APPENDIX 8

Surface Water Management

Readymix Holdings Pty Limited

Surface Water Assessment
Proposed Lynwood Quarry, Marulan

May 2005

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FIGURES

APPENDICES

1.0 INTRODUCTION

1.1 LOCATION OF THE PROJECT AREA

Readymix Holdings Pty Limited (Readymix) proposes to establish a hard rock quarry on its land to the west of Marulan in the Southern Tablelands region of NSW (refer to **Figure 1.1**). The proposed quarry will be located approximately 160 kilometres southwest of Sydney and approximately 27 kilometres northeast of Goulburn.

The project area is situated to the west of Marulan township in the Greater Argyle Local Government Area (refer to **Figure 1.2**). It is bounded on its southern side by the Hume Highway and bisected in an east-west direction by the Main Southern Railway. It incorporates the headwaters of Joarimin and Lockyersleigh Creeks and, on its southern side running approximately parallel to the Hume Highway, Marulan Creek.

An aerial photograph of the site showing the project area is included as **Figure 1.2**. A Conceptual Quarry Plan and associated major infrastructure are shown on **Figure 1.3**.

The Lynwood property is currently used for cattle grazing except for an area on the eastern boundary which is leased to Orica Explosives and is occupied by an explosives depot. A substantial portion of the northern area of the site is occupied by woodland, with the majority of the remaining area being cleared grazing land with scattered patches of woodland. The site is surrounded primarily by grazing land with a developing rural residential area located adjacent to project buffer land on the northeastern boundary and residential areas associated with the township of Marulan further to the east. Marulan's waste management facility is adjacent to the eastern boundary of the project area.

1.2 NATURE OF THE DEVELOPMENT

The project area contains a substantial, high quality hard rock resource with ready access to key transport infrastructure (Main Southern Railway and Hume Highway). Readymix has a sound knowledge of the hard rock resource, due to both an extensive exploration drilling program and experience from operation of the existing Johniefelds Quarry, located on Brayton Road approximately 2 kilometres north of the project area.

It is proposed that Lynwood Quarry will produce up to 5 million tonnes per annum (Mtpa) with the quarry resource having an expected life of in excess of 90 years. Initial approval will be sought for a 30 year quarry period.

The conceptual design for Lynwood Quarry has evolved throughout the environmental impact assessment (EIA) process, taking into account ongoing exploration and geological modelling work, environmental constraints and opportunities and stakeholder consultation outcomes. A description of the conceptual features that comprise the project is included in the following sections.

1.2.1 Construction Phase

As Lynwood Quarry is a greenfields project, substantial construction works will be required prior to the quarry becoming operational. The construction phase is expected to last approximately two years and will include the following key activities:

- construction of initial site access road and set-up of construction compounds including supply of services (e.g. electricity, water, etc);
- set-up of mobile concrete and crushing plants;

Home Previous Next TOC

FIGURE 1.1

Locality Plan

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Base Source: LPI 2004, Readymix Holdings Pty Ltd (Aerial Photo March 2005)

0 0.5 1 1.25km

Legend

Project Area

FIGURE 1.2

Aerial View of Project Area

File Name (A4): R04_V1/1829_109.dgn

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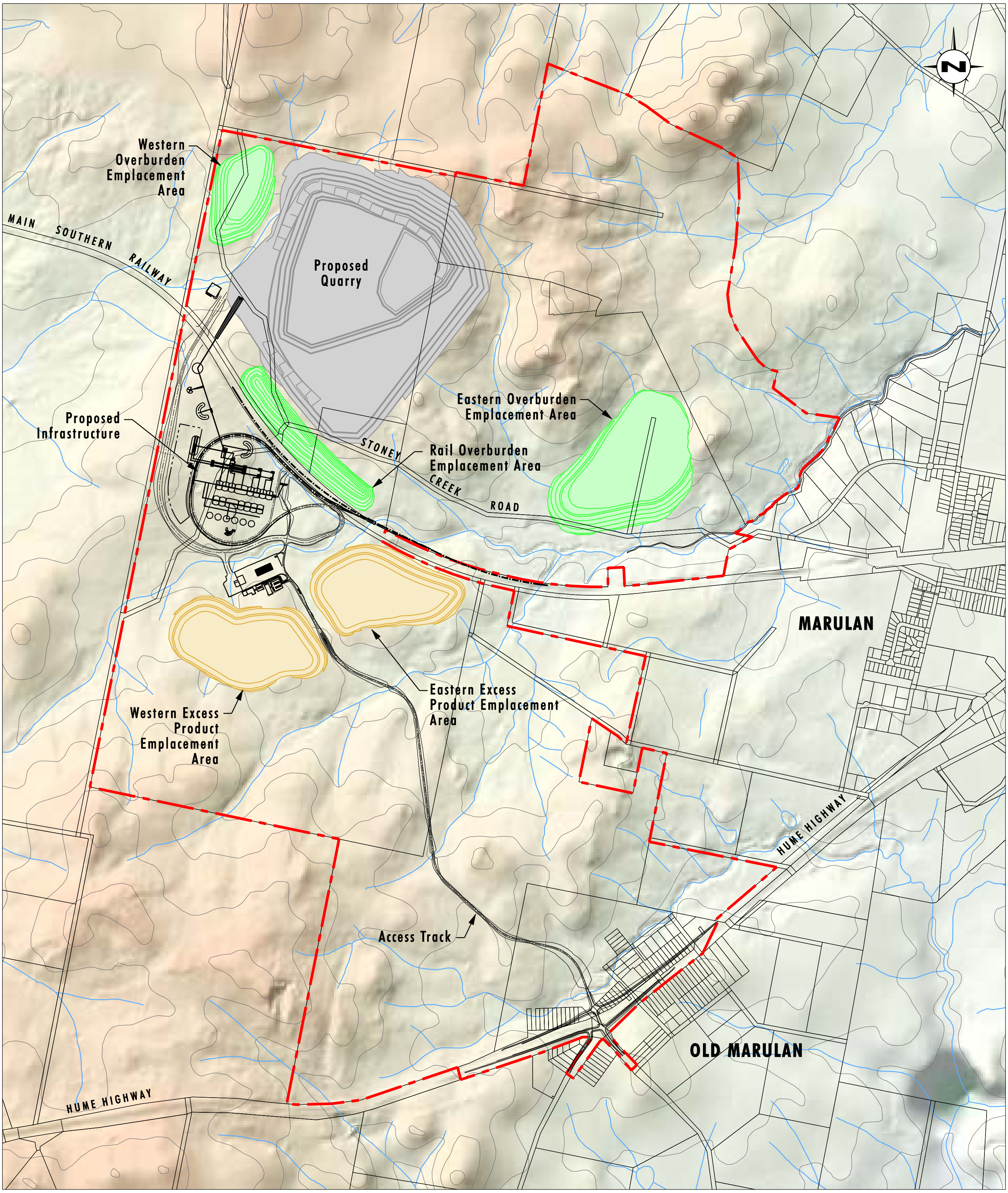


Source: Readymix Holdings Pty Ltd
Base Source: LPI 2004

0 0.5 1 1.25km

Legend

Project Area

FIGURE 1.3

Conceptual Quarry Plan and Associated Infrastructure

File Name (A4): R04_V1/1829_110.dgn

- construction of the Hume Highway interchange and permanent site access road;
- construction of the rail overpass;
- extraction of material from the primary crusher area. The excavation of this material is likely to require blasting with the excavated material processed through the mobile crushing plant to produce road base / fill to be used in the construction project;
- excavations for the rail loop and reclaim tunnel. Again the excavation process may require blasting and removal of overburden and moderately weathered material. This material will also be utilised in the construction project;
- construction of the crushing plant, rail facility, truck loading facility and other infrastructure;
- construction of rail lines and connection to the Main Southern Railway;
- construction of the remaining facilities including workshops, site offices, amenities, laboratory, weighbridge, stores, parking areas, site roads, safety bunds etc.;
- construction of water management structures and installation of pumps, pipelines etc; and
- installation of security fencing and gates to ensure public safety and security for the quarry operations.

The conceptual locations of the construction compounds and mobile crushing and concrete plants are shown on **Figure 1.4**.

1.2.2 Operational Phase

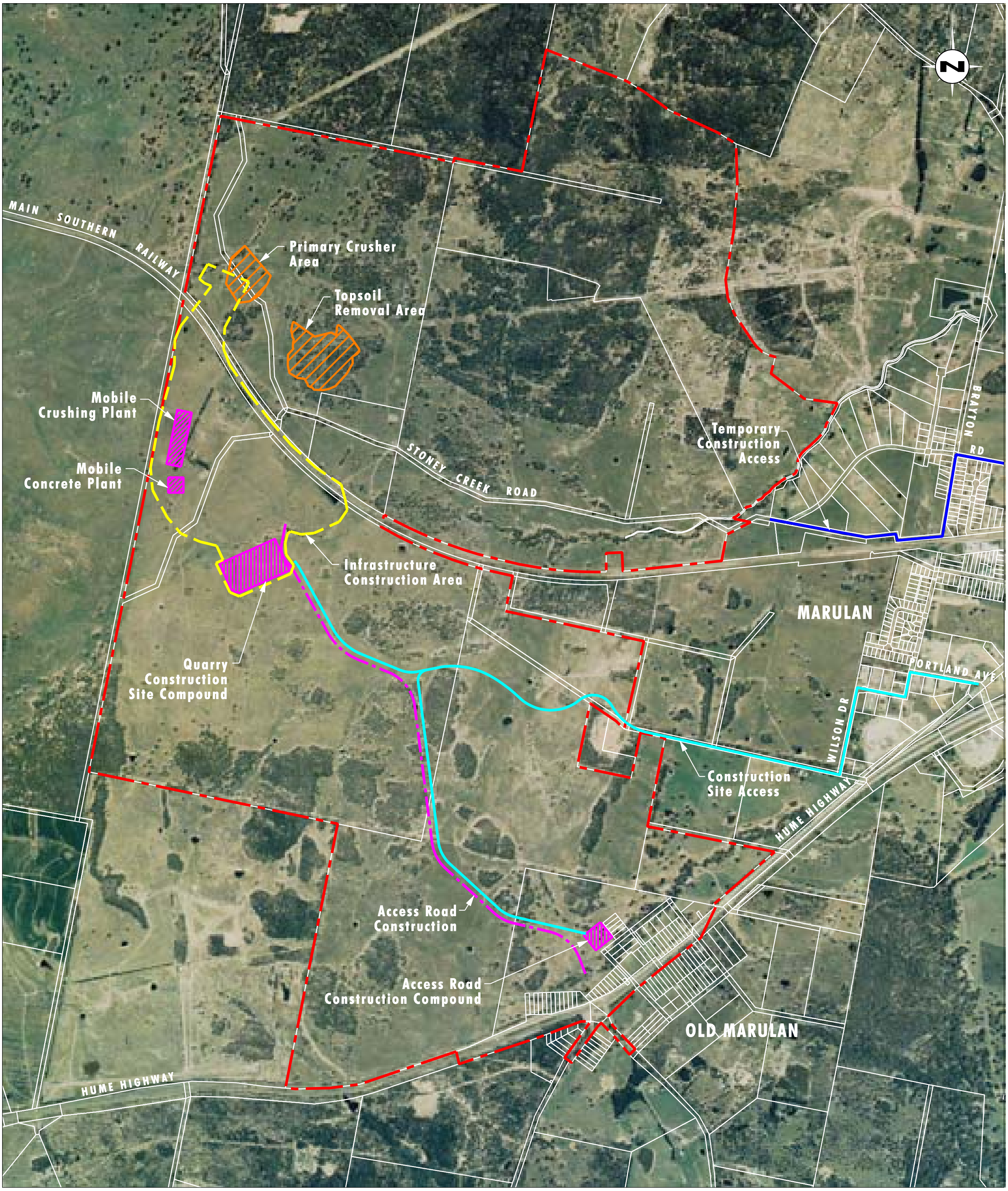
Over the initial 30 year operation period, Lynwood Quarry will produce approximately 145 Mt of quarry product. Some of the material extracted as part of the quarrying process will not be suitable for sale and consequently emplacement areas will be required. This material consists of both overburden material which will be excavated and taken directly to emplacement areas without passing through the crushing and screening plant and also material generated at various phases of the crushing and screening process. Due to the depth of the resource and the number of years which will be required in order to reach a terminal face, in-pit dumping will not be possible during the initial 30 year quarry period without sterilising future resources, and therefore all emplacement areas are planned to be out-of-pit.

The footprint of the conceptual quarry plan and associated infrastructure for the Year 2, 10 and 30 quarry plans are shown on **Figures 1.5**, **1.6** and **1.7**.

The initial quarry will commence in the southern portion of the proposed quarry area. In Year 2 (refer to **Figure 1.5**), the quarry pit will continue to expand and deepen, and will extend to the west. By Year 10 (refer to **Figure 1.6**) the quarry pit will have extended further to the north occupying an area approximately two-thirds of the 30 year quarry footprint. The quarry footprint continues to expand between Years 10 and 15, with the 15 year footprint almost totally occupying the 30 year footprint (refer to **Figure 1.7**). After this time, the majority of quarry development is through increased depth with only minimal footprint increases between Year 15 and Year 30. As a result, the majority of works required to construct the emplacement areas will be completed by Year 15.

The quarrying process will involve the following broad steps:

- clearing and topsoil stripping – likely equipment will typically include a dozer, excavator, loaders and dump trucks;



Base Source: LPI 2004, Readymix Holdings Pty Ltd (Aerial Photo March 2005)

0 0.5 1 1.25km

Legend

- Project Area
- Access Road Construction
- Construction Site Access
- Temporary Construction Access
- Infrastructure Construction Area
- Construction Compounds and Plant Locations

FIGURE 1.4

Proposed Construction Phase

File Name (A4): R04_V1/1829_160.dgn

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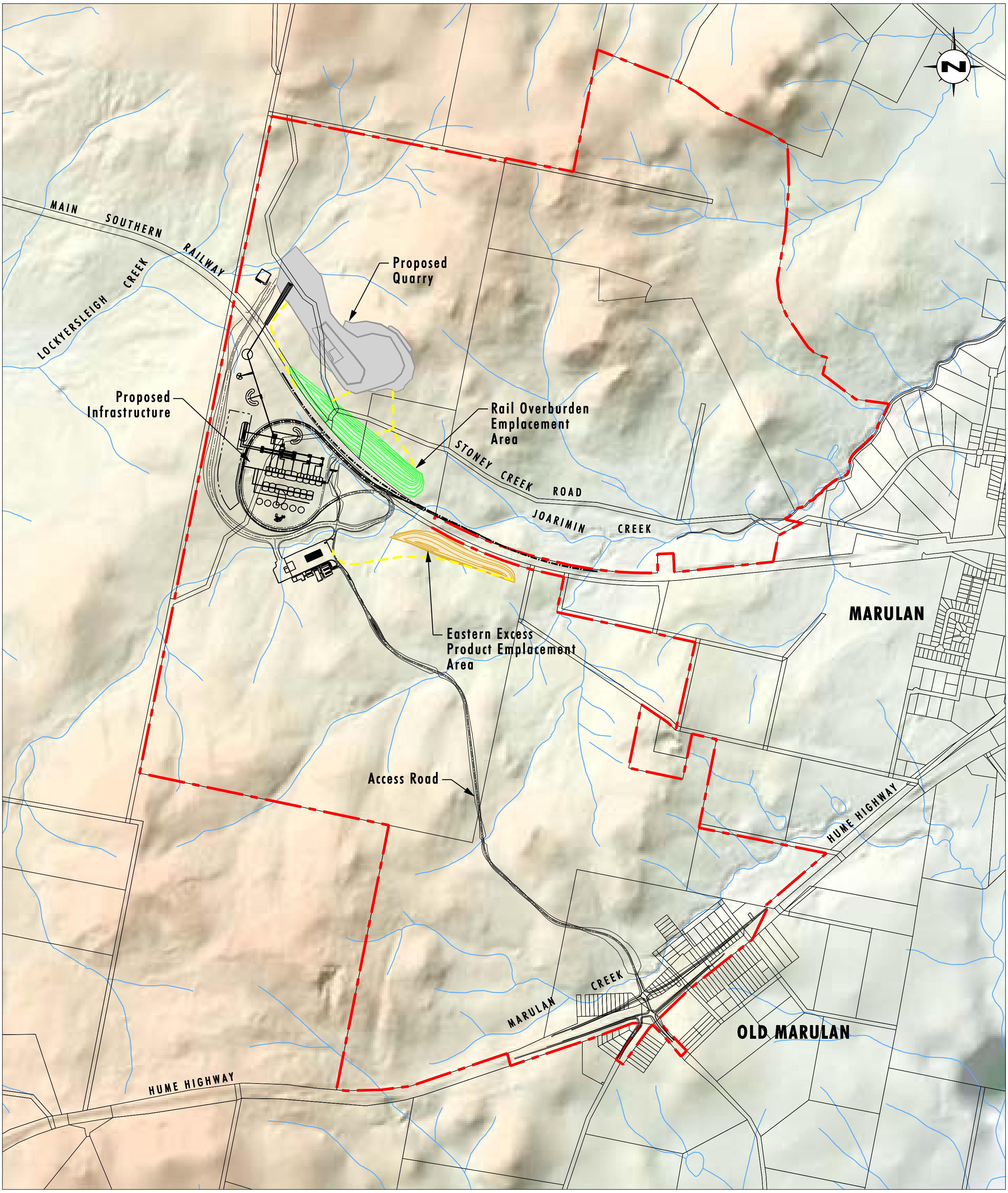

Source: Readymix Holdings Pty Ltd
Base Source: LPI 2004

Legend

- Project Area
- Haul Road

FIGURE 1.5

Year 2 Quarry Plan

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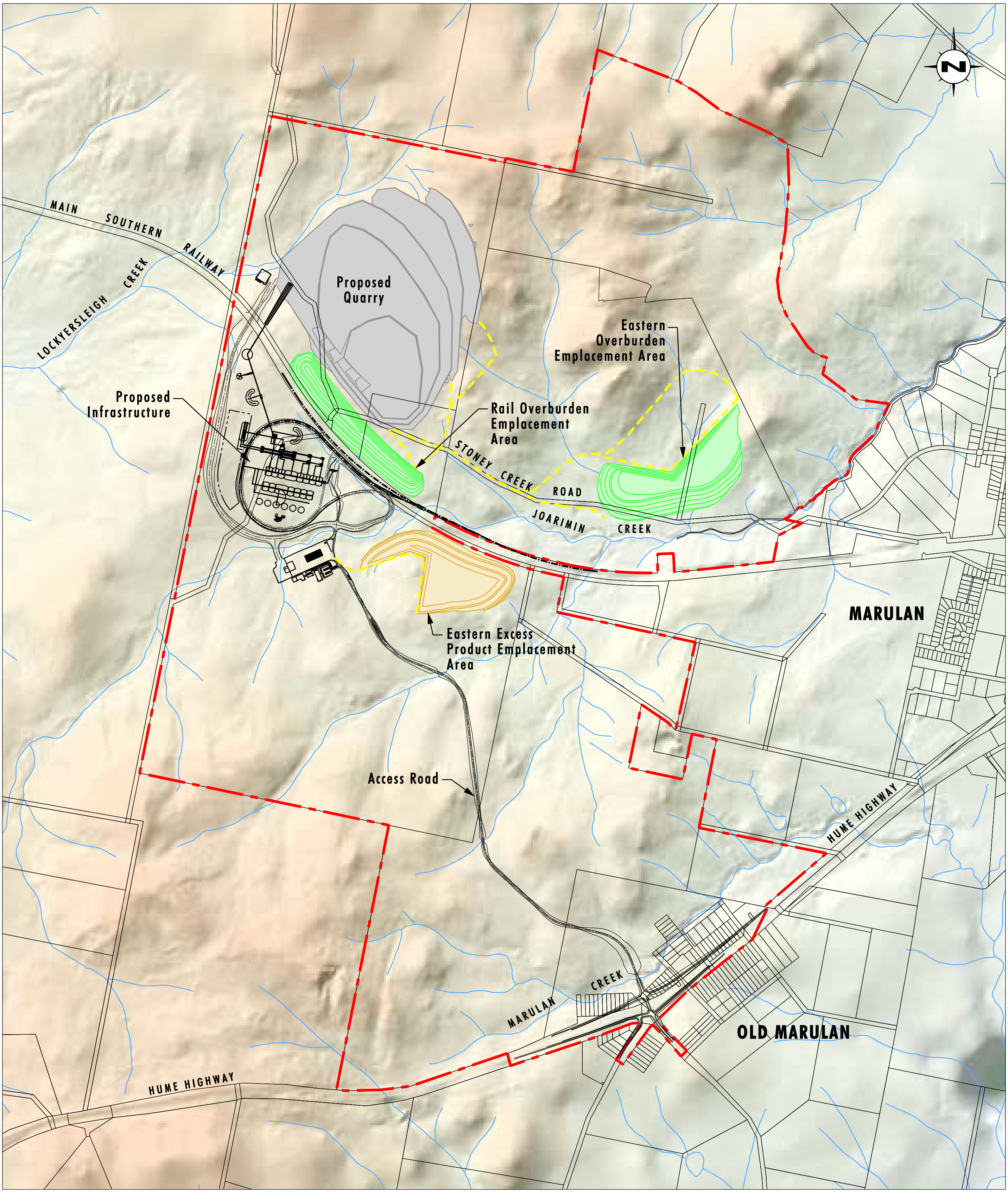

