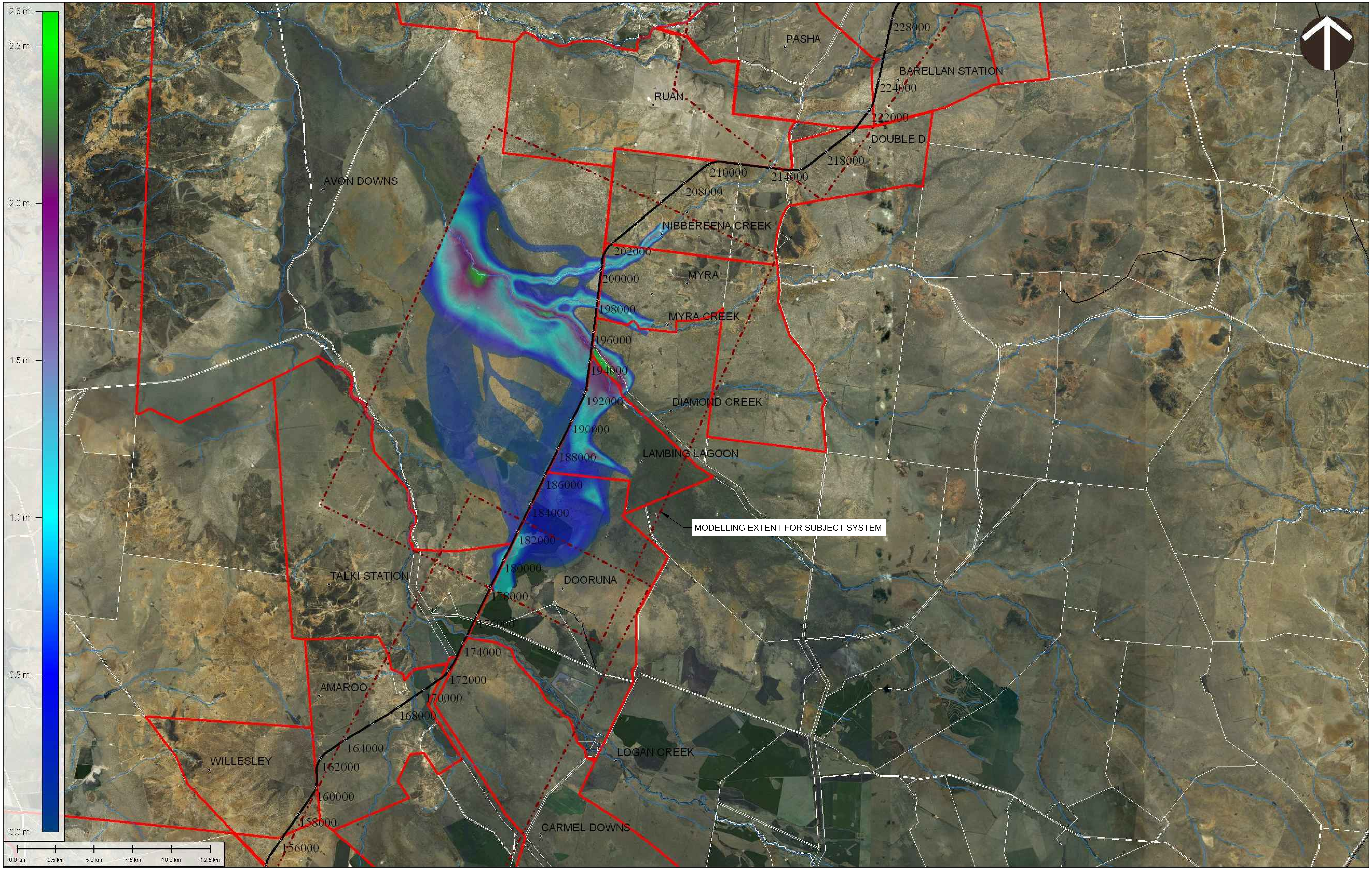

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HANCOCK COAL PTY LTD

ALPHA COAL PROJECT
RAIL ALIGNMENT - MINE TO ABBOT POINT
DEPTH
DIAMOND CREEK / MYRA CREEK - Q50

SHEET SIZE A1

PN No CJVP10007

SCALE NTS

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HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0657

