Appendix F

Hydrology section from Parsons Brinckerhoff report 'West Surat Rail Link – Hydraulic Study' (September 2012)

West Surat Rail Link – Hydraulic study

19 September 2012

Northern Energy Corporation Ltd.

PARSONS BRINCKERHOFF

Parsons Brinckerhoff Australia Pty Limited
ABN 80 078 004 798

Level 4, Northbank Plaza
69 Ann Street
Brisbane QLD 4000
GPO Box 2907
Brisbane QLD 4001
Australia
Telephone +61 7 3854 6200
Facsimile +61 7 3854 6500
Email brisbane@pb.com.au

Certified to ISO 9001, ISO 14001, AS/NZS 4801
A+ GRI Rating: Sustainability Report 2010

Revision	Details	Date	Amended By
01	Original	19 September 2012	EustanceA

Author: Kerry Wilkinson ....

Signed: ....

Reviewer: Henning Boshoff...

Signed: ....

Approved by: Amin Shantia ....

Signed: ....

Date: 19 September 2012..

Distribution: New Hope Coal Aust., PB file, PB library.....................................

Please note that when viewed electronically this document may contain pages that have been intentionally left blank. These blank pages may occur because in consideration of the environment and for your convenience, this document has been set up so that it can be printed correctly in double-sided format.

Contents

Contents (Continued)

List of tables

Contents (Continued)

Page number

List of figures

Page number

Appendices

1. Introduction

This report documents the hydraulic study of waterways crossing the proposed West Surat 36 km spur link as part of the environmental assessment process.

Parsons Brinckerhoff was commissioned to complete hydrological and hydraulic modelling of four major crossings to determine key hydraulic design parameters and to assess hydraulic impacts resulting from the proposed bridges and rail embankment.

Simplified hydrological and hydraulic methods were used to complete an initial sizing of approximately 35 – 40 minor crossings.

1.1 Background

The Elimatta Mine is located in south western Queensland in the Surat Basin coal province, located North West of Xstrata's proposed Wandoan Coal project. New Hope Coal is proposing to develop the thermal coal mine for export via coal export facilities at the port of Gladstone. Parsons Brinckerhoff has previously undertaken a transport options study and developed concept alignments for the rail link as the basis for the initial planning and approvals.

As part of previous investigations, high level flood modelling of the existing scenario was completed for the major waterway crossings. An existing XP-RAFTS hydrological model, calibrated to the Juandah Creek stream-flow gauge located at Windamere was used to estimate design flows at the four major waterway crossings. An existing MIKE-11 hydraulic model of Juandah Creek and HEC-RAS hydraulic models of Horse Creek, Mud Creek and Spring Creek were used to estimate design flood levels under existing conditions.

1.2 Scope of assessment

The scope of this assessment was to:

- develop hydraulic models for identified crossings (major and minor) within the 36km spur link from Elimatta Mine to its crossing at Surat Basin Railway
- run hydraulic models for major crossings
- run four different scenarios for each major crossing which include a scenario for the current condition in order to investigate the impacts of flooding on upstream and downstream of the proposed crossings
- undertake analysis for a range of ARIs (10, 100 and 1000 year)
- size bridge openings and determine hydraulic impacts
- provide flood impact assessment report.

2. Description of proposed development

The Surat West Link project is described as a proposed open access railway commencing at a connection point on the proposed Surat Basin Railway, located north of the Wandoan Township and travelling west for approximately 36 km to the proposed Elimatta Coal Mine with potential for the line to also carry additional tonnages from adjacent projects.

The work undertaken to date shows that the proposed railway will consist of a single track with a passing loop positioned adjacent to the takeoff with the Surat Basin Rail (SBR) and provision within the design to accommodate an additional passing loop on the western side of Juandah Creek to allow for potential future increases in tonnage throughput. The railway has been designed to accommodate trains of up to approximately 2.4 km in length. The railway has been designed for a maximum speed of 80 km/h with maximum ruling grades of 1.25% loaded and 2% unloaded.