Source: Readymix Holdings Pty Ltd
Base Source: LPI 2004

0 0.5 1 1.25km

Legend
Project Area
Haul Road

FIGURE 1.6

Year 10 Quarry Plan

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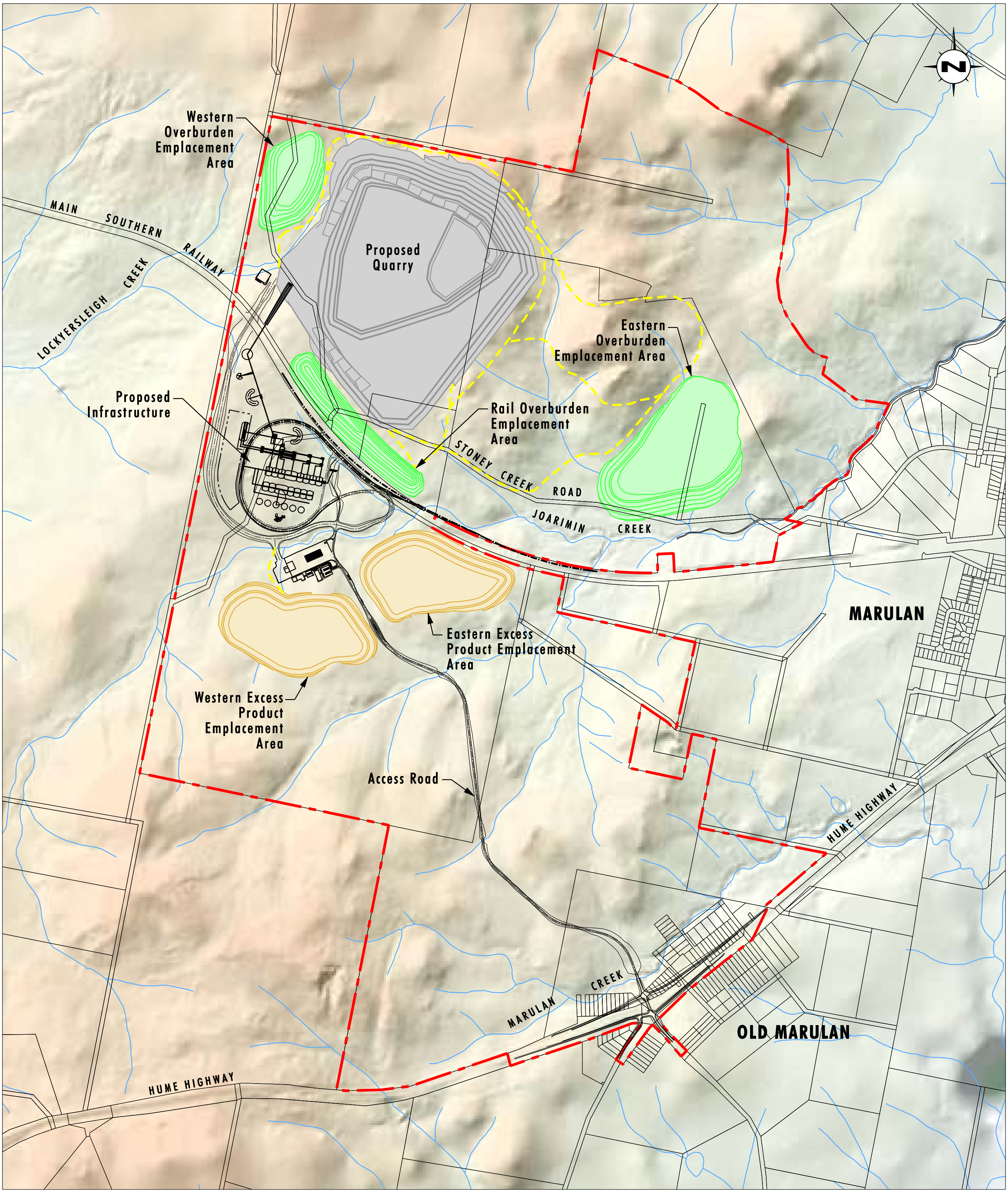


Source: Readymix Holdings Pty Ltd
Base Source: LPI 2004

0 0.5 1 1.25km

Legend
Project Area
Haul Road

FIGURE 1.7

Year 30 Quarry Plan

- drill and blast – this will include a percussion drill, drilling holes to a bench height of approximately 15 metres; and

- the resultant material from the blast will be loaded by front-end loaders into dump trucks and transported to the crushing and screening plant. Any pieces of rock that are too large to be transported or loaded into the primary crusher will be broken into smaller pieces by a hydraulic rock breaker.

Three overburden emplacement areas have been designed to accommodate the overburden material removed during the initial 30 year quarrying period. These three dumps are shown on the staged conceptual quarry plans included as **Figures 1.5** to **1.7** and are known as Rail Overburden Emplacement Area, Eastern Overburden Emplacement Area and Western Overburden Emplacement Area. The Rail Overburden Emplacement Area will be the first developed and will have a capacity of approximately 1.3 million metres cubed (Mm^3) and will occupy an area of approximately 12 hectares. This emplacement area will be used for the first approximately three years of the operation, following which emplacement will commence in the Eastern Overburden Emplacement Area. This emplacement area has a capacity of approximately 3.2 Mm^3, a footprint of approximately 31 hectares and will reach its capacity in approximately Year 12. Following this time, all overburden will be emplaced in the Western Overburden Emplacement Area which will have a capacity of approximately 1.1 Mm^3 and a footprint of approximately 11 hectares.

The overburden emplacement areas will require vegetation clearance and topsoil stripping prior to development.

By approximately Year 12 of the proposed operations the quarry pit will have progressed to nearly its maximum footprint and all overburden dumps will be either rehabilitated or operating. As such, the water management system will need to be constructed early in the quarry life so that the controls are well established prior to becoming operational.

1.2.3 Proposed Infrastructure

The proposed infrastructure includes:

- a crushing and screening plant;

- a rail loading facility and rail transportation infrastructure;

- a truck loading facility and roads;

- areas for storage of product, including the excess product stockpiles;

- workshop facilities;

- administration and washroom facilities; and

- electrical and power reticulation facilities.

Figures 1.3 to **1.7** indicate the conceptual location for these facilities.

1.3 POTENTIAL SURFACE WATER IMPACTS

The key features of the project that have the potential to impact on the water management requirements for Lynwood Quarry are summarised below and discussed in further detail in **Section 4.0**.

Apart from the general landform changes associated with quarrying and ancillary activities, there will be specific creek and drainage line impacts. These include loss of some sections of the lower order tributaries of Lockyersleigh Creek and Joarimin Creek, damming of some of these tributaries, overburden emplacement areas, excess product emplacement areas and quarry infrastructure. Further impacts on the upper catchment of Lockyersleigh Creek and Joarimin Creek will result from the construction of haul roads and other internal mine roads.

Flows in Marulan Creek and some of the upper tributaries of Joarimin Creek will also be impacted by the construction of the access road from the Hume Highway. Marulan Creek will largely be unaffected, although the access road will require a creek crossing which will directly impact on approximately 100 metres of the creek (refer to **Figures 1.5** to **1.7**).

1.4 WATER PLANNING CONTEXT

The proposal has been assessed against the following water planning polices/plans:

- State Water Management Outcomes Plan;
- Warragamba Catchment Blueprint;
- Southern Catchment Blueprint;
- Statement of Joint Intent for the Hawkesbury Nepean River System;
- Statement of Joint Intent for the Shoalhaven River System;
- SEPP 58 – Protecting Sydney's Water Supply; and
- Draft REP – Sustaining the Catchments.

The details of this assessment are included in Appendix 8B of the EIS.

2.0 EXISTING ENVIRONMENT

2.1 RAINFALL AND EVAPORATION

Daily rainfall data is available from three Bureau of Meteorology Stations in the Marulan area. These stations are "Arthursleigh" (Station 70001), George Street, Marulan (Station 70063) and "Johniefelds" (Station 70269). Of these three stations George Street, Marulan (Station 70063) has the longest period of record for rainfall with daily rainfall recorded from 1895 to 2000. However, this record is intermittent. None of the Bureau of Meteorology Stations at Marulan record evaporation.

There are eighteen Bureau of Meteorology Stations in the Goulburn area, of which one station records evaporation. This station is Progress Street, Goulburn (Station 70263) and has a rainfall and evaporation record of 27 years. For rainfall/runoff and water balance modelling purposes it is considered important to use a daily rainfall record of approximately 100 years if possible. The longest period of daily rainfall records in the area has been recorded at Kippilaw, Goulburn (Station 70055) with daily rainfall recorded since 1886. No evaporation has been recorded at this site, however, evaporation data from Progress Street, Goulburn is considered to adequately represent the evaporation rates experienced at Kippilaw, as evaporation is regionally driven and the sites are only 15 kilometres apart.

An analysis of rainfall data for Kippilaw, Goulburn (Station 70055) and George Street, Marulan (Station 70063) for the periods from 1895 to 1918 and 1942 to 1973 where both stations have records, shows that the 10th percentile annual rainfall is 5% higher at Marulan. The analysis also shows that the average annual rainfall at Marulan is approximately 80 mm more than Goulburn. On average Marulan has approximately 130 mm higher 90th percentile annual rainfall than Goulburn as shown in **Table 2.1**.

Table 2.1 - Comparison of Annual Rainfall Data

Statistic	George Street, Marulan (Station 70063) (1895 – 1918, 1942 – 1973)	Kippilaw, Goulburn (Station 70055) (1895 – 1918, 1942 – 1973)	Difference
10th Percentile Rainfall	430	409	5%
Average Rainfall	697	619	13%
90th Percentile Rainfall	1004	876	15%

Source: Bureau of Meteorology

As a result, use of Goulburn rainfall data from Kippilaw (Station 70055) will tend to underestimate the actual rainfall received at Marulan by approximately 5%, 13% and 15% in dry, average and wet years respectively.

In order to model the water balance for the project, evaporation data that represents that experienced on site is required for the rainfall period used. The annual evaporation for Progress Street, Goulburn (Station 70263) ranges from 938 mm per year to 1983 mm per year for the period of record (1979 to 2003). Analysis of the historical record shows an expected trend of evaporation increasing during the summer months and decreasing during the winter months. Average monthly evaporation data is shown in **Table 2.2**.

Table 2.2 - Average Monthly Evaporation

Month	Average Evaporation (mm)
January	192
February	143
March	105
April	75
May	53
June	42
July	43
August	53
September	72
October	99
November	138
December	189
Total	**1204**

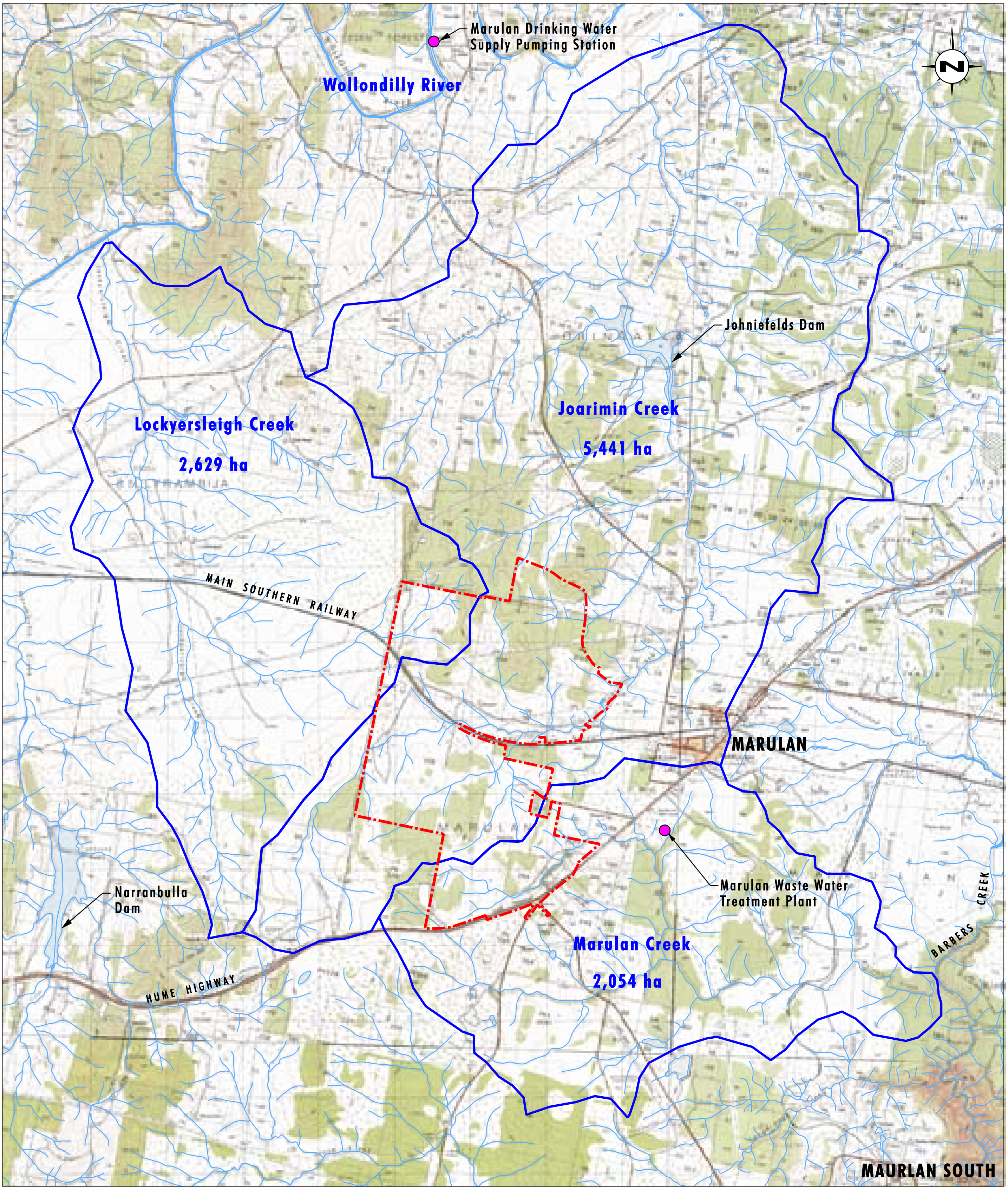
Evaporation rates at Progress Street, Goulburn (Station 70263) are considered to represent a conservative estimate of evaporation rates at Marulan based on analysis of annual rainfall (refer to **Table 2.2**). As no daily evaporation data is available to match the long term rainfall record at Kippilaw, Goulburn (Station 70055) monthly average evaporation data from Progress Street, Goulburn (Station 70263) has been used for water balance modelling at the site. This data is considered suitable to be used to assess evaporation from the project area and dust suppression requirements for the project.

2.2 CATCHMENT AREAS AND WATERCOURSES

The project area is located within the catchments of Joarimin, Lockyersleigh and Marulan Creeks (refer to **Figure 2.1**). Joarimin Creek has a catchment area of approximately 5440 hectares and drains in a northeasterly direction to the Wollondilly River. Lockyersleigh Creek has a catchment area of approximately 2630 hectares and drains in a northwesterly direction to the Wollondilly River, entering the river upstream of the Joarimin Creek confluence. The Wollondilly River has a catchment area of approximately 10,030 km^2 and is part of the Warragamba Dam catchment which contributes to Sydney's drinking water supplies. Marulan Creek has a catchment area of approximately 2055 hectares and drains in a southeasterly direction to the Shoalhaven River via Barbers Creek. The Shoalhaven River is part of the Tallowa Dam catchment area which is approximately 217 km^2 and contributes to Sydney's drinking water supplies. As such, all runoff from the project area flows into rivers that are managed by Sydney Catchment Authority.

The topography of the project area consists of undulating hills to the north and south, with the Joarimin Creek valley running through the middle of the site from the southwest to the northeast (refer to **Figure 2.1**). The southern portion of the property slopes towards Marulan Creek to the south and the Hume Highway to the southeast. The topography of the site ranges in elevation from approximately 710 mAHD in the central north to around 630 mAHD near Joarimin Creek in the northeastern corner of the site.

The boundaries of the subcatchments are shown on **Figure 2.1** and the subcatchment areas are listed in **Table 2.3**.



Source: 1:25 000 Topographic Maps LPI NSW 2000

Legend
Project Area
Catchment Boundary

FIGURE 2.1

Subcatchment Areas

Table 2.3 - Project Area Subcatchments

Creek	Catchment Area	
	Total Area (ha)	Within Project Area (ha)
Joarimin Creek	5440	749
Lockyersleigh Creek	2630	102
Marulan Creek	2055	160

2.2.1 Joarimin Creek Catchment

Joarimin Creek has a catchment area of approximately 5440 hectares, is a fifth order stream and drains in a northeasterly direction to the Wollondilly River. Land use within the catchment is predominantly grazing and residential with some forested areas. A large proportion of the town of Marulan lies within the catchment area. Johniefelds Quarry, operated by Readymix, is also located in the Joarimin Creek catchment to the north of the project area.

Joarimin Creek extends from the Hume Highway approximately 12 kilometres north to its confluence with the Wollondilly River. The confluence is located approximately 6.2 kilometres downstream of Marulan Pumping Station. There is one major dam (Johniefelds Dam) located along the creek approximately 6.4 kilometres downstream of the project area. Johniefelds Dam is estimated to have a capacity of 550 ML and supplies water to the landholder for irrigation, domestic, stock, and industrial use (refer to **Section 2.4**). In addition there are several harvestable rights dams located within the catchment area, including thirteen within the project area. Harvestable rights dams downstream of the project area are not located along the main reach of the creek.

The catchment area has slopes varying from 2 to 3% in the northeast of the catchment and up to 25% in the upper slopes in the west of the catchment.

Joarimin Creek is an ephemeral creek system with flows only occurring in the creek during storm events or after prolonged periods of heavy rain. Generally the creek system is predominantly dry, however, some pools of permanent or semi-permanent water are present in the downstream reaches. There is little or no riparian vegetation along the upper reaches of the creek, i.e. upstream of the Main Southern Railway, with well established riparian vegetation, dominated by Gum-Box-Apple Woodland, downstream of the Main Southern Railway. There is also evidence of erosion of the creek banks in the upper reaches where little or no riparian vegetation is present.

Four soil landscape units have been identified in the project area by soil landscape mapping undertaken by the Department of Infrastructure, Planning and Natural Resources (DIPNR) (2004). The soil landscapes include Bindook Road, Bindook Road variant A, Jaqua and Marulan. Jaqua soils occur around the main creek bed with Bindook Road soils generally to the south of the Main Southern Railway and Binbook Road Variant A soils generally to the north of the Main Southern Railway. The soil landscape mapping undertaken by DIPNR indicates that all four soil landscapes have limitations in regard to gully erosion hazard and sheet erosion hazard. Recent laboratory testing indicates, however, that the soils are not dispersive (Asset Geotechnical, 2005). Soil sampling has also indicated that the soils in the project area have the potential to contain a significant proportion of clay fines in the mid to lower horizons.

Approximately 380 hectares (7%) of the catchment area of Joarimin Creek lies upslope of the project area. Approximately 750 hectares (14%) of Joarimin Creek catchment lies within the project area. This area is predominantly grazing pastures with some isolated pockets of woodland. The progressive stream order of Joarimin Creek and its tributaries within the project area are shown on **Figure 2.2**.

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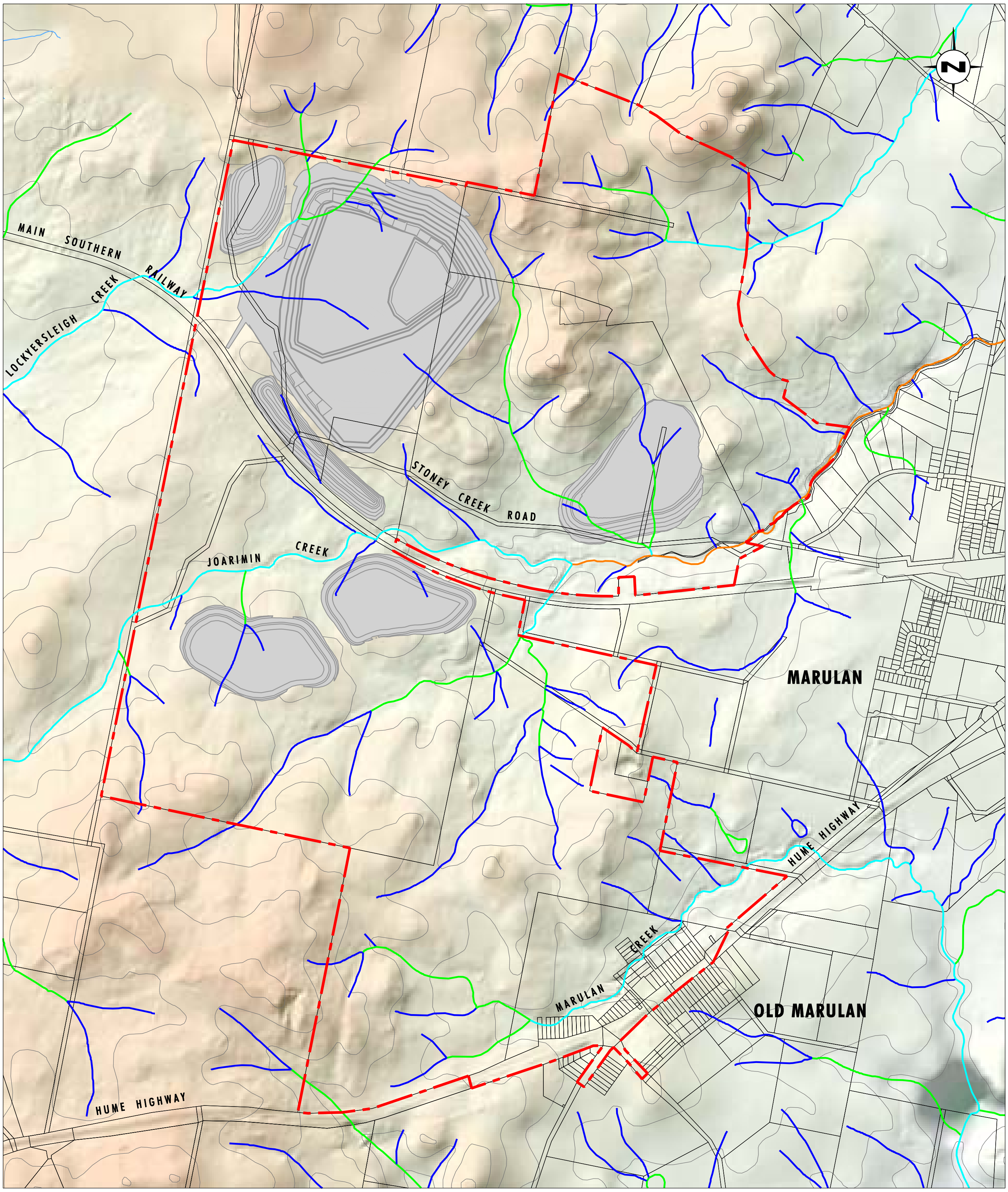

Base Source: LPI 2004, Readymix Holdings Pty Ltd

Legend
- Project Area
- First Order Stream
- Second Order Stream
- Third Order Stream
- Fourth Order Stream

FIGURE 2.2

Stream Ordering within the Project Area

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2.2.2 Lockyersleigh Creek Catchment

Lockyersleigh Creek has a catchment area of approximately 2630 hectares, is a fourth order stream and drains in a northwesterly direction to the Wollondilly River. Land use within the catchment is predominantly grazing with some forested areas.