REV B

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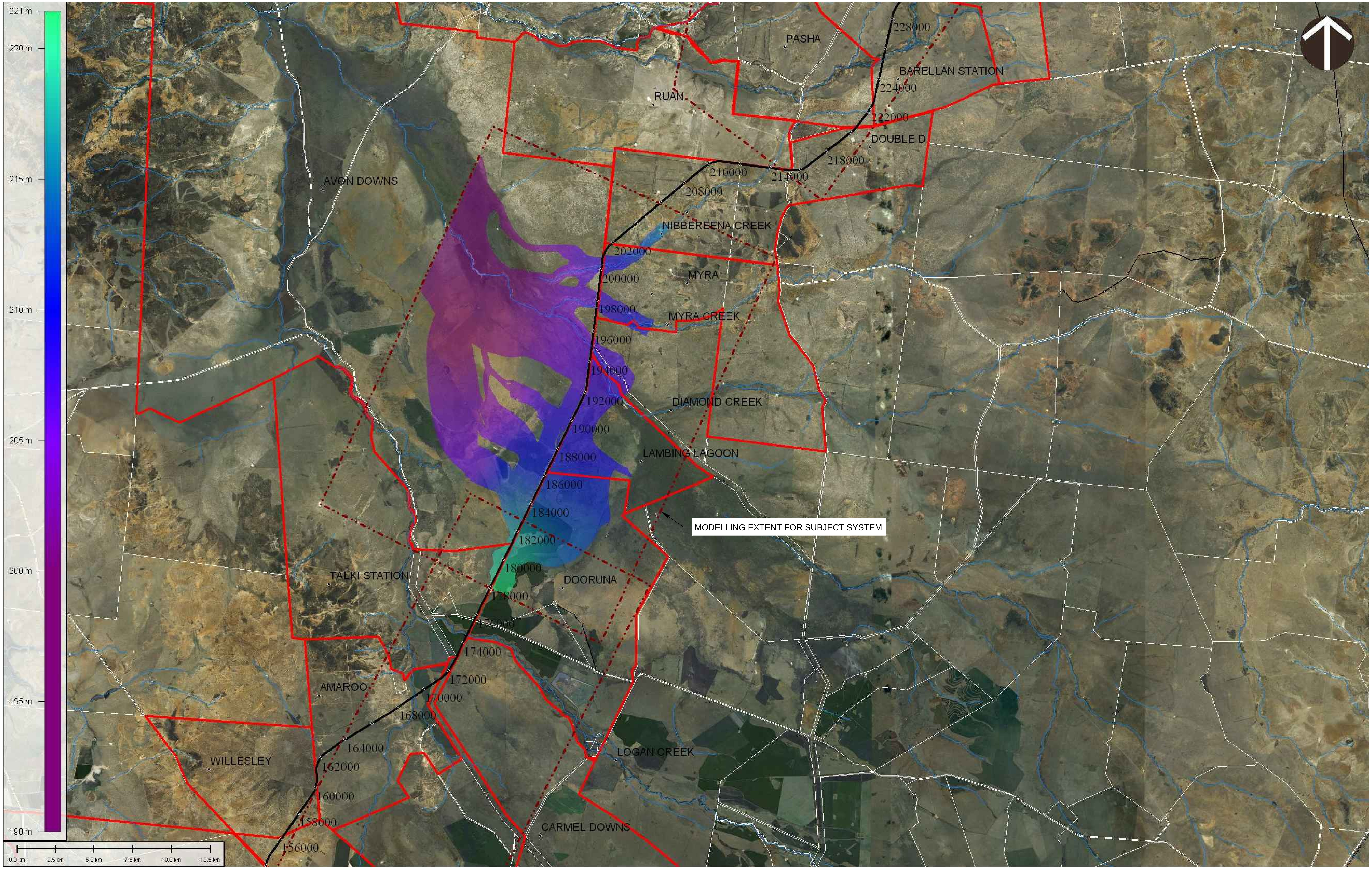