To construct the proposed railway the following activities will need to be undertaken:

- earthworks
- major and minor structures
- cross and longitudinal drainage including diversion drains
- road works
- private access crossings
- utilities and services crossings
- signalling and telecommunications
- fencing and revegetation.

All of the required works have a varying impact on the projects permanent land requirements and also maintenance access requirements. These requirements need to be considered when determining the permanent rail corridor.

In addition to the proposed railway, potentially a water pipeline and an overhead electricity transmission line may be required to run adjacent to the railway. The final location of these services needs to be determined with further engineering investigation including consultation with relevant service authorities.

It has been assumed that both the water and electricity services will generally follow the rail alignment where possible. It is recognised that the power line will more than likely divert away from the rail corridor at or before the Leichhardt Highway and head towards the Wandoan substation. At this stage the corridor has been defined with the power line following the full length of the rail alignment from the Elimatta Mine to Nathan Road. Any alternative transmission route will most likely impact a number of common property owners and include a separate transmission line corridor/easement. At this stage the transmission line has been incorporated into the rail and services corridor and further project development may result in a reduction of the corridor requirements and colocation with property owners. It has been assumed that these issues will be discussed by NEC as part of the community consultation.

3. Hydrology

The design flows in watercourses crossing the proposed rail link have been estimated using three hydrological assessment methods as follows:

- flood frequency analysis
- XP-RAFTS hydrological modelling
- rural probabilistic rational method.

Flood frequency analysis was used to determine peak design flows in Juandah Creek at the stream-flow gauge at Windamere, located approximately 1.6 km upstream of the proposed rail crossing. This analysis updates a previous flood frequency analysis by including the 2010 flood event which is the largest event recorded at Windamere.

A hydrological model was previously developed using XP-RAFTS to represent rainfall runoff processes in the Juandah Creek, Mud Creek, Spring Creek and Horse Creek catchments. Historical flood flow data from the stream-flow gauge on Juandah Creek at Windamere and rainfall data was used to calibrate the hydrological model.

The rural probabilistic rational method was used to estimate peak design flows from the minor crossing catchments.

3.1 Catchment descriptions

3.1.1 Juandah Creek

The Juandah Creek catchment extends approximately 45 km to the south of the proposal rail link crossing. The catchment mainly comprises rural farmland.. In its lower reaches, Juandah Creek is characterised by a well-defined and incised main channel flowing through a wide floodplain.

3.1.2 Mud Creek

The Mud Creek catchment extends approximately 25 km to the south-west of the proposed rail link crossing. The catchment mainly comprises rural farmland. In its lower reaches, Mud Creek is characterised by a small main channel with several smaller channels on its floodplain. The proposed rail link also crosses a tributary of Mud Creek (approximately 800m south east of the main Mud Creek crossing).

3.1.3 Spring Creek

The Spring Creek catchment extents approximately 11 km to the south of the proposed rail link crossing. The catchment mainly comprises rural farmland. In its lower reaches, Spring Creek is characterised by a well-defined main channel flowing through a wide floodplain with several smaller flood channels.

3.1.4 Horse Creek (southern alignment)

The Horse Creek catchment extends approximately 41 km south of the proposed southern rail link crossing. The catchment mainly comprises rural farmland. In its lower reaches, Horse Creek is characterised by a well-defined main channel flowing through a wide floodplain with several smaller flood channels.

3.1.5 Horse Creek (northern alignment)

The Horse Creek catchment extends approximately 43.5 kilometres south of the proposed northern rail link crossing. The catchment mainly comprises rural farmland. In its lower reaches, Horse Creek is characterised by a well-defined main channel flowing through a wide floodplain with several smaller flood channels.

3.1.6 Minor catchments

There are numerous minor catchments crossing the proposal rail link. These minor catchments typically comprise rural farming land. Peak flows from the minor catchments have been estimated using the probabilistic rational method and are discussed in Section 4.5.

3.2 Available data

3.2.1 Rainfall data

Rainfall data from several pluviographs (6 minute time interval) and daily rainfall stations are available within or close to the catchments. These rainfall data have been used in the calibration of the rainfall runoff model as discussed in Section 4.4.2.