Lockyersleigh Creek drains generally in a northerly direction from its headwaters near the Hume Highway approximately 9.2 kilometres north to the Wollondilly River. The confluence of Lockyersleigh Creek with the Wollondilly River is located approximately 9.2 kilometres upstream of Marulan Drinking Water Supply Pumping Station. There area several harvestable rights dams located within the catchment area, including three within the project area.

The catchment area has slopes varying from 2 to 3% in the north of the catchment to 20% in the upper slopes in the south of the catchment.

Lockyersleigh Creek is an ephemeral creek system with flows only occurring in the creek during storm events or after prolonged periods of heavy rain. Generally the creek system is predominantly dry, however, some pools of permanent or semi-permanent water are present in the downstream reaches of the creek. There is little or no riparian vegetation along the upper reaches of the creek, with established riparian vegetation in the downstream reaches. There is also evidence of erosion of the creek banks in the upper reaches where little or no riparian vegetation is present.

Two of the soil landscapes identified within the area occur in the Lockyersleigh Creek catchment component of the project area. Bindook Road soils generally occur to the east of the proposed extraction area and Binbook Road Variant A soils on the ridges to the east of the creek. The soil landscape mapping undertaken by DIPNR indicates that both soil landscapes have limitations in regard to gully erosion hazard and sheet erosion hazard. Recent laboratory testing indicates that the soils are not dispersive (Asset Geotechnical, 2005). Soil sampling has also indicated that the soils in the catchment area have the potential to contain a significant proportion of clay fines in the mid to lower horizons.

Approximately 21 hectares (less than 1%) of the catchment area of Lockyersleigh Creek lies upslope of the project area. Approximately 102 hectares (4%) of the Lockyersleigh Creek catchment lies within the project area. The areas of Lockyersleigh Creek catchment within the project area are predominantly grazing pastures with some isolated pockets of woodland. The progressive stream order of Lockyersleigh Creek and its tributaries within the project area are shown on **Figure 2.2**.

2.2.3 Marulan Creek Catchment

Marulan Creek has a catchment area of approximately 2055 hectares, is a fourth order stream and drains in a southeasterly direction to the Shoalhaven River via Barbers Creek. Land use within Marulan Creek catchment is predominantly grazing and residential with some forested areas. A section of the town of Marulan lies within the catchment area.

Marulan Creek extends from its confluence with Barbers Creek approximately 7.5 kilometres due west to the Hume Highway and Marulan. There is one major dam located along a tributary of the creek located approximately 3.6 kilometres to the west of the project area. In addition there are several harvestable rights dams located within the catchment area. All of these dams are located downstream of the project area.

The catchment area has slopes varying from 1 to 2% in the east of the catchment to 15% in the upper slopes in the west of the catchment.

Marulan Creek is an ephemeral creek system with flows only occurring in the creek during storm events or after prolonged periods of heavy rain. There is limited riparian vegetation along the upper reaches of the creek, with established riparian vegetation downstream of the Hume Highway.

Three of the soil landscapes identified within the project area occur in the Marulan Creek catchment component of the project area. Jaqua soils occur around the main creek bed with Marulan soils bounding either side of the main creek area. Bindook Road soil landscapes generally occur on the upper slopes of the northern extent of the Marulan Creek catchment area. The soil landscape mapping undertaken by DIPNR indicates that all three soil landscapes have limitations in regard to gully erosion hazard and sheet erosion hazard. Laboratory testing of soils has been undertaken in the regions of the site where the proposed quarry and its associated infrastructure are to be located. These tests indicate that the topsoils and subsoils over the majority of the site are not dispersive. Site inspection along Marulan Creek at the location of the proposed access road crossing indicates that the subsoils in this region are dispersive. At this location the creek channel is deeply incised (up to 4 metres deep) for a length of approximately 1.1 kilometres. Soil landscape mapping undertaken by DIPNR indicates that the erosion of the creek channel occurs at the boundary of the Marulan and Jaqua soil landscapes. Both these soil types have dispersive subsoils on the mid to lower slopes, footslopes and channels, as indicated in the soil landscape mapping and site inspection. The extent of erosion evident along Marulan Creek is not present along the creek lines located elsewhere within the project area. Generally the creek system is predominantly dry, however, some pools of permanent or semi-permanent water are present in the incised reaches.

Approximately 40 hectares (2%) of the catchment area of Marulan Creek lies upslope of the project area. Approximately 160 hectares (8%) of the Marulan Creek catchment lies within the project area. The proposed development within Marulan Creek catchment area consists of the access road to the proposed quarry and the associated interchange located at the Hume Highway. This area is predominantly grazing pastures with some isolated pockets of woodland. The progressive stream order of Marulan Creek and its tributaries within the project area are shown on **Figure 2.2**.

2.3 WATER QUALITY

A surface water quality monitoring program has been established for the project to provide baseline data. Surface water quality has been monitored at four locations on Joarimin Creek and two locations on Marulan Creek (shown on **Figure 2.3**) since July 2004. A monitoring point on Lockyersleigh Creek was also established in November 2004. These sites are monitored for flow (by way of observation as streams are ephemeral), pH, electrical conductivity, Total Dissolved Solids (TDS), sodium (Na), chloride (Cl), iron (Fe), manganese (Mn), arsenic (As), nitrite, nitrate, oxidised nitrogen, Total Kjeldahl Nitrogen (TKN), total nitrogen (total N), orthophosphate (ortho P), total phosphorous (total P), Total Petroleum Hydrocarbon (TPH), and Benzene, Toluene, Ethylbenzene, and Xzylene (BTEX). Detailed results of the monitoring program are shown in **Appendix A**.

Joarimin Creek is ephemeral and the number of water quality samples collected has therefore varied. A full monthly record of water quality is available at the most downstream monitoring point (SW6) only, where ponding of water occurs during dry periods. The water quality records for upstream sites are intermittent as no regular flows have occurred at these locations during the monitoring period. Water quality in Joarimin Creek ranged from neutral to alkaline with pH ranging from 6.2 to 9.7. Electrical conductivity ranged from 256 µS/cm to 3255 µS/cm.

Marulan Creek is ephemeral at the two monitoring locations and water quality data has been collected on three occasions from each location. Water quality was neutral with pH ranging from 6.2 to 6.8. Electrical conductivity ranged from 100 µS/cm to 1003 µS/cm.

Only one water sample has been taken on Lockyersleigh Creek as the creek has been dry at all other sampling times. This sample, taken in February 2005, had a pH of 6.6 and electrical conductivity of 3700 µS/cm.

Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC Guidelines) indicate that for upland rivers in slightly disturbed ecosystems in south-east Australia pH values

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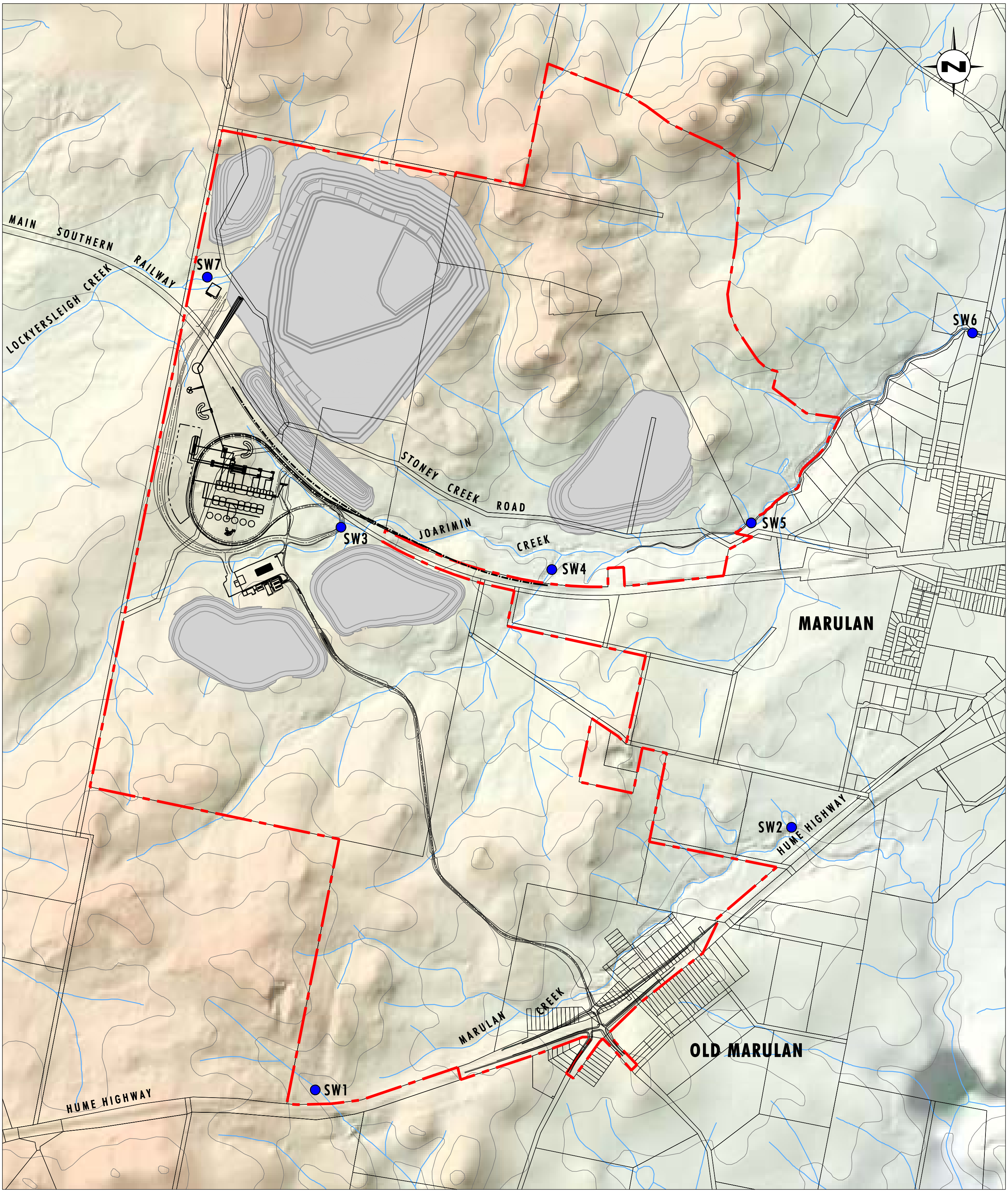


Base Source: LPI 2004, Readymix Holdings Pty Ltd

0 0.5 1 1.25km

Legend

Project Area

Surface Water Monitoring Location

FIGURE 2.3

Surface Water Monitoring Locations

File Name (A4): R04_V1/1829_164.dgn

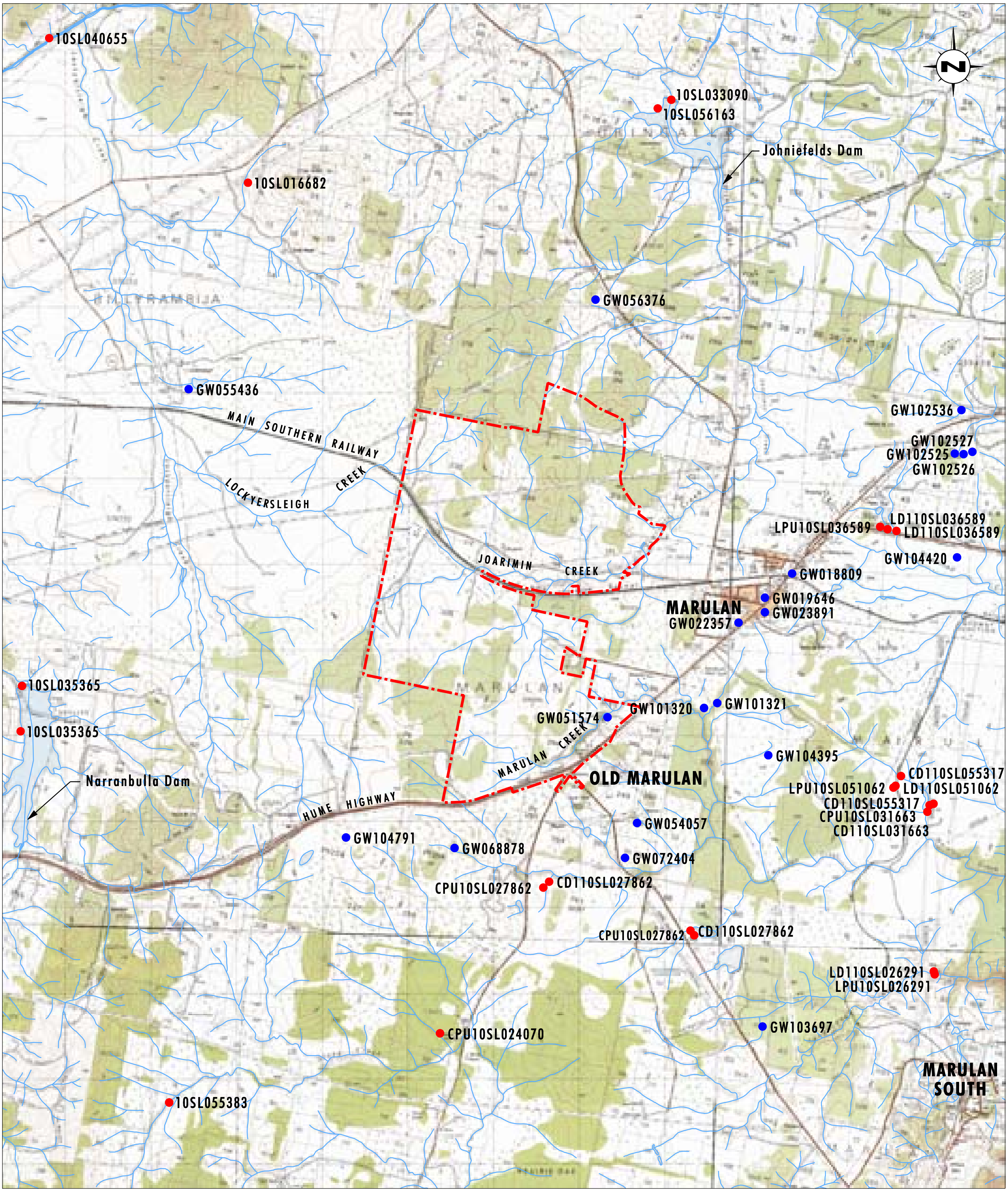
between 6.5 and 7.5 are typical default trigger values. As can be seen in the detailed results in **Appendix A**, one of the collected water samples has a pH higher than the upper limit of 8.0 and three water samples have a pH lower than the lower limit of 6.5. The default trigger value for salinity in upland rivers in south-east Australia ranges from 125 µS/cm to 350 µS/cm. Salinity readings from water samples collected in Joarimin, Lockyersleigh and Marulan Creeks exhibit values in excess of the upper trigger value.

2.4 WATER USERS

Land use surrounding the project area is primarily grazing but also includes residential areas, rural residential areas, Greater Argyle Council's waste management facility and land zoned and proposed for industrial development.

Groundwater is extracted at several locations in Marulan to support the aforementioned land uses. No surface water licences exist within 6 kilometres downstream of the project area on Joarimin and Lockyersleigh Creeks. There is one water licence located within the project area on Marulan Creek. The location of surface water and groundwater licences within and surrounding the proposed development are shown on **Figure 2.4**.

Appendix B provides the licence number, purpose and allocation for each licence shown on **Figure 2.4**, from DIPNR licence records as at 16 March 2005.



Base Source: LPI 2000 1:25 0000 Topographic Map, DIPNR (Bore Licence Data)

0 1 2 3km

Legend

- Project Area
- Surface Water Extraction Point
- Groundwater Extraction Points

FIGURE 2.4

Licensed Surface Water and Groundwater Extraction Points

File Name (A4): R04_V1/1829_105.dgn

3.0 LYNWOOD QUARRY WATER MANAGEMENT SYSTEM

3.1 PREDICTED WATER DEMANDS

Predicted water uses at the quarry include:

- the crushing and screening plant;
- haul road dust suppression;
- stockpile dust suppression; and
- potable water.

3.1.1 Crushing and Screening Plant

The crushing and screening plant will be a major water user at the quarry with an estimated average use of 1489 ML (114.9 L/s) of water pumped through the plant per year at a production level of 5 Mtpa. Most of the water used will be recycled through the plant. The net water usage in the plant will be through evaporation losses and losses in product. It is estimated these losses will equate to on average approximately 125 ML/year (i.e. 8.4 % of the total plant water demand). As such the total water demand for the crushing and screening plant is predicted to be on average 125 ML/year at production levels of 5 Mtpa.

It is currently predicted that the quarry will reach full production levels of 5 Mtpa by Year 3 of operations. Predicted production during Years 1 and 2 is 2.5 Mtpa and 3 Mtpa respectively.

3.1.2 Haul Road Dust Suppression

The volume of water required for dust suppression will vary according to prevailing climatic conditions, the extent of haul road development and the usage of the haul roads. It is considered that on days where the daily rainfall exceeds evaporation it is unlikely that dust suppression will be required. As such the yearly rate for haul road watering has been calculated using the effective evaporation for the site, i.e. total evaporation on days where the daily evaporation exceeds the daily rainfall, multiplied by the area of haul road to be watered and then multiplied by a factor of 1.4 to allow for increased evaporation due to vehicle movements on the haul road. Based on this calculation, the typical annual water demand for haul road dust suppression will range from 15.0 ML/km to 16.2 ML/km of haul road for a wet rainfall year and dry rainfall year respectively. This rate may be able to be reduced by use of chemical stabilisers, however for the site water demand use of stabilisers has not been considered due to their application specific effectiveness.

3.1.3 Stockpile Dust Suppression

The infrastructure area will include raw and product stockpile areas. Of these stockpiles it is considered that the manufactured sand stockpiles, primary surge stockpile and scalps/roadbase stockpile will require dust suppression. The other stockpiles will consist of rinsed aggregate greater than 4.5 mm in diameter and as such are not considered to require dust suppression.

Up to five manufactured sand stockpiles, the primary surge stockpile and the scalps/roadbase stockpile will require dust suppression. The total area to be watered is approximately 1000 m^2. The water requirement for these stockpiles has been calculated based on watering only on days where no rain falls. Based on the number of historical rain days per year and operation of the quarry for 300 days per year, the number of days when stockpile watering will be required has been calculated to range between 219 and 236 days per year.

It is estimated that on average water sprays will be required for 10 minutes per hour, 12 hours per day. At this rate (estimated at 0.0468 ML/day) water requirement for stockpile dust suppression will range from 10.2 to 11.0 ML/year. During a dry rainfall year approximately 10 ML/year has been calculated as the water required to offset the potential evaporation from the stockpile area requiring dust suppression. It is considered that an additional 10% of water may be lost during application. As such a typical rate of 11.0 ML/year has been used for the dust suppression requirements for these stockpiles.

3.1.4 Potable Water

The potable water requirement for the site has been calculated as 3.5 ML/year. This is based on 115 personnel on site with a usage rate of 85 L/day/person.