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HANCOCK COAL PTY LTD

ALPHA COAL PROJECT
RAIL ALIGNMENT - MINE TO ABBOT POINT
SURFACE ELEVATION
DIAMOND CREEK / MYRA CREEK - Q50

SHEET SIZE A1

PN No CJVP10007

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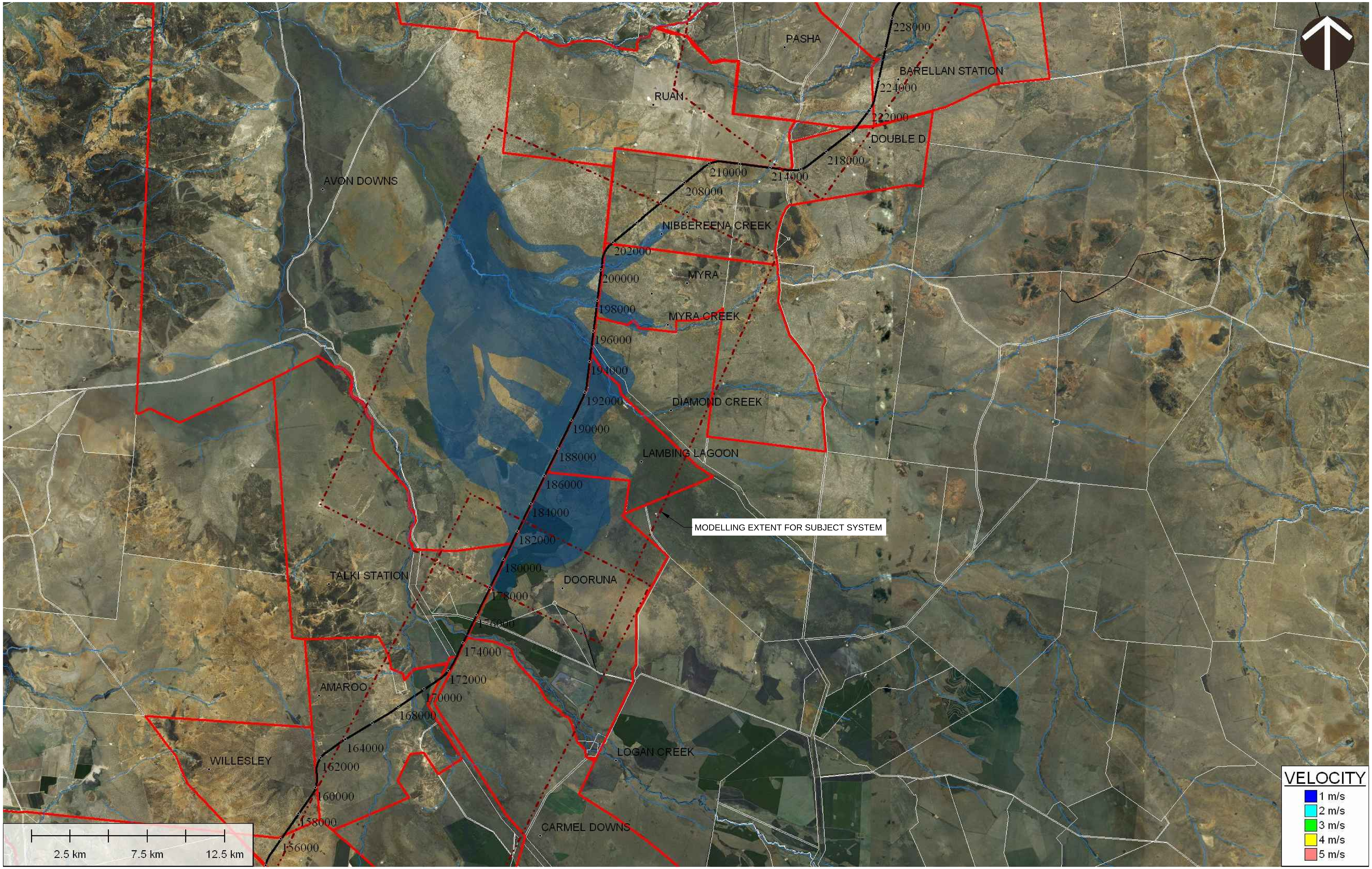

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ALPHA COAL PROJECT
RAIL ALIGNMENT - MINE TO ABBOT POINT
VELOCITY
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SHEET SIZE A1

PN No CJVP10007

SCALE NTS

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HANCOCK COAL REFERENCE No. HC-CRL-24100-DRG-0659

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