3.2.2 Stream flow data

Stream flow data are available within the catchment for Juandah Creek at Windamere (130344A), located approximately 1.5 km upstream of the proposal rail link crossing, from 1974. These stream flow data have been used for flood frequency analysis (Section 4.3) and calibration of the rainfall runoff model (Section 4.4.2)

3.3 Flood frequency analysis

Peak design flows for Juandah Creek at the Windamere stream flow gauge were estimated using flood frequency analysis. As recommended in Australian Rainfall and Runoff (Pilgrim, 1987) (ARR87), a Log-Pearson Type III distribution was fitted to the peak annual flows at the site. The maximum recorded flow is 1,057 m^3/s recorded in December 2010. Two low outliers (1986 and 1992) were removed from the annual series to produce a better fit to the data. The results of the flood frequency analysis are shown in Figure 3.1 and Table 3.3.

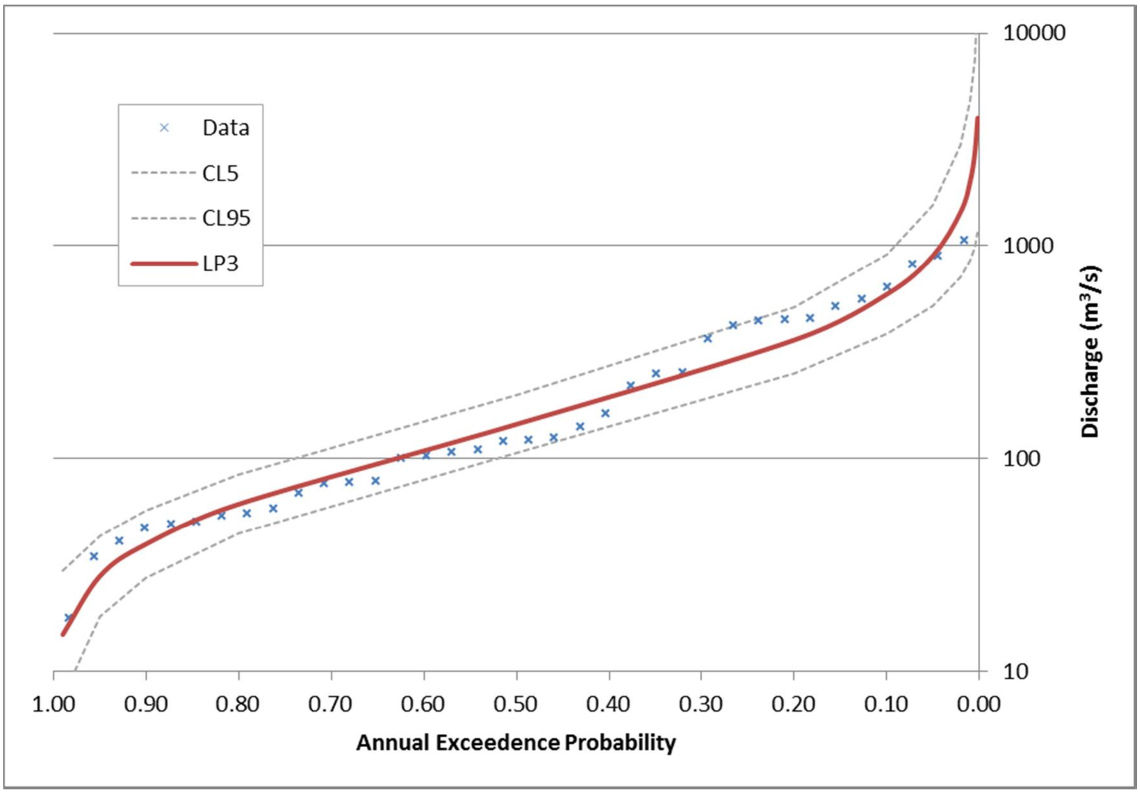

Figure 3.1 Flood frequency curve for Juandah Creek at Windamere (130344A)

3.4 Rainfall runoff modelling

Hydrological models simulate rainfall-runoff processes within catchments. They are used to estimate catchment flows generated from either design storm events or historical rainfall records.