3.2 WATER SUPPLY AND STORAGE

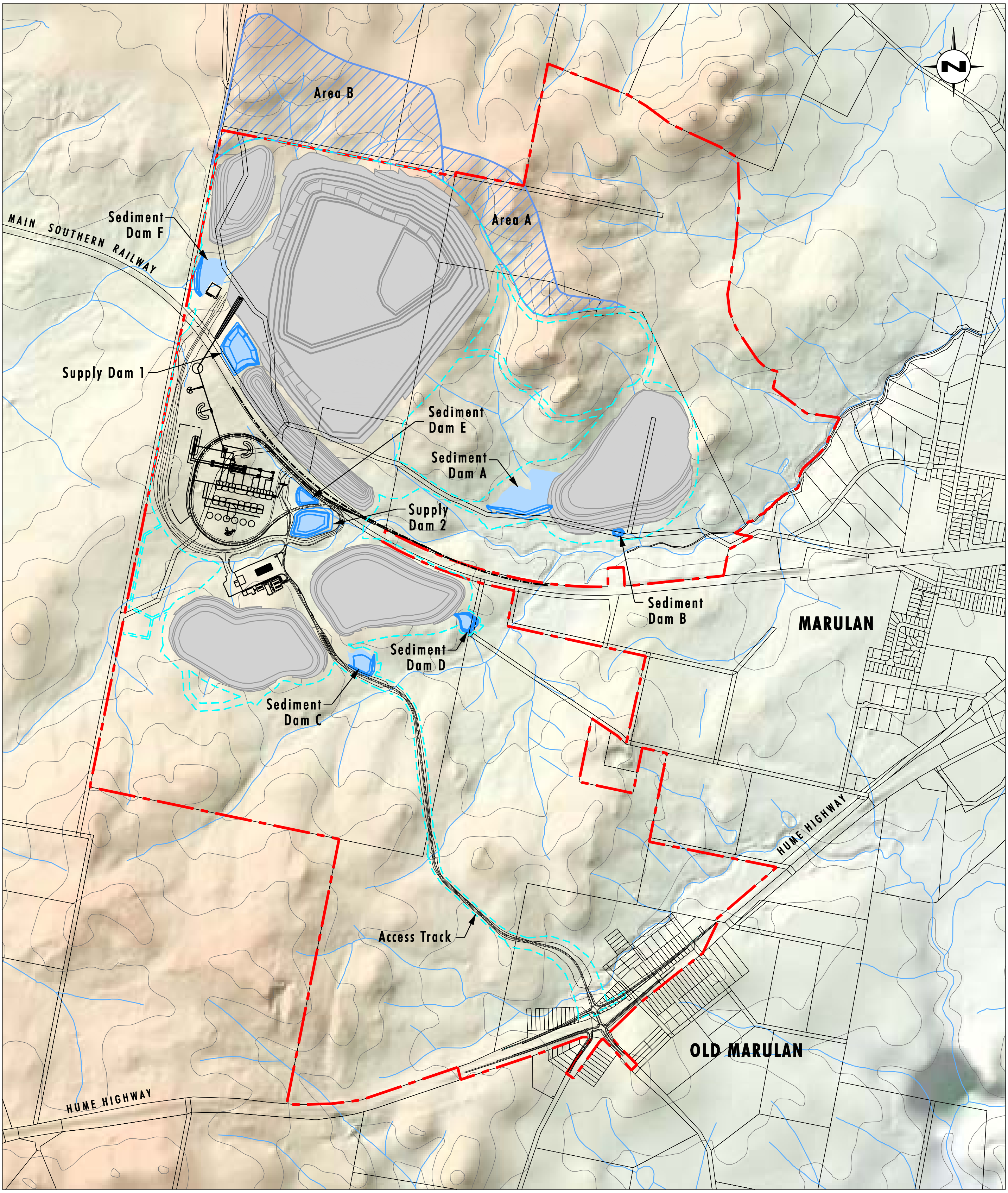
The water management system will capture runoff from the footprint of the Year 30 disturbance area. This area is defined on **Figure 3.1** and contains the quarry pit, overburden and excess product emplacement areas, haul road routes and infrastructure area. The runoff water captured will be stored on site along with groundwater extracted from the pit, externally sourced water and water recycled through the process plant. During prolonged wet periods a proportion of this water may be released off site. The controls required to treat dirty runoff from the Year 30 footprint are detailed in **Sections 3.2.1** to **3.2.4** and **Section 5.0**. The controls will consist of a series of diversion and catch drains, five sediment control dams and two water storage dams (refer to **Figures 3.1** and **3.2**). The two water storage dams are turkeys nest dams. The design characteristics of each of the seven dams are detailed in **Table 3.1**. The design characteristics of each of the catch drains are detailed in **Appendix E**.

Table 3.1 - Dam Characteristics

Dam Name	Design Capacity (ML)	Freeboard (m)	Wall Crest Elevation (mAHD)	Side Slopes (v:h)	Wall Crest Width (m)
Supply Dam 1	89	1	672	1:3	3
Supply Dam 2	30	1	660	1:3	5
Sediment Dam A	70	1	648.5	1:3	3
Sediment Dam B	0.5	0.5	639	1:3	3
Sediment Dam C	7.5	0.5	660	1:3	3
Sediment Dam D	7.8	0.5	651	1:3	3
Sediment Dam E	5.9	0.5	656.5	1:3	3
Sediment Dam F	32	1	660.5	1:3	4

The area that drains to the proposed water management system is shown on **Figure 3.1**. This includes minor areas that are not contained within the perimeter of the Year 30 disturbance area. These are 21 hectares of Joarimin Creek catchment (Area A on **Figure 3.1**) immediately to the north east of the Year 30 pit extent and an area of 47 hectares of Lockyersleigh Creek catchment (Area B on **Figure 3.1**) to the north of the project.

To divert runoff from Area A, a diversion channel would have to be constructed from elevation 686 mAHD for a length of approximately 640 metres. This would require excavation up to a depth of 19 metres through the ridge located in the south eastern section of Area A. To divert runoff from Area B, a diversion channel would have to be constructed from elevation 680 mAHD for a length of approximately 520 metres. This would require excavation to a depth of 11 metres through the ridge immediately to the west of the project area. Diversion of runoff from these two areas away from the



Base Source: LPI 2004, Readymix Holdings Pty Ltd

0 0.5 1 1.25km

Legend

Project Area

Approximate Disturbance Footprint

FIGURE 3.1

Year 30 Disturbance Footprint

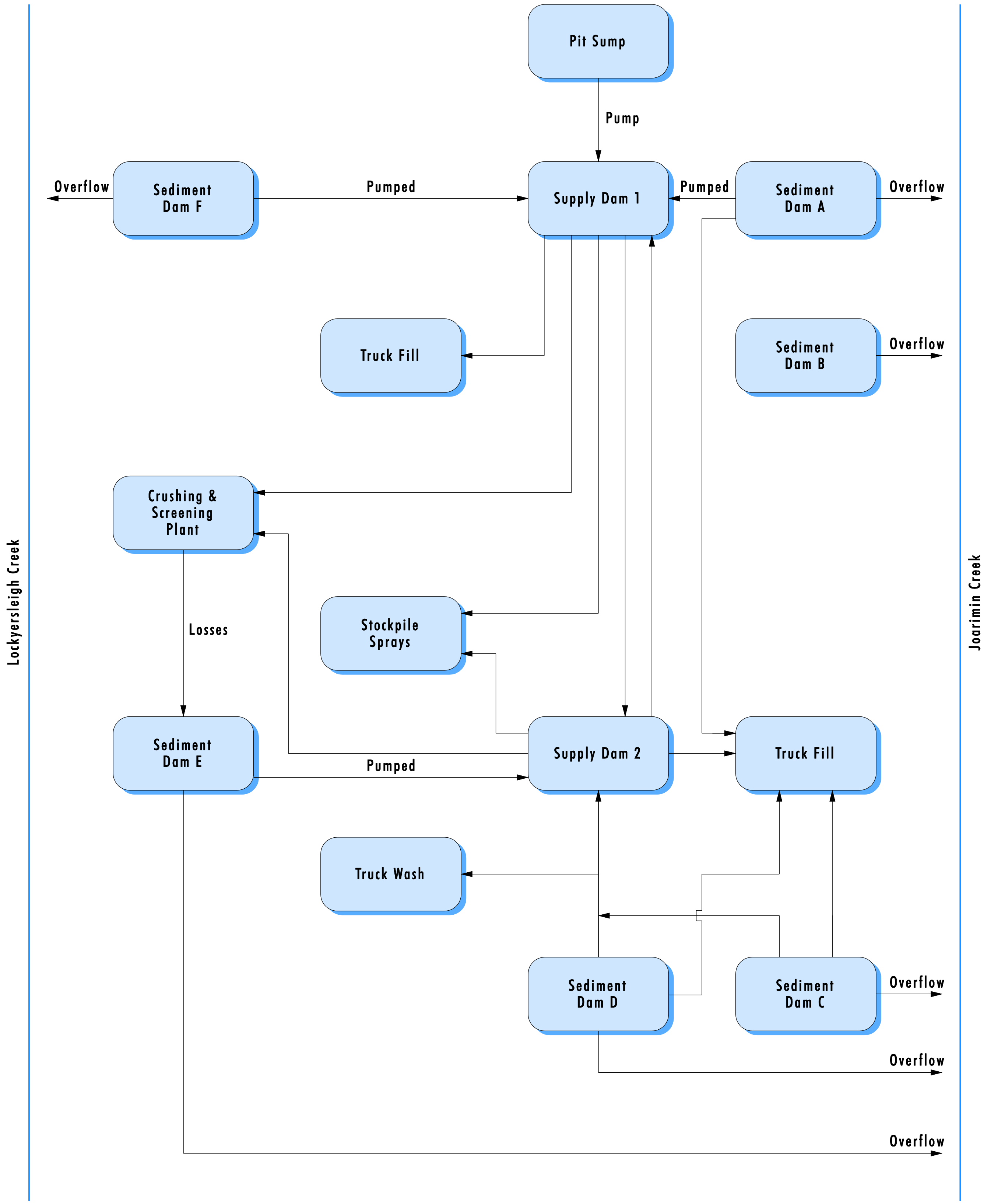


FIGURE 3.2

Schematic of Water Management System

File Name (A4): R04_V1/1829_168.dgn

water management system would require excavation through existing ridge lines which would substantially increase the disturbance in these areas of the site. As such, due to these topographical and space constraints, it is not considered feasible to direct runoff from these areas away from the proposed site water management system.

Potable water for the administration offices and workshop is proposed to be sourced from the Marulan Town Water Supply System and supplied to the site via a pipeline from Marulan. Should this not be possible, a water treatment plant will be established at the site to treat water from the quarry water management system to a meet potable water requirements. Approval for construction and operation of the pipeline will be sought once an exact route has been determined as part of the detailed design process.

Wastewater from the administration offices and workshops is to be collected by a series of gravity and rising mains and treated on site in an aerated wastewater treatment plant. The treated effluent from the wastewater treatment plant will then be recycled through the plant. It is proposed that the wastewater treatment plant be located within the infrastructure area.

The proposed water management controls for Years 2, 10 and 30 are shown on **Figures 3.3** to **3.5**, respectively. These stages are indicative of changes required to the proposed water management system to facilitate the development of the quarry.

3.2.1 Joarimin Catchment Water Management Controls

3.2.1.1 Eastern Tributary

It is proposed to place a sedimentation dam, Sediment Dam A, on the tributary of Joarimin Creek to the east of the proposed Year 30 quarry pit extent to capture and treat runoff from the disturbance footprint in this area (refer to **Figures 3.3** to **3.5**). The tributary is located within the footprint of the Year 30 disturbance area. The proposed sediment dam location has a catchment area of 203 hectares and will have a storage capacity of 70 ML. The tributary at this location is a 2nd order creek.

As part of the proposed quarry water management system, runoff from the majority of the Eastern Overburden Emplacement Area and the Rail Overburden Emplacement Area will be diverted to Sediment Dam A for capture and treatment. In addition, runoff from all haul roads to the east of the proposed quarry pit will be captured in Sediment Dam A for treatment (refer to **Figures 3.3** to **3.5**). The design characteristics of Sediment Dam A are detailed in **Section 4.4.2**.

A small sediment dam, Sediment Dam B (refer to **Figures 3.3** to **3.5**), with a 0.5 ML capacity will be constructed to treat runoff from the remaining area of the Eastern Overburden Emplacement Area. This dam will overflow to the tributary of Joarimin Creek. The design characteristics of Sediment Dam B are detailed in **Section 4.4.2**.

3.2.1.2 Excess Product Emplacement Area Controls

Runoff from the Western Product Emplacement Area and the Eastern Product Emplacement Area will be captured in two separate sediment dams, Sediment Dam C and Sediment Dam D (refer to **Figures 3.3** to **3.5**) with sizes of 7.5 ML and 7.8 ML, respectively. These two dams have been sized in accordance with the Blue Book (NSW Department of Housing, 1998) (refer to **Section 4.4.2**). It is proposed that treated water from these sediment dams is reused in the crushing and screening plant and for dust suppression.

3.2.1.3 Infrastructure Area Controls

The proposed crushing and screening plant and associated water management layout is shown on **Figures 3.3** to **3.5**. Runoff from the infrastructure area will be treated in Sediment Dam E (refer to **Section 4.4.2**) prior to being pumped to Water Supply Dam 2. Sediment Dam E will have a capacity

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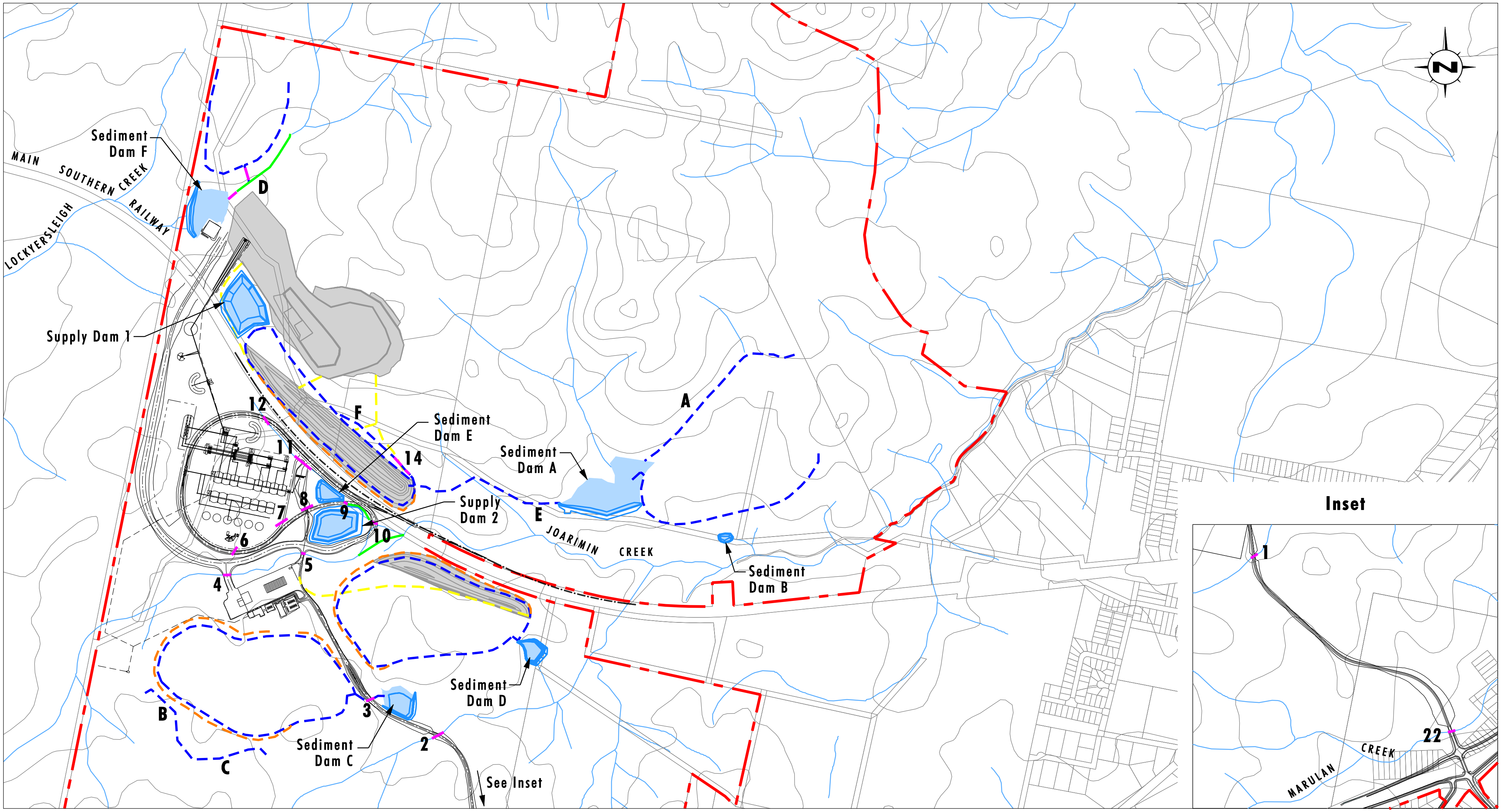


Base Source: LPI 2004, Readymix Holdings Pty Ltd

0 0.25 0.5 1km

Legend

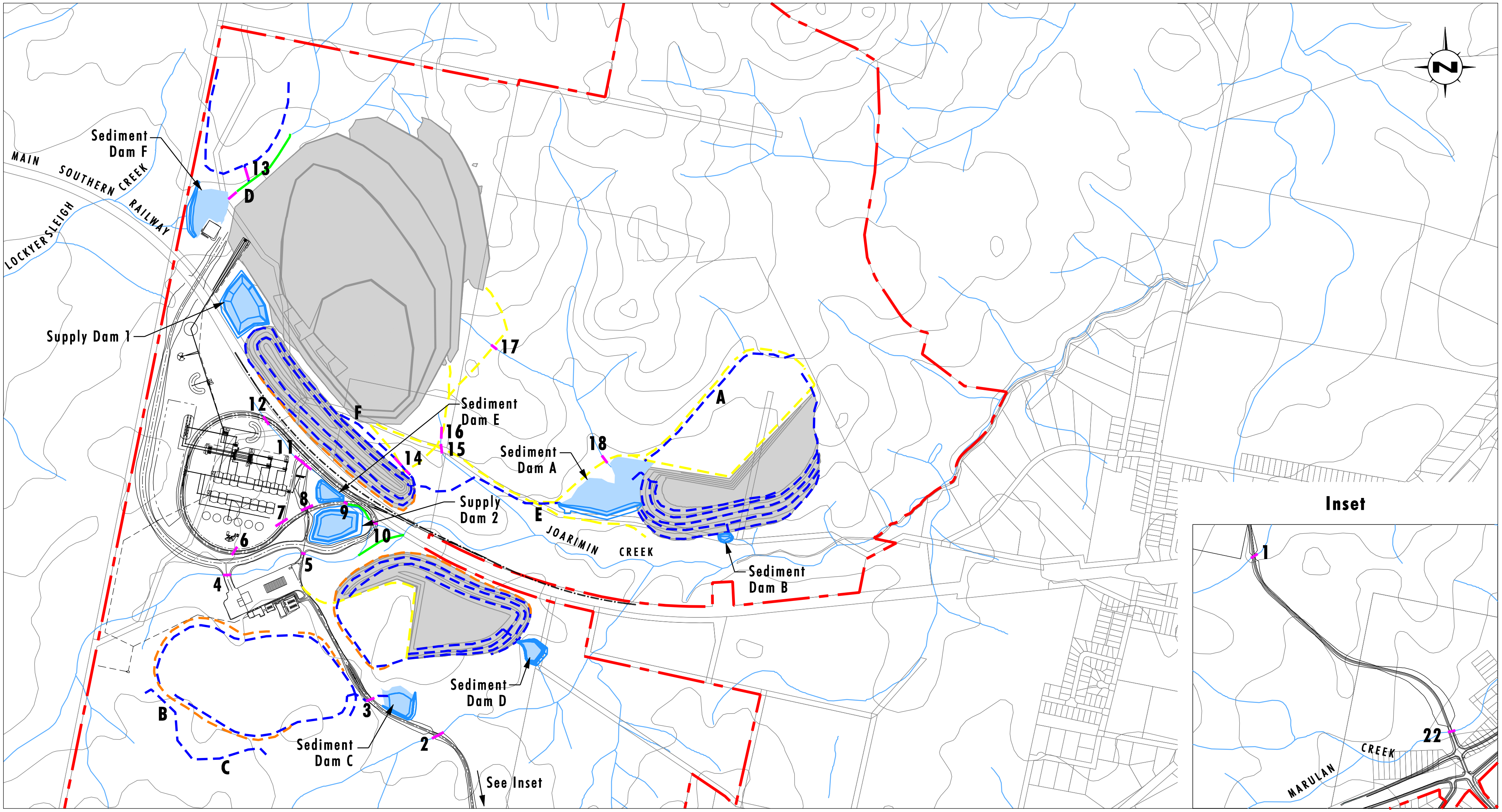
- Project Area
- Creek Realignment
- Catch Drain
- Sedimentation Fence
- Culvert
- Haul Road
- A, 1 See Appendix E

FIGURE 3.3

Proposed Water Management Controls - Year 2

File Name (A4): R04_V1/1829_170.dgn

Umwelt
Environmental Consultants



Base Source: LPI 2004, Readymix Holdings Pty Ltd

0 0.25 0.5 1km

Legend

- Project Area
- Creek Realignment
- Catch Drain
- Sedimentation Fence
- Culvert
- Haul Road
- A, 1 See Appendix E

FIGURE 3.4

Proposed Water Management Controls - Year 10

File Name (A4): R04_V1/1829_171.dgn

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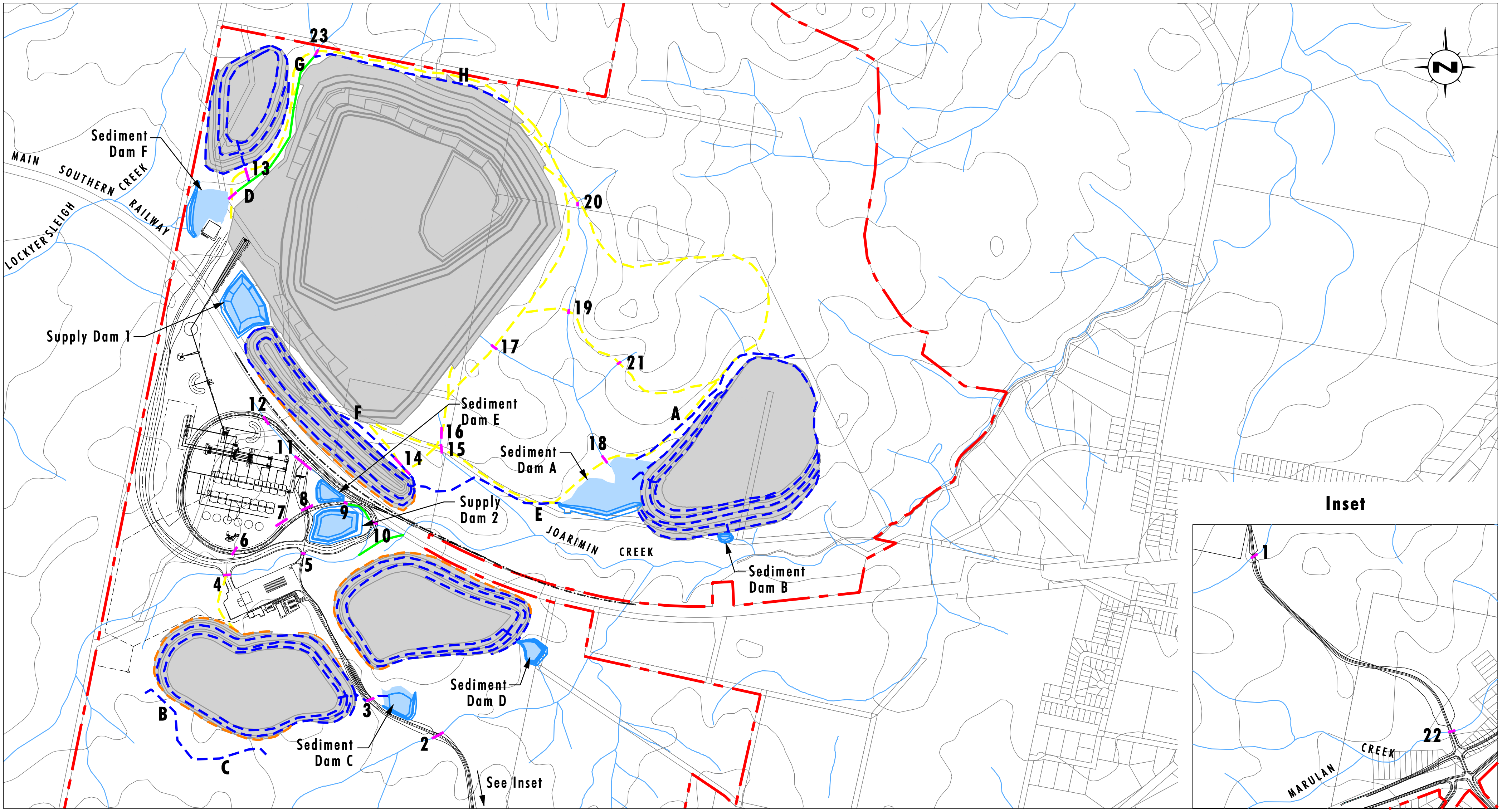


Base Source: LPI 2004, Readymix Holdings Pty Ltd

Legend

- Project Area
- Creek Realignment
- Catch Drain
- Sedimentation Fence
- Culvert
- Haul Road
- A, 1 See Appendix E

FIGURE 3.5

Proposed Water Management Controls - Year 30

File Name (A4): R04_V1/1829_169.dgn

of 5.9 ML and has been sized in accordance with the Blue Book (NSW Department of Housing, 1998) (refer to **Section 4.4.2**). It is proposed that treated water from this sediment dam will be reused in the process plant and for haul road dust suppression.

3.2.2 Lockyersleigh Catchment Water Management Controls

It is proposed to place a sedimentation dam, Sediment Dam F, on Lockyersleigh Creek. Sediment Dam F will be located immediately to the west of the proposed Year 30 quarry pit extent to capture and treat runoff from a portion of the disturbance footprint (refer to **Figures 3.3** to **3.5**). The majority of the catchment is located within the footprint of the Year 30 disturbance area. The proposed sediment dam location has an existing catchment area of 138 hectares and the dam will have a storage capacity of 30 ML. Lockyersleigh Creek at the proposed dam location is a 3rd order stream.

As part of the proposed quarry water management system, runoff from the Western Overburden Emplacement Area will be diverted to Sediment Dam F for capture and treatment. In addition, runoff from all haul roads to the west and north of the proposed quarry pit will be captured in Sediment Dam E for treatment (refer to **Figures 3.3** to **3.5**).

Sediment Dam F has been sized to be able to capture and treat runoff from its receiving catchment. The design characteristics of Sediment Dam E are detailed in **Section 4.4.2**.

3.2.3 External Water Supply

As set out in **Section 3.4**, analysis indicates that the quarry will be a net water user during dry rainfall years. To supplement on site supply, it is proposed to source external water supplies to the site. Two potential off-site sources to supplement general quarry and processing water are:

- purchase of an existing allocation and conversion to an industrial allocation, if required, for use at the site. Water pumping location to be determined in consultation with DIPNR, including possible use of the existing industrial allocation from Johniefelds Dam by way of agreement with the owner (refer to **Figure 2.1**); and

- supply of treated effluent from Marulan Wastewater Treatment Plant.

In addition, it is proposed subject to agreement with Greater Argyle Council to source potable water from Marulan Town Water Supply System.

3.2.3.1 External Water Supply – Water Licence Allocation

It is proposed to supplement water supply on site by using existing surface water extraction licences, either from Johniefelds Dam (refer to **Figure 2.1**) or from another location using a purchased water allocation in consultation with DIPNR. There are a number of other existing water allocations within the Wollondilly and Shoalhaven catchments in close proximity or upstream of the project area that may be able to be purchased and converted to industrial allocations in consultation with DIPNR. Readymix is currently investigating supply options from a number of these sources.

The surface water licence for Johniefelds Dam (SL056163) includes an existing industrial allocation (refer to **Section 2.4**). Readymix is currently finalising an agreement with the owner to use an existing 74 ML/year industrial allocation at Lynwood.

The location of a pipeline to enable transport of water from Johniefelds or another pumping location to the proposed quarry will be determined as part of the detailed design phase. Several viable options exist for the location of the pipelines including existing infrastructure corridors. Separate approval will be sought for the construction and operation of the pipeline once an exact route has been determined as part of the detailed design process.

3.2.3.2 Treated Effluent

It is proposed to use treated effluent from Marulan Wastewater Treatment Plant (refer to **Figure 2.1**) as a supplementary water supply by agreement with Council. Discussions with Council indicate that the flow rates from the plant are variable and as such it is considered that this cannot be treated as a reliable water supply to the quarry during extended dry weather periods. Indications are that 20 ML to 30 ML per year of treated effluent may be available to supplement on-site water requirements.

A separate approval for construction and operation of the pipeline will be sought once an exact route has been determined as part of the detailed design process.

3.3 MANAGEMENT OF SURFACE WATER

3.3.1 Quarry Pit and Emplacement Areas

Catch drains will be constructed to capture runoff from the footprint of the quarry. In addition, catch drains will be constructed along the top of the quarry pit to prevent the inflow of runoff water into the pit from the surrounding catchment areas. As a result, there will be limited water inflow to the quarry pit throughout the life of the quarry other than from rain falling within the pit perimeter.

Water that collects in pit will be pumped to Supply Dam 1 and used in the process plant and for dust suppression (refer to **Figure 3.1** and **3.2**). This will continue as the pit progresses to the east and north. The detailed design of drains around the pit is outlined in **Section 4.4.2**.

The proposed overburden and excess product emplacement areas will have catch drains constructed upslope to divert clean water away from the these areas. The dirty water runoff from emplacement areas will be captured and treated on site in sediment dams (refer to **Section 5.2**).

3.3.2 Supply to Crushing and Screening Plant, Stockpiles and Water Carts

Water supply to the plant and stockpiles will be pumped from either Supply Dam 1 or Supply Dam 2. Water will be pumped to Supply Dam 1 or Supply Dam 2 from five of the six sediment dams (Sediments Dam A, C, D, E and F) in order to maintain drawn down water levels in the sediment dams for treatment of runoff from disturbed areas. Supply Dam 1 and Supply Dam 2 will be maintained at full storage levels whenever possible by pumping from the sediment dams or sourcing of water from off site.

Water from the Lynwood Quarry water management system will be drawn from truck fill points for dust suppression on haul roads and unsealed access roads.

3.3.3 Discharges to Creeks

Any discharges from the site will occur after treatment via the sediment dams that form part of the water management system.

Overflows from these dams will only occur when design capacity is exceeded. The design specifications for these dams are discussed in **Section 4.4.2.2**.

3.4 PROJECT WATER BALANCE

3.4.1 Model Structure

A computer model of the proposed water management system has been developed for Lynwood Quarry. In this model the proposed quarry water management system is represented by modules that represent catchments and components of the proposed quarry operation.

The model operates on a daily time step and has been set up to provide for, or calculate:

- water to be transferred to and from each module;
- runoff volumes entering each of the modules based on daily rainfall;
- evaporative losses from each of the modules based on water storage area and daily evaporation;
- net water usage for dust suppression and processing;
- water imported from external sources;
- overflows from on-site dams; and
- changes in water storage volumes for each module on a daily basis.

The model provides for future development of the quarry and also enables a range of management options to be explored and modelled. Operational data, catchment and storage characteristics, rainfall and evaporation data and water usage data are stored in a database that enables data to be readily updated/modified, and subsets of time series data to be easily generated.

The model uses PHP scripting language to utilise the information stored in the database to simulate the responses of the water management system to prevailing climatic conditions. The scripting language used also enables data to be archived and model outputs to be graphed or exported to files for further analysis. Adoption of this system provides considerable flexibility in terms of exploring potential modifications to the water management system and analysing any of the output data that has been generated during a simulation.

The model can be set to run over any daily time period and can be programmed to stop at preset times or when predetermined trigger levels are reached to allow modifications to be made to the water management system.

Runoff is calculated from two components. The first runoff component is direct rainfall onto the dam surfaces, in this case 100 per cent runoff is used (i.e. none of the rainfall is lost). The second component is runoff from overland flow across the catchment areas. For this component of runoff two losses are considered; an initial loss and a continuing loss.

Evaporation is calculated as the direct evaporation from the water surface of the dams.

Rainfall/runoff and evaporation relationships used in the model are:

- Initial Loss = 7 mm/day;
- Continuing Loss = $(\text{Rainfall} – \text{Initial Loss})^{0.79}$;

- Runoff = 1.0 x (Rainfall – Initial Loss – Continuing Loss)$^{0.66}$; and
- Evaporation Loss = 0.7 x Pan Evaporation x Wetted Surface Area of Dam/Storage.

The relationships described above for rainfall/runoff and evaporation were developed based on analysis of water management systems for quarrying and mining operations. The variables used for the proposed Lynwood Quarry water model have been selected to simulate the soil and climatic conditions experienced in the project area (refer to **Section 3.4.2**).

3.4.2 Model Calibration

Ideally local stream gauging data would be used to determine a rainfall/runoff relationship for the site. Unfortunately there is no stream gauging data available for Joarimin, Lockyersleigh or Marulan Creeks and there is only limited stream gauging data available within the Wollondilly catchment area.

As such, an analysis of stream gauging data available from DIPNR for the Wollondilly catchment area has been undertaken to derive a relationship between rainfall/runoff for the proposed development site. The stream gauging sites for which the analysis was undertaken are listed with their period of record in **Table 3.2**.

Table 3.2 - Stream Gauging Stations

Site Number	Site Name	Period of Record	
		From	To
212040	Kialla Creek at Pomeroy	1979	1987
212006	Wollondilly River at Pomeroy	1971	1979
212020	Tarlo River at Swallowtail Crossing	1978	1988

The analysis of the rainfall/runoff relationship has been undertaken on an annual basis as it is considered that sufficient water storage will be available on site to buffer the effects of daily fluctuations in terms of modelled versus actual daily runoff.

A comparison of annual runoff volumes at the three gauging sites (refer to **Table 3.2**) indicates that the average annual measured runoff volume is 9.8% of the annual rainfall volume. In comparison the average annual runoff volume for these catchments, predicted by the water model, is 9.6% of annual rainfall.

On this basis it is considered that the model is calibrated to site conditions to an acceptable degree of accuracy, and can be used to predict the quarry water balance.

3.4.3 Modelled Water Balance for Years 1 to 30

To explore the water balance at the proposed quarry over a range of climatic conditions, daily rainfall data for Goulburn from 1886 to January 2004 and derived daily evaporation data were used (refer to **Section 2.1**).

The modelled water balance for Years 1 to 30 of the proposed quarry operations is shown in **Table 3.3**. A full breakdown of the inputs and outputs of the water model is included in **Appendix C**.

Table 3.3 - Predicted Lynwood Water Balance

Rainfall Condition	Annual Rainfall (mm)	Water Balance (ML/Year)				
		Year 1	Year 5	Year 12	Year 20	Year 30
Dry Year (10th percentile)	407	51	-70	-83	-65	-48
Average Year (50th percentile)	607	193	69	54	80	93
Wet Year (90th percentile)	872	421	297	283	303	320

In order to meet water demands for the future quarry operations, water will be required to be imported from sources external to the quarry for all dry rainfall years from Year 3 of the quarry life.

The maximum modelled future water deficit without importing water is 83 ML in a dry rainfall year in Year 12. This deficit will need to be met from water sourced externally from the site. Similarly the maximum modelled future water surplus without importing water is 421 ML in a wet rainfall year in Year 1.

From the data contained in **Table 3.3** it can be seen that for all dry years of the quarry operation (post Year 3) water will need to be sourced externally from site to meet water demands. However, the modelling indicates that during average and dry rainfall years, discharges from the site via the sediment dams may also occur. As discussed in **Section 3.2.3** it is proposed that additional water will be sourced from a purchased water allocation and from Marulan Wastewater Treatment Plant.

4.0 SURFACE WATER IMPACTS AND MANAGEMENT METHODS

4.1 FLOODING

4.1.1 Modelling Methodology

The peak flows, velocities and flood levels for the 20 year and 100 year Average Recurrence Interval (ARI) storm events in Joarimin, Lockyersleigh and Marulan Creeks were modelled using XP-Storm version 9.1, a one-dimensional hydrodynamic model which can be used to model stormwater flows in watercourses, culverts and street drainage systems. XP-Storm is suitable to calculate overland runoff generated from large natural or developed catchments and is capable of predicting flood levels as a result of backwater effects. Consequently XP-Storm is a suitable model for determining the potential impact the proposed development may have on peak flows, velocities and water levels in Joarimin, Lockyersleigh and Marulan Creeks.

XP-Storm models a watercourse as a series of nodes along the channel, connected by drainage links. Nodes are the locations at which sub-catchment information may be entered into the model, including sub-catchment area, slope and percentage impervious area. Drainage links are characterised by a channel length, slope, cross section, maximum water depth, upstream and downstream channel inverts, and Mannings ‘n’.

The critical parameters used in the XP-Storm analyses were:

- Laurenson Equation $S = BQ^{n+1}$

  Where,
  S = volume of storage (m^3)
  B = Storage Delay Parameter
  Q = instantaneous rate of runoff (m^3/s)
  $n = -0.285$

- Horton Infiltration $F_p = F_c + (F_o + F_c) .e^{-kt}$

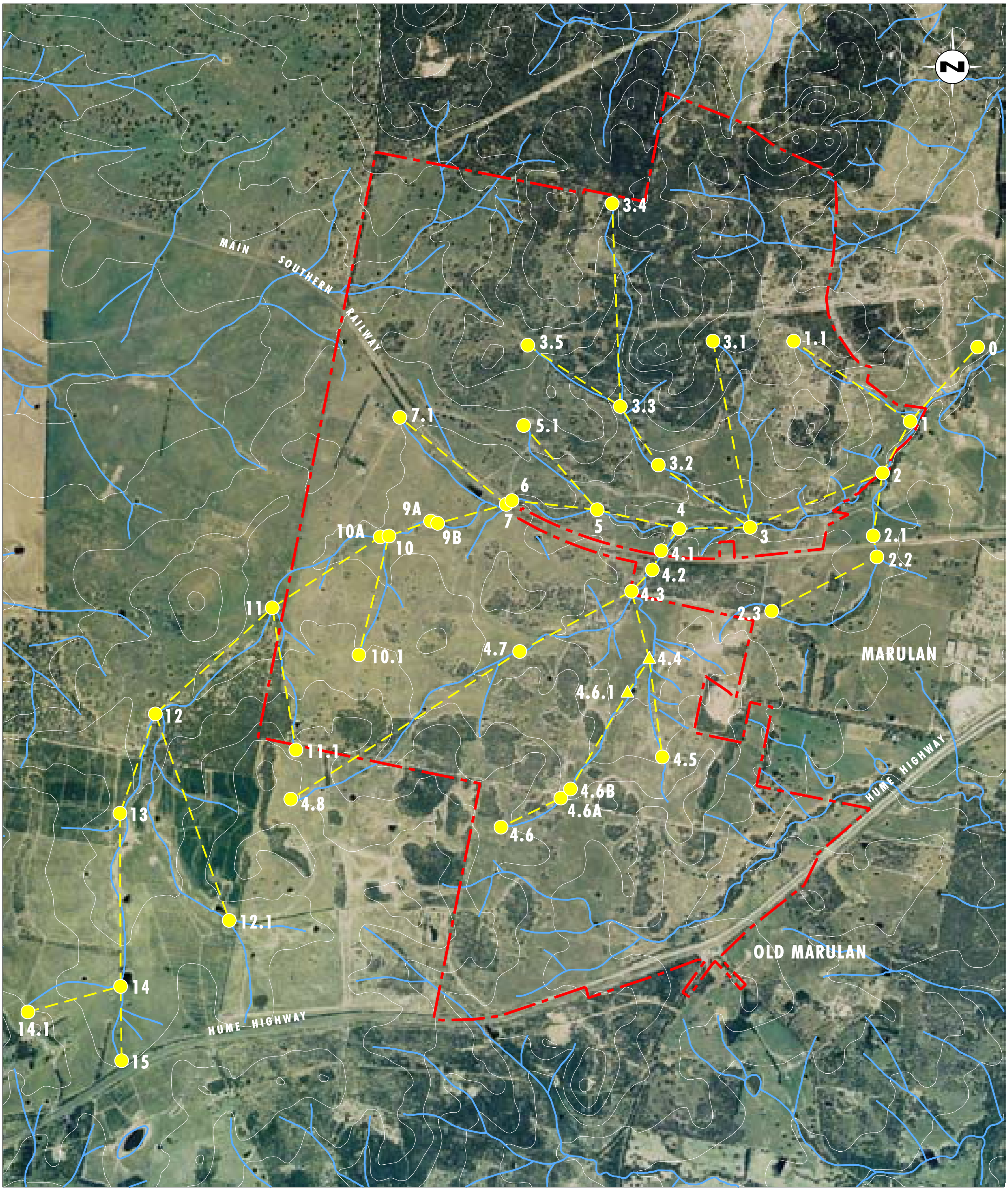
  Where,
  F_p = Horton Infiltration (mm/hr)
  F_o = 30 mm/hr
  F_c = 1.27 mm/hr
  k = 0.0015 1/sec
  t = time (sec)

Three XP-Storm models were established with a series of nodal points used to describe the existing catchments and creek systems of Joarimin, Lockyersleigh and Marulan Creeks (refer to **Figures 4.1**, **4.2** and **4.3**). These models were then modified to assess the impact of the proposed quarry on the flows, velocities and flood levels in each of the creeks.

The creek cross sections and values of Mannings ‘n’ were sourced from information gathered during site inspections and from aerial photographs. The values used for Mannings ‘n’ to represent the different catchment elements are listed in **Table 4.1**.