Hydrological models represent catchments and their tributaries as a series of sub-catchment areas which are linked together to replicate the stream network. The model input data include parameters to represent factors such as rainfall patterns (temporal and spatial), catchment size, catchment slope, drainage features, channel and floodplain storage, and variations in catchment land use.

Hydrological modelling software suitable for design flood estimation is described in ARR87. In current Australian engineering practice, examples of commonly used models include XP-RAFTS, RORB, WBNM and URBS.

The XP-RAFTS hydrologic model was chosen to estimate design hydrographs for this assessment as it is capable of representing a range of physical characteristics that influence runoff behaviour such as rainfall patterns, catchment shape, catchment slope, drainage features, channel and floodplain storage, and variations in catchment land use. The XP-RAFTS model converts rainfall to runoff by applying rainfall losses to both the impervious and pervious catchments within the model to produce excess rainfall hyetographs.

The XP-RAFTS model was calibrated by comparing modelled flows for historic events against historic data from the Juandah Creek stream flow gauge.

The soil loss model used in XP-RAFTS was the Australian Representative Basins Model (ARBM). This method was preferred over an initial loss/continuing loss model because it allows the recovery of rainfall losses between rainfall bursts, which is a significant feature of some of the observed rainfall events.

The XP-RAFTS model has been developed to assess catchment flows for the 10, 100 and 1,000 year ARI design events.

The layout and full details of adopted model parameters for the XP-RAFTS model is included in Appendix B.

3.4.1 Model parameters

3.4.1.1 Design rainfall

Intensity Frequency Duration (IFD) parameters from ARR87 Volume 2 adopted for this project are shown below in Table 3.1.

Table 3.1 IFD Parameters

Parameter	Symbol	Value (mm/hr)
2 year ARI, 1 hour rainfall intensity	${}^{2}I_{1h}$	40.6
2 year ARI, 12 hour rainfall intensity 2I12h	${}^{2}I1_{2h}$	5.98
2 year ARI, 72 hour rainfall intensity 2I72h	${}^{2}I_{72h}$	1.5
50 year ARI, 1 hour rainfall intensity 50I1h	${}^{50}I_{1h}$	71.6
50 year ARI, 12 hour rainfall intensity	${}^{50}I_{12h}$	10.9
50 year ARI, 72 hour rainfall intensity	${}^{50}I_{72h}$	3.03
Skewness	G	0.24
Geographical factor (2 year ARI)	F2	4.27
Geographical factor (50 year ARI)	F50	16.7

The CRC FORGE method (Hargraves, 2005) was used to derive rainfall depths for the 1,000 year ARI event.

In accordance with ARR87, temporal patterns for Zone 3 were applied.

Conservative, areal reduction factors were not applied to the design rainfall depths, however a good match was obtained during model calibration (refer Section 4.4.2)

3.4.1.2 Rainfall losses

In the south-west and north-east of the Juandah/Woleebee Creek catchment, there are several areas where the Orallo (or Gubberamunda), Kumbarilla and Hutton sandstone geological units outcrop. These sandstone units form part of the Great Artesian Basin (GAB), and the outcrop areas make up part of the intake/outflow areas for these aquifers, which might be expected to be areas of high infiltration.

The XP-RAFTS model includes two sets of soil loss models:

1. ARBM_GAB_Intake_Bed

2. ARBM_Non_GAB_Intake_Bed.

Parameters for each soil loss model are included in Appendix B. There are no available data to verify the parameters assumed in the soil loss models other than the accepted ranges of values provided in the XP-RAFTS user manual (which refers to research by Goyen, as referenced in the user manual). Though it is expected that the GAB intake beds will capture more rainfall than the non-GAB intake beds, it is acknowledged that the parameters used are somewhat arbitrary and that they have been adjusted to provide a best fit with the stream flow gauge on Juandah Creek at Windamere.