Table 4.1 - Mannings ‘n’ values for Different Catchment Elements

Element	Mannings 'n'
Natural Channel Sections	0.030 – 0.060
Developed channels	0.030 – 0.035
Pervious Catchment Areas	0.2
Impervious Catchment Areas	0.014



Base Source: LPI 2004, Readymix Holdings Pty Ltd (Aerial Photo March 2005)

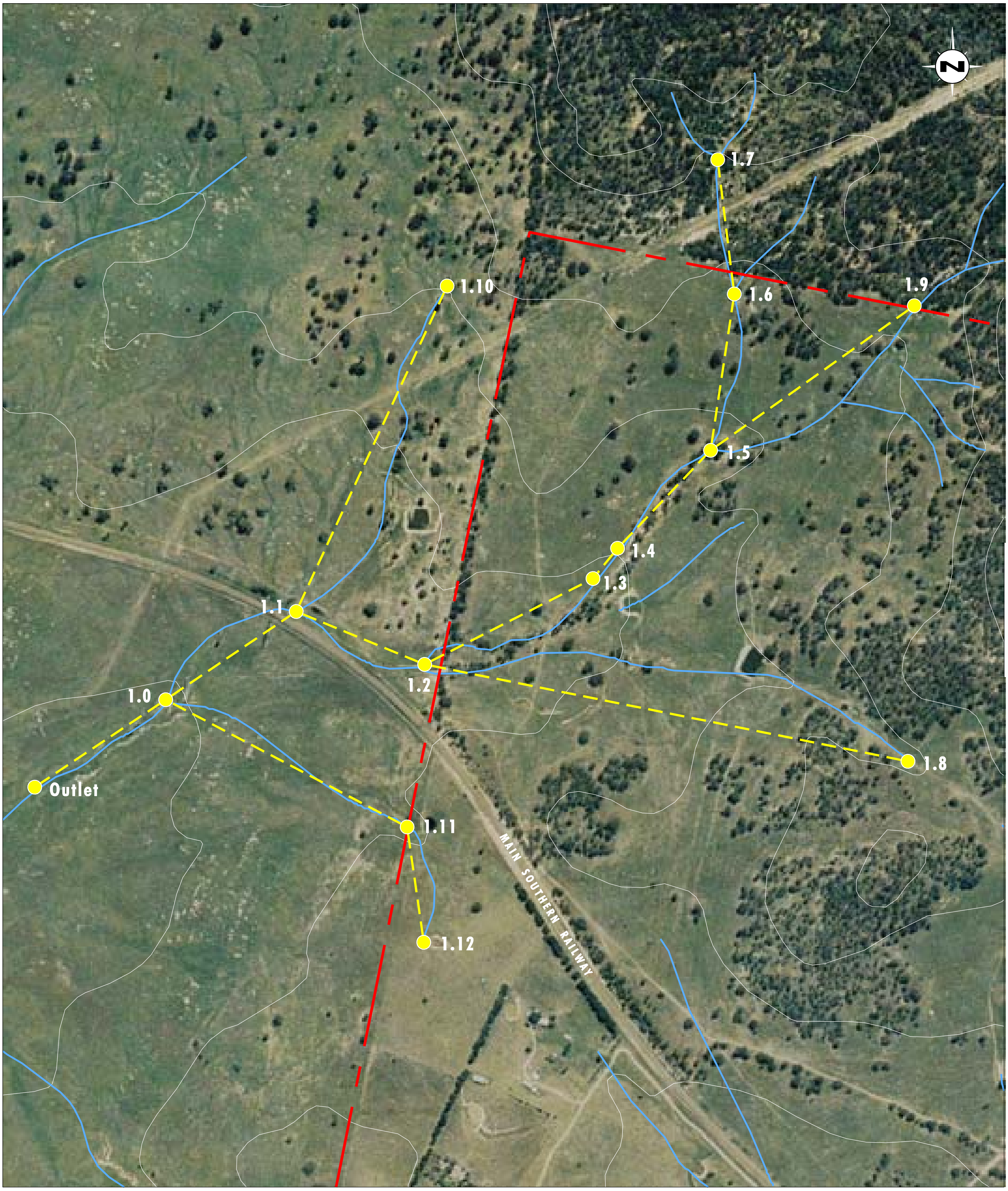
0 0.5 1 1.25km

Legend

- Project Area
- Nodes
- Link

FIGURE 4.1

Joarimin Creek
XP-Storm Model Layout



Base Source: LPI 2004, Readymix Holdings Pty Ltd (Aerial Photo March 2005)

0 100 200 400m

Legend
- Project Area
- Node
- Link

FIGURE 4.2

Lockyersleigh Creek XP-Storm Model Layout

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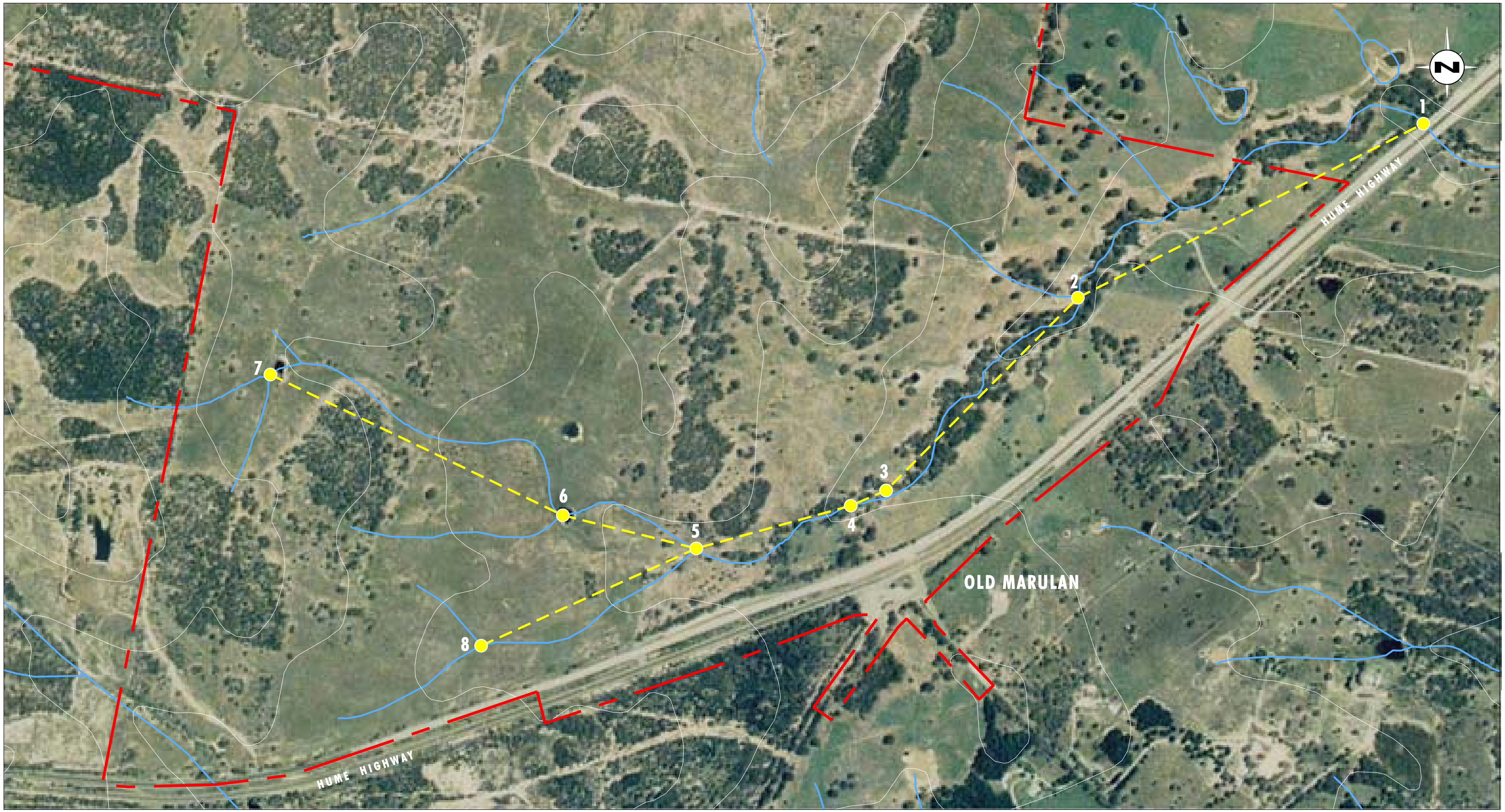

Base Source: LPI 2004, Readymix Holdings Pty Ltd (Aerial Photo March 2005)

Legend
- Project Area
- Nodes
- Link

FIGURE 4.3

Marulan Creek
XP-Storm Model Layout

The roughness of the main channel of a creek system is typically represented with a Mannings 'n' value between 0.03 and 0.06. The values used to represent pervious catchment areas are suitable for the roughness of land with some ground cover and low to medium density of trees.

4.1.2 Joarimin Creek Catchment

The objectives of water management controls within Joarimin Creek catchment are to convey flows around the proposed emplacement and infrastructure areas and control runoff from a proportion of the site to ensure dirty water is treated prior to reuse or potential release off site.

Modelling of the flows for the 1:100 year ARI storm event indicated that the critical storm duration for the catchment is six hours, generating a peak discharge on Joarimin Creek at the downstream boundary of the project area of 46.7 m^3/s. A critical storm duration of six hours was also used for the 1:20 year ARI storm event and generated a peak discharge of 31.8 m^3/s on Joarimin Creek at the downstream boundary of the project area.

To control flows around proposed emplacement and infrastructure areas and enable control of runoff from the Year 30 footprint, a series of channel realignments, diversion drains, catch drains, culverts, sedimentation and water storage dams will be required (refer to **Figures 3.2** to **3.5**). Several of these drains and dams are located within the Joarimin Creek catchment area and have been included in the model of the Year 30 footprint impact. In general, all drains have been designed with 1:3 side slopes (v:h) and to keep peak velocities in the drains less than 1.5 m/s (refer to **Section 4.4.2**).

The proposed infrastructure area is to be located to the south of the Main Southern Railway on the western boundary of the project area. One of the objectives of the design of the infrastructure area has been to minimise impacts on Joarimin Creek and its tributaries. However, the placement of the infrastructure area is constrained by design of the rail loop and associated support infrastructure. Due to the space constraints in this area, the conveyance of flows through the main channel of Joarimin Creek immediately upstream of the Main Southern Railway past the infrastructure area will require construction of two creek crossings and realignment of an approximate 180 metre section of the creek channel (refer to **Figures 3.2** to **3.5**). The proposed realignment will involve the filling of the existing main channel and diverting flows through an existing secondary channel of the creek. At the two creek crossings the culverts will be placed approximately 300 mm deeper than the existing bed of the creek and then backfilled to original bed level with rock sourced from the realigned sections of the creek. This will assist in maintaining a natural creek bed along the alignment of Joarimin Creek.

Hydrographs for selected sections of the existing Joarimin Creek system and the creek system with the proposed quarry at Year 30, are included in **Appendix D**. Results summarising peak flow, peak velocity and peak water levels for Joarimin Creek are detailed in **Tables 4.2** and **4.3**. Node locations are shown on **Figure 4.1**. The modelled flood extent for the 100 year ARI storm event for the existing and developed scenarios for Joarimin Creek is shown on **Figure 4.4**.

Table 4.2 - Modelling Results – Joarimin Creek - 1:100 year ARI storm event

Node	Existing Joarimin Creek			Developed Year 30 Joarimin Creek		
	Peak Flow in upstream reach (m^3/s)	Peak Velocity in upstream reach (m/s)	Peak Water Level at Node (mAHD)	Peak Flow in upstream reach (m^3/s)	Peak Velocity in upstream reach (m/s)	Peak Water Level at Node (mAHD)
1	46.7	2.5	630.2	37.9	2.4	630.0
4	25.8	1.8	639.1	16.5	1.5	639.0
4.2 (tributary)	12.9	2.8	640.9	12.9	2.8	640.9
7	21.1	1.7	652.4	15.1	1.7	652.4

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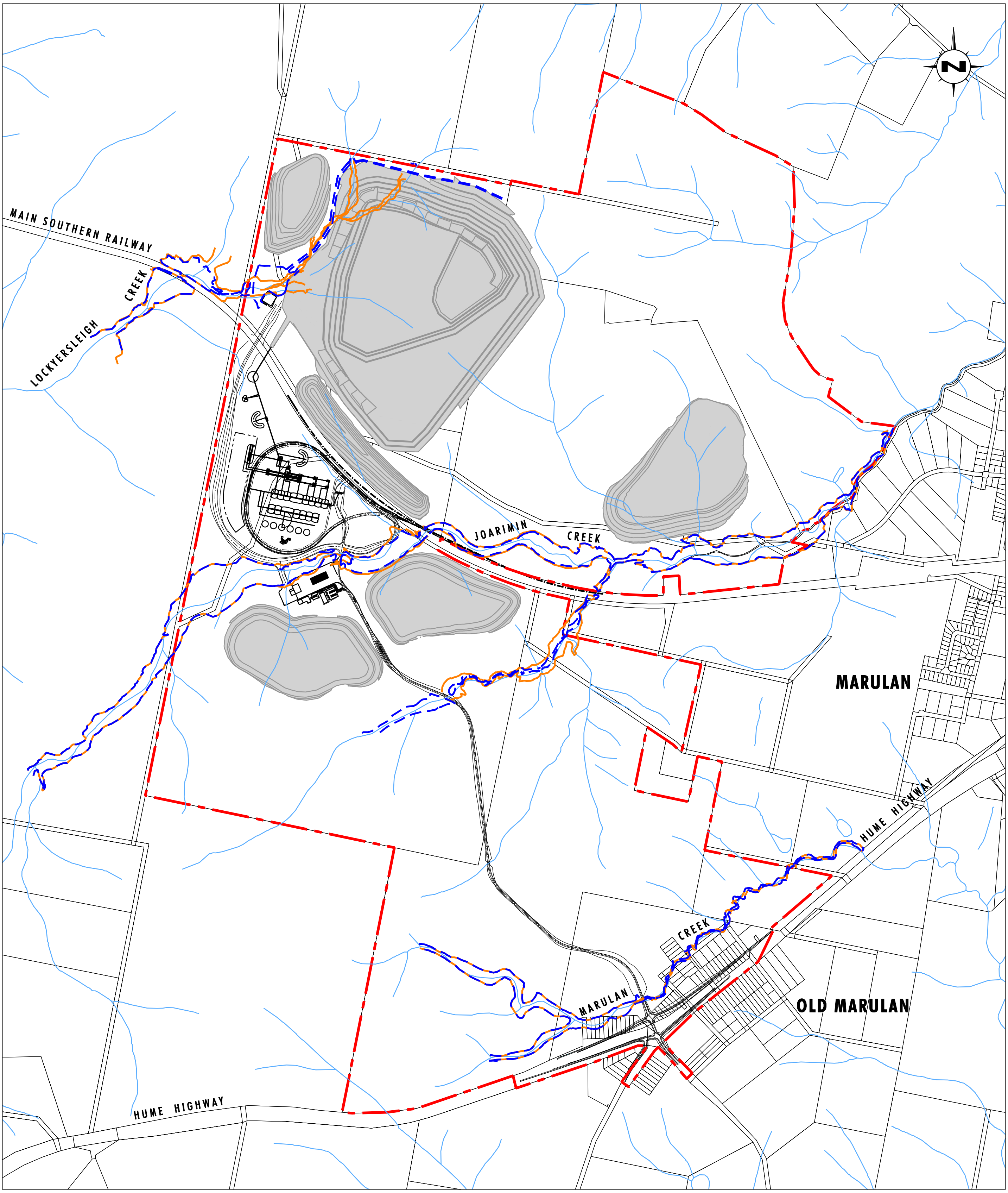

Base Source: LPI 2004, Readymix Holdings Pty Ltd

0 0.5 1 1.25km

Legend

- Project Area
- Existing 100 Year ARI Storm Event Flood Extent
- Developed Year 30 100 Year ARI Storm Event Flood Extent

FIGURE 4.4

Flood Extent - Existing and Developed Year 30

Table 4.3 - Modelling Results – Joarimin Creek - 1:20 year ARI storm event

Node	Existing Joarimin Creek			Developed Year 30 Joarimin Creek		
	Peak Flow in upstream reach (m^3/s)	Peak Velocity in upstream reach (m/s)	Peak Water Level at Node (mAHD)	Peak Flow in upstream reach (m^3/s)	Peak Velocity in upstream reach (m/s)	Peak Water Level at Node (mAHD)
1	31.8	2.3	629.9	25.1	2.1	629.7
4	17.6	1.6	638.9	11.5	1.3	638.9
4.2 (tributary)	8.5	2.5	640.6	9.1	2.5	640.6
7	14.1	1.7	652.3	10.6	1.5	652.3

Modelling indicates that peak flow rates, peak velocities and peak water levels in Joarimin Creek for the 1:100 year ARI and 1:20 year ARI storm events with the proposed Year 30 quarry footprint are similar to, but slightly less than, modelled flows in the existing Joarimin Creek system for all except one node. Modelling indicates that a 7% increase in flow through Node 4.2 will occur during a 1:20 year ARI storm event. Node 4.2 is located on a tributary to the main channel of Joarimin Creek immediately downslope of the proposed Eastern Excess Product Emplacement Area (refer to **Figure 4.1**). However, this increase in peak discharge has negligible effect on velocities and flood levels and by Node 4 (which is located downstream on Joarimin Creek) (refer to **Table 4.3**) peak flows and velocities for the developed scenario are less than for the existing situation.

The proposed realignment of Joarimin Creek immediately upstream of the Main Southern Railway (Node 7) will reduce peak discharges and velocities at the Main Southern Railway (refer to **Tables 4.2** and **4.3**). Modelling indicates that this reduction in peak flows will not impact on flood levels downstream of the site.

4.1.3 Lockyersleigh Creek Catchment

The objectives of water management controls within Lockyersleigh Creek catchment are to divert flows around the proposed emplacement areas, control runoff from a proportion of the site and catchment areas upslope for reuse and ensure dirty water is treated prior to potential release off site.

Modelling of the flows for the 1:100 year ARI storm event indicates that a storm duration of three hours gives a peak discharge at the project boundary of 7.2 m^3/s and a storm duration of nine hours a peak discharge of 7.5 m^3/s. As such a critical storm duration of nine hours has been chosen for the model. A critical storm duration of nine hours was also used for the 1:20 year ARI storm event and generated a peak discharge of 5.3 m^3/s on Lockyersleigh Creek at the downstream boundary of the project area.

To divert water from upslope of the proposed quarry pit and enable capture of the runoff from the Year 30 footprint a series of drains, sedimentation and water storage dams will be required (refer to **Figures 3.3** to **3.5**). Several of these drains and dams are located within the Lockyersleigh Creek catchment area and have been included in the model of the Year 30 footprint impact. In general, all diversion drains have been designed with 1:3 side slopes and to keep peak velocities in the drains less than 1.5 m/s (refer to **Section 4.4.2**).

Hydrographs for selected sections of the existing Lockyersleigh Creek system and the creek system with the proposed quarry at Year 30, are included in **Appendix D**. Results summarising peak flow, peak velocity and peak water levels for Lockyersleigh Creek are detailed in **Tables 4.4** and **4.5**. Node locations are shown on **Figure 4.2**. The modelled flood extent for the 100 year ARI storm event for the existing and developed scenarios for Lockyersleigh Creek is shown on **Figure 4.4**.

Table 4.4 - Modelling Results – Lockyersleigh Creek - 1:100 year ARI storm event

Node	Existing Lockyersleigh Creek			Developed Year 30 Lockyersleigh Creek		
	Peak Flow in upstream reach (m^3/s)	Peak Velocity in upstream reach (m/s)	Peak Water Level at Node (mAHD)	Peak Flow in upstream reach (m^3/s)	Peak Velocity in upstream reach (m/s)	Peak Water Level at Node (mAHD)
1	10.5	2.0	649.8	7.3	1.7	649.7
1.1	7.5	1.1	654.9	4.7	1.0	654.9
1.4	4.4	2.2	662.0	3.0	1.2	661.6

Table 4.5 - Modelling Results – Lockyersleigh Creek - 1:20 year ARI storm event

Node	Existing Lockyersleigh Creek			Developed Year 30 Lockyersleigh Creek		
	Peak Flow in upstream reach (m^3/s)	Peak Velocity in upstream reach (m/s)	Peak Water Level at Node (mAHD)	Peak Flow in upstream reach (m^3/s)	Peak Velocity in upstream reach (m/s)	Peak Water Level at Node (mAHD)
1	7.3	1.7	649.7	5.2	1.5	649.7
1.1	5.3	1.1	654.9	3.4	1.0	654.8
1.4	3.3	2.1	661.9	2.2	1.1	661.5

Modelling indicates that peak flow rates, peak velocities and peak water levels in Lockyersleigh Creek for the 1:100 year ARI and 1:20 year ARI storm events with the proposed Year 30 quarry footprint are similar to but slightly less than modelled flows in the existing Lockyersleigh Creek system.

4.1.4 Marulan Creek Catchment

The objective of water management controls within Marulan Creek catchment is to ensure that flows in the system are not adversely affected as a result of construction of the access road to the proposed Lynwood Quarry (refer to **Figures 1.4** to **1.6**).

Modelling of the flows for the 1:100 year ARI storm event indicates that a storm duration of three hours gives a peak discharge of 9.5 m^3/s at the project boundary whereas a storm duration of nine hours gives a peak discharge of 10.2 m^3/s. As such the critical storm duration chosen for the catchment is nine hours. A critical storm duration of nine hours was also used for the 1:20 year ARI storm event and generated a peak discharge on Marulan Creek of 8.1 m^3/s at the downstream boundary of the project area.

A culvert will be required to convey water from upstream of the proposed access road. The conceptual design characteristics of the proposed culvert are detailed in **Appendix E**. At this crossing, the culverts will be placed approximately 300 mm deeper than the existing bed of the creek and then backfilled to original bed level with rock. Rock will also be placed upstream and downstream of the culvert to prevent localised scouring. The soils in this area will be treated with gypsum to reduce dispersibility and improve soil structure. The disturbed area will also be topsoiled and seeded with grass species to aid stability. This will assist in maintaining a natural creek bed and reducing erosion along Marulan Creek.

Hydrographs for selected sections of the existing Marulan Creek system and the creek system with the proposed quarry, are included in **Appendix D**. Results summarising peak flow, peak velocity and peak water levels for Marulan Creek are detailed in **Tables 4.6** and **4.7**. Node locations are shown on **Figure 4.3**.

Table 4.6 - Modelling Results – Marulan Creek - 1:100 year ARI storm event

Node	Existing Marulan Creek			Developed Year 30 Marulan Creek		
	Peak Flow in upstream reach (m^3/s)	Peak Velocity in upstream reach (m/s)	Peak Water Level at Node (mAHD)	Peak Flow in upstream reach ($^3/s$)	Peak Velocity in upstream reach (m/s)	Peak Water Level at Node (mAHD)
1	10.2	1.6	632.4	10.4	1.5	632.3
4	6.0	2.1	648.7	6.0	2.4	650.1

Table 4.7 - Modelling Results – Marulan Creek - 1:20 year ARI storm event

Node	Existing Marulan Creek			Developed Year 30 Marulan Creek		
	Peak Flow in upstream reach (m^3/s)	Peak Velocity in upstream reach (m/s)	Peak Water Level at Node (mAHD)	Peak Flow in upstream reach (m^3/s)	Peak Velocity in upstream reach (m/s)	Peak Water Level at Node (mAHD)
1	8.1	1.5	632.3	8.3	1.5	632.3
4	4.7	2.1	648.6	4.7	2.4	648.5

Modelling indicates that peak velocities and peak water levels in Marulan Creek for the 1:100 year ARI storm event at the quarry boundary are reduced with the proposed development. There is an increase in flood level upstream of Node 4 which is immediately upstream of the access road culvert. The change in extent of flooding is shown on **Figure 4.4**.

Modelling indicates that peak flow rates for the 1:20 year ARI storm event with the proposed Year 30 quarry footprint are similar but increased at the project boundary. Modelling indicates an increase in peak discharges from the project area for the 1:20 year ARI storm event will increase peak flood levels up to by 6 mm downstream of the site which will not increase the flooding extent.

4.2 ANNUAL FLOW VOLUMES

The proposed capture of runoff from the Year 30 quarry footprint for treatment and on site use will impact annual flow volumes in Joarimin and Lockyersleigh Creeks. The outputs from the water balance model (refer to **Section 3.4**) have been used to determine the potential impact the proposal may have on annual flow volumes in Joarimin and Lockyersleigh Creeks. The impacts on annual flow volumes have been calculated for Year 2, Year 5, Year 12, Year 20 and Year 30 of the proposed quarry operations.

Tables 4.8 and **4.9** show the potential reduction in annual flow volumes in Joarimin Creek at the quarry boundary and at Johniefelds Dam (refer to **Figure 2.1**). **Tables 4.10** and **4.11** show the potential reduction in annual flow volumes in Lockyersleigh Creek at the project area boundary, approximately 1 kilometre downstream. (Note: As discussed in the main text of the EIS, Readymix is currently finalising an agreement to lease an approximately 1 kilometre buffer of land to the west of the project area for the life of the quarry.) **Table 4.12** shows the potential reduction in annual flow volumes in Wollondilly River downstream of the confluence with Joarimin Creek. It has been assumed that overflows from the water management system will be proportional to the catchment area captured within the water management system. As such it has been assumed that 60% of overflows from the water management system will be to Joarimin Creek and 40% of overflow to Lockyersleigh Creek.

Table 4.8 - Predicted Reduction in Average Annual Flow Volumes at Project Area Boundary - Joarimin Creek

Scenario	Year 1	Year 5	Year 12	Year 20	Year 30
Dry Rainfall Year	15%	25%	25%	25%	24%
Average Rainfall Year	11%	20%	21%	20%	19%
Wet Rainfall Year	6%	12%	13%	12%	11%

Table 4.9 - Predicted Reduction in Average Annual Flow Volumes at Johniefelds Dam - Joarimin Creek

Scenario	Year 1	Year 5	Year 12	Year 20	Year 30
Dry Rainfall Year	5%	8%	8%	8%	8%
Average Rainfall Year	4%	7%	7%	7%	6%
Wet Rainfall Year	2%	4%	4%	4%	4%

Table 4.10 - Predicted Reduction in Annual Flow Volumes at Project Area Boundary – LockyersleighCreek

Scenario	Year 2	Year 5	Year 12	Year 20	Year 30
Dry Rainfall Year	91%	93%	93%	93%	92%
Average Rainfall Year	62%	73%	77%	72%	66%
Wet Rainfall Year	31%	38%	41%	37%	33%

Table 4.11 - Predicted Reduction in Average Annual Flow Volumes at Buffer Area Boundary – LockyersleighCreek

Scenario	Year 1	Year 5	Year 12	Year 20	Year 30
Dry Rainfall Year	24%	33%	33%	33%	32%
Average Rainfall Year	20%	28%	29%	28%	27%
Wet Rainfall Year	16%	21%	21%	21%	20%

Table 4.12 - Predicted Reduction in Average Annual Flow Volumes at Wollondilly River Confluence – Lockyersleigh Creek

Scenario	Year 1	Year 5	Year 12	Year 20	Year 30
Dry Rainfall Year	3%	6%	6%	6%	6%
Average Rainfall Year	2%	5%	5%	5%	4%
Wet Rainfall Year	1%	2%	3%	2%	2%

Table 4.13 - Predicted Reduction in Average Annual Flow Volumes in Wollondilly River Downstream of Confluence with Joarimin Creek

Scenario	Year 1	Year 5	Year 12	Year 20	Year 30
Dry Rainfall Year	0.1%	0.1%	0.1%	0.1%	0.1%
Average Rainfall Year	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
Wet Rainfall Year	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%

The tables above indicate that the reduction in annual flow volumes for Joarimin Creek at the project area boundary will range from 6% to 25%, with the reduction in annual flow volumes at Johniefelds Dam being between 2% and 8%.

Similarly, the tables above indicate that the reduction in annual flow volumes for Lockyersleigh Creek at the project area boundary will range from 31% to 93% and at 1 kilometre downstream of the project area boundary will range from 16% to 33%. The reduction in annual flow volumes at the confluence of Lockyersleigh Creek with the Wollondilly River is between 1% and 6%.

Table 4.13 indicates that the estimated reduction in annual flow volumes for dry, average and wet years on the Wollondilly River downstream of the confluence of Joarimin Creek will be less than or equal to 0.1% for the life of the proposed quarry.

4.3 EXTERNAL WATER SOURCING

In order to meet water demands for the future quarry operations at Lynwood, water will be required to be imported from sources external to the quarry in dry rainfall years. The maximum 10th percentile modelled future water deficit without importing water is 83 ML in a dry rainfall year in Year 12 (refer to **Section 3.4.3**). Details of potential external sources are discussed in **Section 3.2.3**.

4.4 SEDIMENT AND EROSION CONTROL

4.4.1 Construction Phase

Erosion and sediment control measures will be developed as part of the construction plans to satisfy the following objectives:

- comply with appropriate statutory requirements, including the development consent, Environment Protection Licence (EPL), SEPP58 and Sustaining the Catchments (Draft REP);
- carry out all construction in accordance with relevant guidelines for erosion and sediment control, including NSW Department of Housing (1998) and DIPNR (1999);
- identify potential erosion and sedimentation impacts that may occur as a result of construction and associated operations;
- describe mitigation strategies that seek to address the potential impacts identified; and
- develop effective mechanisms for monitoring and maintenance of erosion and sediment control measures.

The measures to be adopted for the construction phase of the project to control water quality of runoff will include the following:

- construction and regular maintenance of catch drains, silt fences and sedimentation basins to contain sediment downslope of disturbed areas;
- construction of all sediment dams required for the proposal early in the construction period;
- seeding and controlled fertilising of all disturbed areas to provide for rapid grass cover. Areas will be seeded with a grass mix specific to the needs of the area to be grassed;

- development of an inspection, maintenance and management system to ensure that the soil and erosion control measures for the construction phase are performing adequately;

- placement of oil separators downslope of high traffic areas and flotation curtains at the outlets of all dams; and

- maintain the mobile concrete plant within a bunded area to ensure control and treatment of runoff from the plant area.

These controls will be designed and constructed to a standard consistent with *Managing Urban Stormwater: Soils and Construction* (NSW Department of Housing 1998) (the Blue Book).

4.4.2 Operational Phase

Water quality measures will be implemented for the project during the operational phase to minimise impact on the surrounding environment. These measures will include:

- clearly identifying and delineating areas required to be disturbed and ensuring that disturbance is limited to those areas, clearing as little vegetation as required and minimising machinery disturbance outside of these areas;

- limiting the number of roads and tracks established;

- construction of sediment dams to capture and treat runoff from disturbed catchment areas. These dams will be designed with a two cell system to enable flocculation of sediment if required to ensure that sediment concentrations of discharge water do no exceed 50 mg/L;

- construction of drains upslope of areas to be disturbed to convey clean runoff away from most disturbed areas;

- constructing access road and earthworks cut and fill batters at slopes of 1V:3H or less, where possible, to maximise long term stability;

- reshaping, topsoiling and vegetating road and cut and fill batters as soon as practical;

- progressively stripping and stockpiling topsoil for later use in rehabilitation;

- diversion of surface and road runoff away from disturbed areas;

- regular maintenance of all erosion control works and rehabilitated areas;

- regular inspections of access tracks/roads to ensure that drainage is working effectively and that the tracks/roads are stable, particularly after rain;

- prompt revegetation of areas as soon as earthworks are complete; and

- placement of oil separators downslope of all high traffic areas and placement of flotation curtains at the outlets of all dams.

Specific controls have been designed for the site and these are outlined in **Section 4.4.2.2**.

4.4.2.1 General Erosion and Sediment Control Measures

The proposed quarry will result in ongoing disturbance and handling of soils, overburden material and excess product material within the project area. In order to mitigate the erosion and sediment export potential from disturbed areas appropriate controls will be implemented.

Erosion and sediment control measures will be developed as part of the operational plans to satisfy the following objectives:

- comply with appropriate statutory requirements, including the development consent, Environment Protection Licence (EPL), SEPP58 and Sustaining the Catchments (Draft REP);
- carry out all construction in accordance with relevant guidelines for erosion and sediment control, including NSW Department of Housing (1998) and DIPNR guidelines;
- identify potential erosion and sedimentation impacts that may occur as a result of quarrying and associated operations;
- describe mitigation strategies that seek to address the potential impacts identified; and
- develop effective mechanisms for monitoring and maintenance of erosion and sediment control measures.

These controls will be designed and constructed to a standard consistent with *Managing Urban Stormwater: Soils and Construction* (NSW Department of Housing 1998) (the Blue Book) and Guidelines for Establishing Drainage Lines on Rehabilitated Minesites (Draft) (DLWC, 1999).

In addition to these project specific controls, Readymix will also implement a program of rehabilitation works along existing drainage lines to reduce the current extent of bank and bed erosion and associated sediment transport. Details of the proposed rehabilitation works including the development of a Property Management Plan are included in the main text of the EIS.

4.4.2.2 Infrastructure and Emplacement Areas

A series of catch drains will be established to convey runoff from the overburden emplacement areas to sedimentation dams. The catch drains have been designed to convey peak discharges from critical duration 1 in 20 year ARI storm events and will provide a minimum of 0.5 metre freeboard. In addition, a series of catch drains will be constructed to limit the potential for erosion at the base of emplacement areas or along the top of the pit wall. It is proposed to rehabilitate all overburden emplacement areas within six months of placement of the final landform surface.

All catchments serviced by the catch drains will be small and as a consequence flow durations following critical storm events will be short. All catch drains will be grassed and will be constructed to convey peak discharges during a 1 in 20 year ARI event at less than erosive velocities for the respective materials.

All catch drains have been designed for two phases of rehabilitation after construction has occurred. Phase 1 is the pre-vegetative stage which occurs in the period from 0 to 5 years after construction for which a runoff coefficient of 0.7 has been used. Phase 2 is the post-vegetative stage which occurs in the period greater than 5 years from construction. For this stage a runoff coefficient of 0.35 has been used. This approach is consistent with (Draft) Guideline for Establishing Stable Draining Lines on Rehabilitated Mine Sites (DLWC, 1999), although it is proposed to complete initial rehabilitation works on the overburden emplacement areas within six months of construction. The layout for the catch drains is provided on **Figures 4.5** to **4.10**. Catch drain design specifications are provided in **Appendix E**.

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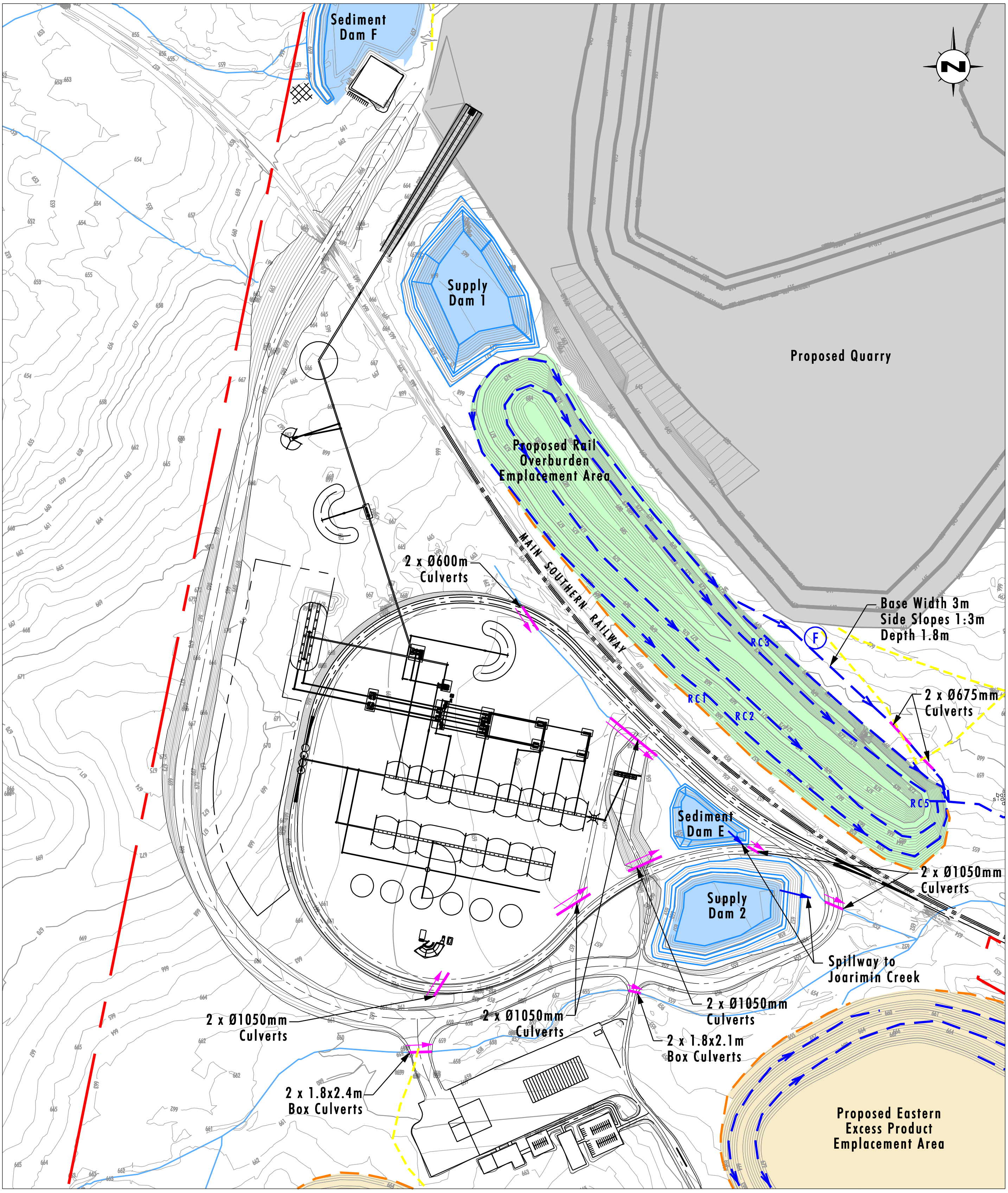


Base Source: LPI 2004, Readymix Holdings Pty Ltd

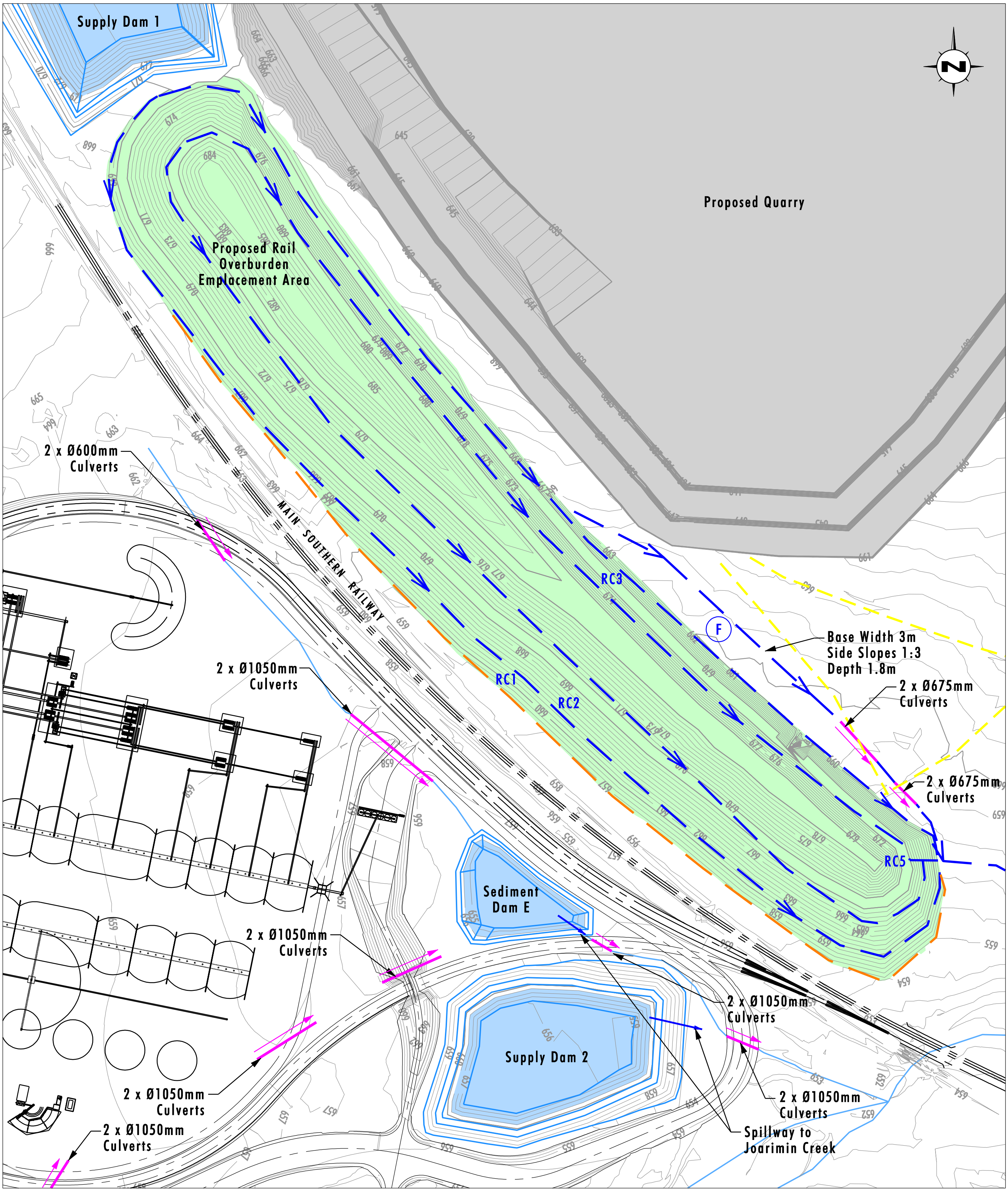
Legend

- Project Area
- Catch Drain
- Sediment Fence
- Culvert
- Direction of Flow
- Haul Road

FIGURE 4.5

Proposed Infrastructure Area Sediment and Erosion Controls

File Name (A4): R04_V1/1829_172.dgn



Base Source: LPI 2004, Readymix Holdings Pty Ltd

Legend

- Catch Drain
- Sediment Fence
- Culvert
- Direction of Flow
- Haul Road

FIGURE 4.6

Proposed Rail Overburden Emplacement Erosion and Sediment Controls

File Name (A4): R04_V1/1829_155.dgn

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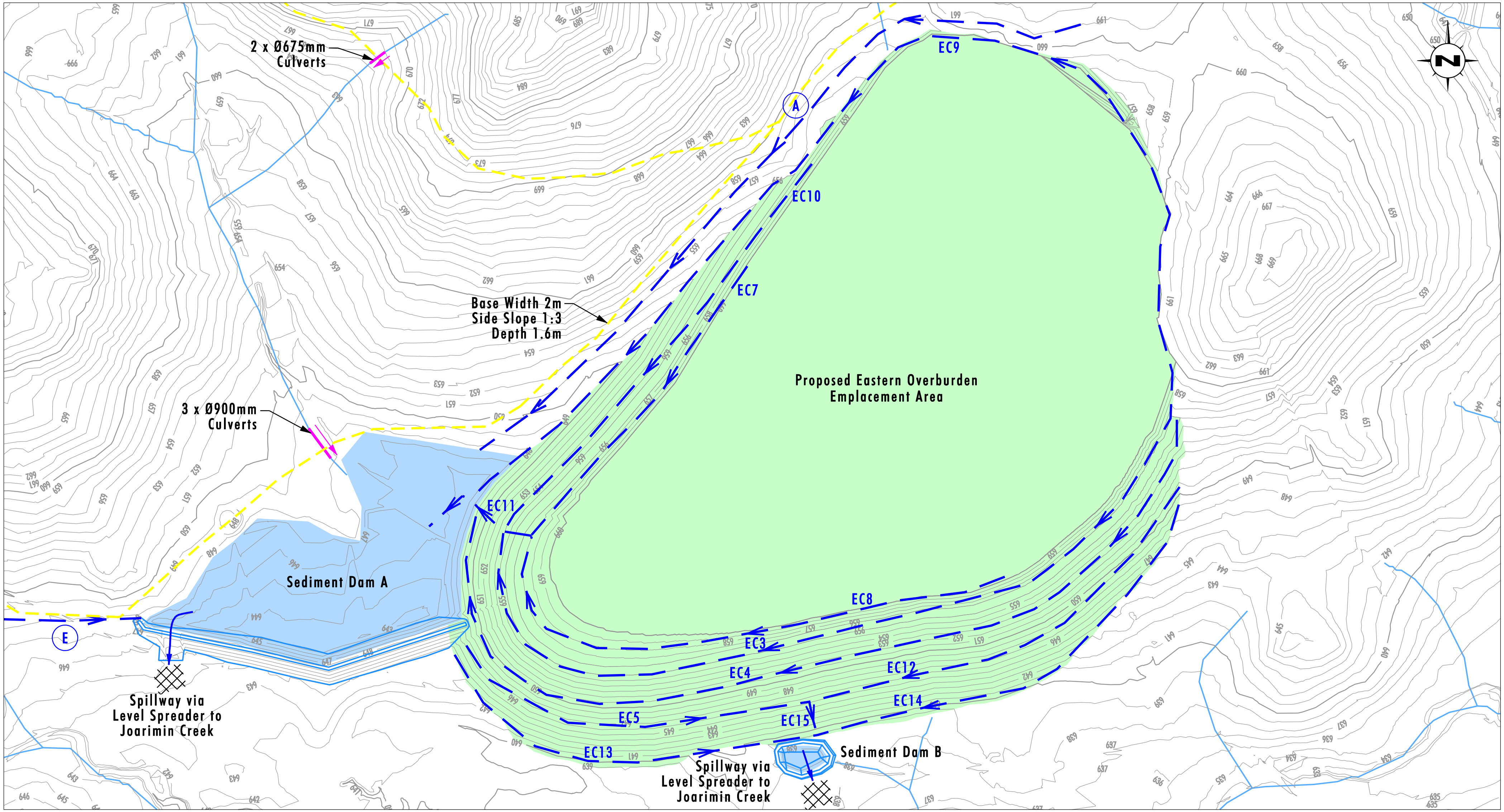