3.4.1.3 Sub-catchment areas, impervious and roughness

Catchment areas have been identified using a digital terrain model (DTM) using survey data from several sources. The XP-RAFTS model, covering a total of approximately 3,600 km², extends downstream to the confluence of Horse Creek and Juandah Creek.

A uniform fraction impervious of 0% and Manning's 'n' roughness value of 0.07 were adopted.

3.4.1.4 Catchment lag and channel routing

The storage delay coefficient for each of the sub-catchments in XP-RAFTS is calculated using the Equal Area Method which determines the average vectored slope of the catchment together with catchment area, percentage impervious, Manning's 'n' value, loss rates and rainfall data.

Routing of hydrographs through each channel link was completed using estimated channel cross section dimensions, reach lengths and slopes and the Manning equation open channel flow.

3.4.2 Calibration

Six historic events were identified for the calibration of the XP-RAFTS model using recorded rainfall and stream flow data.

Given the size of the catchment, significant spatial distribution of rainfall occurs during storm events. This has been accounted for by the construction of isohyet maps for each storm event then the application of location specific local storms to each model sub-catchment area.

The XP-RAFTS model was calibrated by adjusting the ARBM loss model to obtain the best fit possible for all storm events. A comparison of the peak flows in given in Table 3.2. Recorded rainfall hyetographs, recorded hydrographs and modelled hydrographs are given in Appendix B.

Table 3.2 XP-RAFTS model calibration events peak flow comparison

Date	Windamere gauge (m^3/s)	XP-RAFTS (m^3/s)
October 1989	366	206
April 1990	441	51
February 1991	828	829
March 1997	264	0

Date	Windamere gauge (m^3/s)	XP-RAFTS (m^3/s)
August 1998	815	914
December 2004	104	40

The results in Table 3.2 and Appendix B show that the XP-RAFTS model provides a reasonable estimate for large flood events however there is appreciable uncertainty for smaller events.

3.4.3 Validation

The results of the flood frequency analysis (Section 3.3) were used to validate the results of the XP-RAFTS model. Table 3.3 shows that there is good agreement between the two methods.

Table 3.3 Comparison of flood frequency analysis and XP-RAFTS modelled peak flows (m^3/s)

ARI (years)	Flood frequency analysis	XP-RAFTS
10	592	637
100	2024	2114

3.5 Probabilistic rational method

The rural probabilistic rational method (PRM) has been utilised for estimation of design flows for minor crossings of the proposed rail link. The rural probabilistic rational method adopts design rainfall data applicable to the area and parameters which describe the catchment (including catchment area, time of concentration for the catchment, and a runoff coefficient describing catchment loss characteristics) to determine peak flows resulting from design rainfall events. The rural PRM procedure as outlined in the Road Drainage Manual (Department of Main Roads 2010) as deemed suitable by ARR87 has been adopted.

The rural PRM for Queensland is applicable for catchments up to 25 km^2 in area. As outlined in the Road Drainage Manual, the rational method formula is:

$$Q_Y = \frac{1}{360} C_Y . I_{t_c,Y} A$$

Where:

- Q_Y = peak flow rate (m^3/s) of average recurrence interval (ARI) of Y years
- C_Y = runoff coefficient (dimensionless) for ARI of Y years
- A = catchment area (ha)
- $I_{tc,Y}$ = average rainfall intensity (mm/h) for design duration of t_c hours ($t_c = \frac{F \times L}{A^{0.1} \times S_e^{0.2}}$ Brasnsby-Williams formula) and ARI of Y years.

The Bransby-Williams formula for time of concentration, t_c (as detailed above) was adopted for ease of use. The mean catchment slope was adopted in place of the equal area slope.

3.6 Adopted design flows

The peak design flows shown in Table 3.4 have been adopted as inputs to the hydraulic models.

Table 3.4 Peak design flows (m^3/s)

Crossing	XP-RAFTS model node	10 year ARI	100 year ARI	1000 year ARI
Juandah Creek	Gauge	608	2114	3345
Mud Creek	C1	127	318	503
Mud Creek Tributary	C1b	8.5	21	34
Spring Creek	A15C	38	90	144
Horse Creek	A06	199	875	1433