Base Source: LPI 2004, Readymix Holdings Pty Ltd

0 100 200 250m

Legend

- Catch Drain
- Culvert
- Direction of Flow
- Level Spreader
- Haul Road

FIGURE 4.7

Proposed Eastern Overburden Emplacement Erosion and Sediment Controls

File Name (A4): R04_V1/1829_154.dgn

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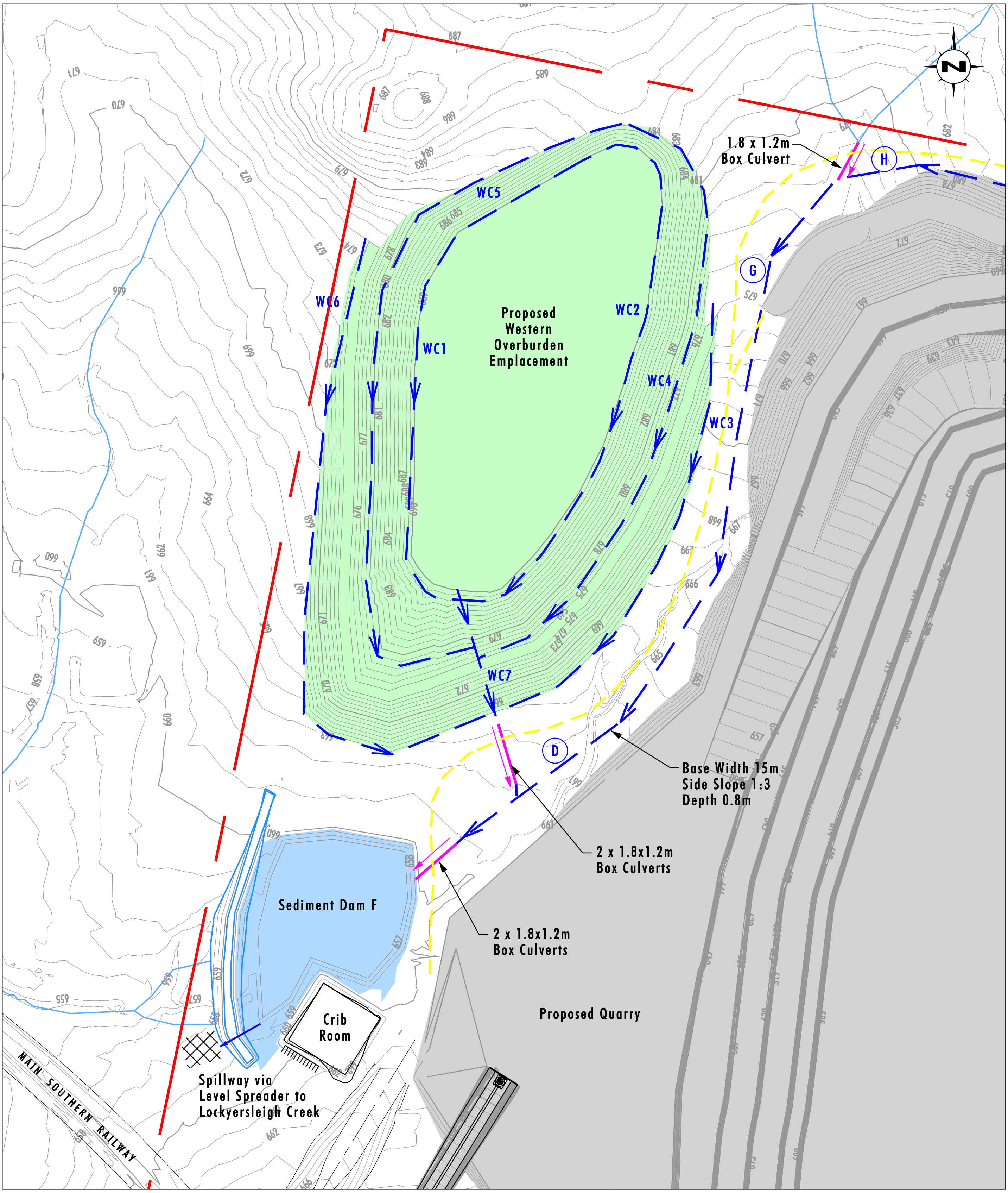

Base Source: LPI 2004, Readymix Holdings Pty Ltd

Legend

- Project Area
- Catch Drain
- Culvert
- Direction of Flow
- Level Spreader
- Haul Road

FIGURE 4.8

Proposed Western Overburden Emplacement Erosion and Sediment Controls

File Name (A4): R04_V1/1829_156.dgn

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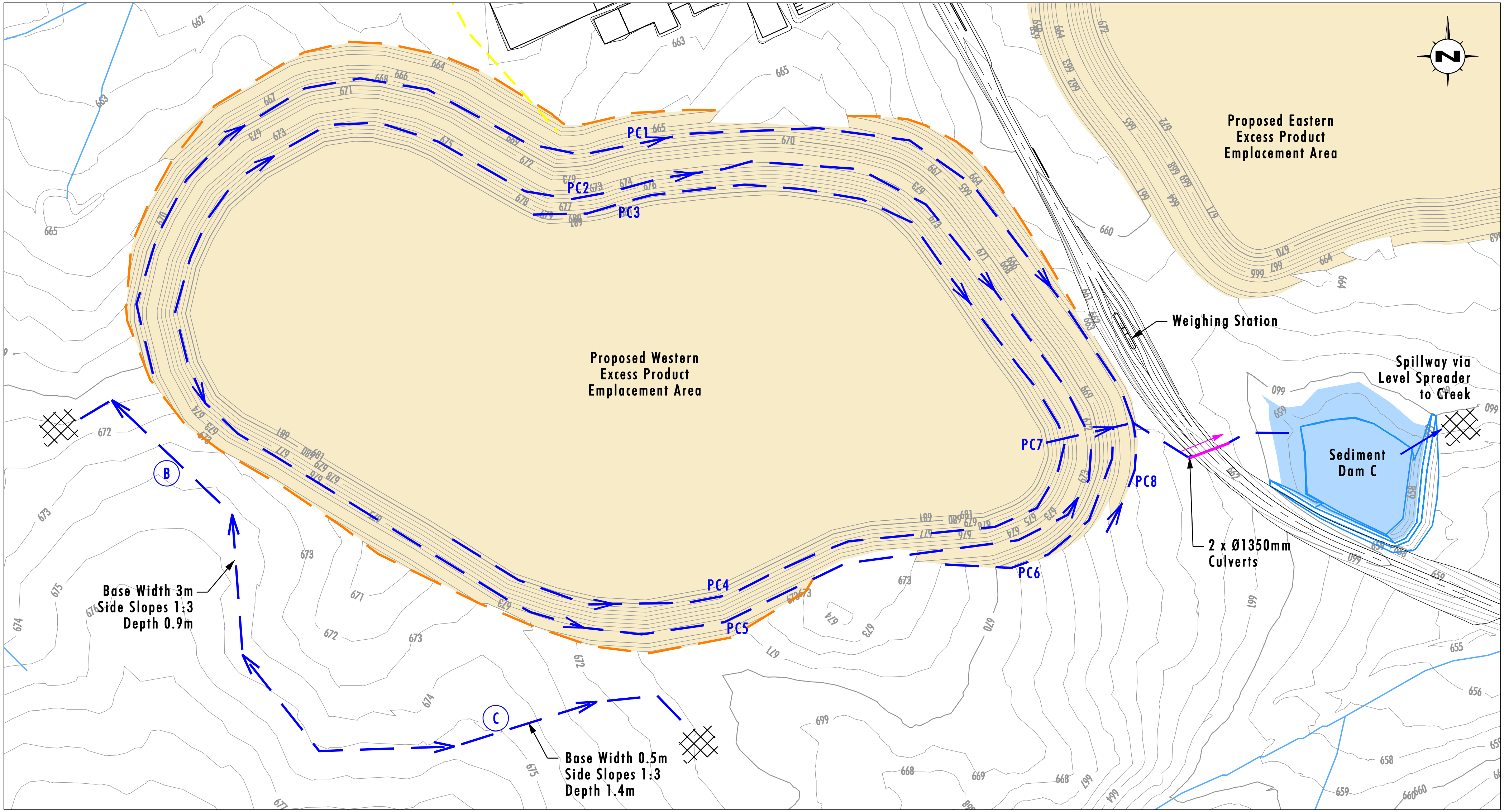

Base Source: LPI 2004, Readymix Holdings Pty Ltd

0 50 100 200m

Legend

- Catch Drain
- Sediment Fence
- Culvert
- Direction of Flow
- Level Spreader
- Haul Road

FIGURE 4.9

Proposed Western Excess Product Emplacement Erosion and Sediment Controls

File Name (A4): R04_V1/1829_157.dgn

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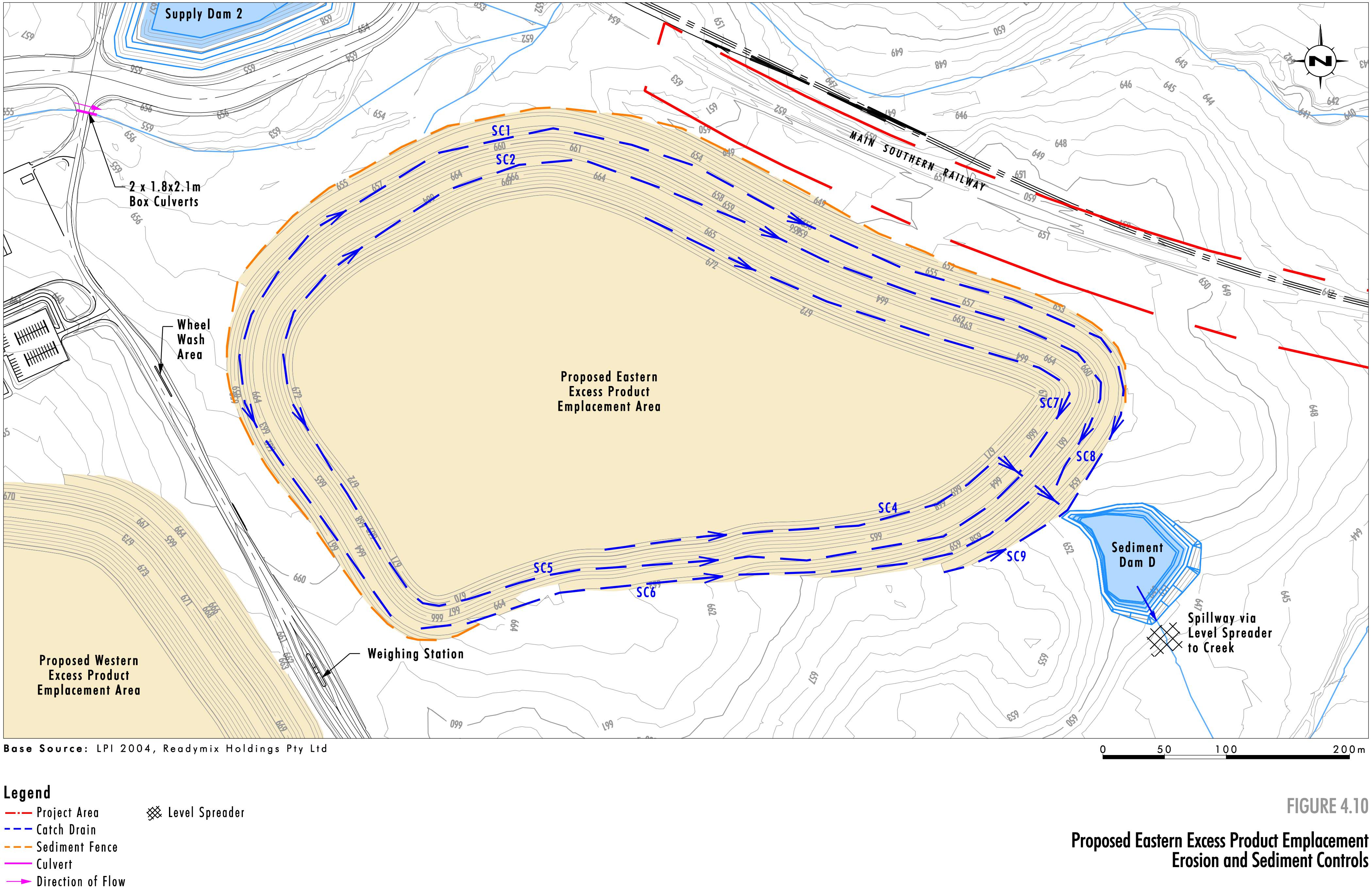

FIGURE 4.10

Proposed Eastern Excess Product Emplacement Erosion and Sediment Controls

File Name (A4): R04_V1/1829_158.dgn

Catch drains will be constructed with 1:3 (v:h) side slopes and grassed channels with base widths varying between 1 metre and 8 metres. Peak velocities will generally be kept below 1.5 m/s. Where peak velocities are likely to exceed 1.5 m/s rock bars will be placed along the drain at intervals no greater than 30 metres to reduce peak velocities, or flumes will be used. In addition, where drains are used in locations where the grade of the drain is in excess of 5% the drain is to be lined with geofabric to reduce the potential for erosion.

The proposed sediment and erosion controls for the overburden emplacement areas, excess product emplacement areas and the infrastructure area are shown on **Figures 4.5** to **4.10**. The indicative sizes and grades of the controls are detailed in **Appendix E**.

Each of the emplacement areas are serviced by a sedimentation dam. Catchment areas, required storage volumes and design criteria for each of these dams are listed in **Tables 4.14** and **4.15**.

Table 4.14 - Sediment Dam Design Criteria

Dam	Catchment Description	Catchment Area (ha)	Maximum Disturbed Area (ha)	Design Type*
A	Eastern Tributary Catchment	203	57	D/F
B	Eastern Overburden Emplacement Area – Southern Region	2	2	D/F
C	Eastern Excess Product Emplacement Area	22	22	C
D	Western Excess Product Emplacement Area	28	28	C
E	Infrastructure Area	48	5	D/F
F	Lockyersleigh Catchment	138	16	D/F

* Design type in accordance with Blue Book (Department of Housing, 1998) requirements

Table 4.15 - Proposed Sediment Dams

Dam	Catchment Description	Minimum Design Requirements*			Selected Design Characteristics	
		Sediment Storage Zone (m^3)	Settling Zone (m^3)	Total Volume (m^3)	Total Design Volume (m^3)	Total Design Surface Area (ha)
A	Eastern Tributary Catchment	3370	37250	40620	70000	4.2
B	Eastern Overburden Emplacement Area – Southern Region	118	367	485	500	0.05
C	Eastern Excess Product Emplacement Area	650	4700	5350	7500	1.0
D	Western Excess Product Emplacement Area	700	5100	5800	7800	0.5
E	Infrastructure Area	100	5700	5800	6300	0.4
F	Lockyersleigh Catchment	925	25320	26245	32000	1.7

* In accordance with Blue Book (Department of Housing, 1998) requirements

Sedimentation dams have been sized in accordance with the minimum requirements of "Managing Urban Stormwater" (The Blue Book) (1998) based on topsoil and overburden characteristics of the proposed quarrying area and the final landform catchment area of each dam. The storage volumes for each of the dams will be required to service runoff based on the soil type and characteristics of the emplacement area and other disturbed catchment areas. This size has been determined assuming a typical soil erodibility factor of 0.04 which is considered suitable for areas which have soils of medium to high erodibility. Generally, design of Type D/F dams is based on the 75th percentile five day rainfall event for the area. Due to the proximity of the disturbance areas to Joarimin and Lockyersleigh Creeks and the receiving waters of the Wollondilly River forming part of Sydney's drinking water supply, the Type D/F dams have been designed for the 90th percentile five day rainfall event for Goulburn. A review of the current proposed design for Sediment Dam A indicates that the design storage volume actually equates to the 98th percentile maximum predicted weekly (seven days) runoff for the catchment area for the dam.

All sediment dams will be maintained in a drawn down state as far as practicable. The basins that will control runoff from overburden emplacement areas, haul roads and the infrastructure area have been designed as Type D/F basins due to the proportion of fines in the soils found in these areas. Soil testing indicates that the soils are not dispersive (refer to **Section 2.2**) however, flocculation of these dams can be provided if required. The water quality of dams and their overflows will be monitored (refer to **Section 6.1**) so that any requirement for flocculation can be identified. Flocculation will be used to ensure that sediment loads from the site are not increased from the existing situation and that overflows have suspended sediments at concentrations of less than 50 mg/L.

Oil separators will be placed downslope of high traffic areas, e.g. within the rail loop and the workshop/road truck parking area, and flotation curtains will be placed at the outlets of all dams in order to protect downstream water quality in the event of oil spillage.

4.4.2.3 Topsoil Stockpiles

Topsoil stockpiles are to be placed within the perimeter of the overburden emplacement area footprints which will be contained within the proposed water management system. Sediment fences are to be placed around the downslope batter of all topsoil stockpiles to reduce the potential for sediment transport from the stockpile.

Stockpiles that are to remain undisturbed for periods of greater than six months are to be grassed.

4.4.3 Landscaping and Rehabilitation

All areas disturbed during construction that are not required for the ongoing operation of the site are to be rehabilitated. This rehabilitation will be undertaken as soon as practicable following the completion of site earthworks and shall include the maximum possible area, and will consist of seeding reshaped and topsoiled areas. An indicative schedule for rehabilitation of the overburden dumps is shown in **Table 4.16**.

Table 4.16 - Indicative Rehabilitation Schedule

Year of Operations	Indicative Overburden Emplacement Area Rehabilitated (ha)		
	Rail Overburden Emplacement Area	Eastern Overburden Emplacement Area	Western Overburden Emplacement Area
1	2.4 (50%)	0 (0%)	0 (0%)
2	5.2 (60%)	0 (0%)	0 (0%)
5	11.8 (100%)	5.5 (60%)	0 (0%)
10	11.8 (100%)	10.8 (60%)	0 (0%)
15	11.8 (100%)	31.4 (100%)	4.8 (60%)
20	11.8 (100%)	31.4 (100%)	6.3 (60%)
25	11.8 (100%)	31.4 (100%)	12.7 (100%)
30	11.8 (100%)	31.4 (100%)	12.7 (100%)

Assuming that the quarry is decommissioned at the end of the current development application period (30 years) all sediment dams will remain in use as farm dams after decommissioning, although the capacity of the dams may be reduced. The two water supply dams will be rehabilitated into the final landform as free draining areas. Catch drains will remain as part of the final landform. Any future development application for continued quarry operations beyond 30 years would include a revision of the existing water management system.

4.5 WATER QUALITY

4.5.1 Existing Pollutant Generation

The Water Quality module of XP-Storm was used to determine the existing annual pollutant generation for phosphorus, nitrogen and suspended solids for the project area for a dry, average and wet rainfall year. The XP-Storm models developed to model peak flows, velocities and flood levels in Joarimin and Lockyersleigh Creeks (refer to **Figures 4.1** and **4.2**) were used with daily rainfall data and daily timesteps in the water quality modelling. XP-Storm is suitable to be used with daily timesteps as the model will, if required, reduce the specified maximum timestep interval to achieve a stable solution.

No water quality pollutant generation data is available for the project area or for the surrounding region that would enable the modelled pollutant and sediment generation to be calibrated. In developing the model, the following values were used to model the pollutant generation rates for the existing landscape:

- event mean concentration (EMC) of 0.22 mg/L for phosphorus (NSW EPA, 1996);
- EMC of 2.4 mg/L for nitrogen (NSW EPA, 1996);
- soil factor ‘K’ of 0.04;
- control practice (P) for existing landscape of 0.05 (ground cover of pasture);
- crop factor (C) for existing landscape of 1.0 (none);
- area subject to erosion for existing landscape of 10%.

Table 4.17 details the predicted pollutant generation rates for dry, average and wet rainfall years for the existing landscape.

Table 4.17 - Predicted Pollutant Generation Rates for Existing Landscape

Landuse	Pollutant	Dry Rainfall Year	Average Rainfall Year	Wet Rainfall Year
Existing Landform	Total Phosphorus (kg/ha)	0.7	1.0	1.8
Existing Landform	Total Nitrogen (kg/ha)	8	11	19
Existing Landform	Total Suspended Solids (kg/ha)	104	1487	2362

As the disturbed area for the proposal lies generally within the water management system (refer to **Figure 3.1**), the water quality assessment has been carried out for the water management system area. The predicted existing pollutant generation for the area to be captured by the water management system is shown in **Table 4.18**.

Table 4.18 - Predicted Existing Pollutant Generation for Water Management System Area

Pollutant	Dry Rainfall Year	Average Rainfall Year	Wet Rainfall Year
Total Phosphorus (kg)	288	411	740
Total Nitrogen (kg)	3288	4521	7809
Total Suspended Solids (kg)	42744	611157	970782

4.5.2 Predicted Pollutant Generation

Based on the stage quarry plans and the associated changes to land use and catchment areas, the predicted pollutant generation for the area to be captured by the water management system was determined over the proposed 30 year life of the quarry.

The following values were used in the modelling to determine pollutant generation rates from the disturbed areas (i.e. emplacement areas, haul roads and infrastructure area):

- EMC of 0.22 mg/L for phosphorus (NSW EPA, 1996);
- EMC of 2.4 mg/L for nitrogen (NSW EPA, 1996);
- soil factor 'K' of 0.04;
- control practice (P) for existing landscape of 0.9 (compact, smooth, ripped with bulldozer across slope);
- crop factor (C) for existing landscape of 0.4 (temporary seedlings, first 60 days); and
- area subject to erosion of 25%.

The modelling indicates suspended solid generation rates from the disturbed areas will be approximately 793 kg/ha for a dry rainfall year, 3065 kg/ha for an average rainfall year and 7661 kg/ha for a wet rainfall year.

The predicted pollutant generation for Years 2, 5, 10, 15, 20, 25 and 30 was determined and the results are provided in **Appendix E**. A summary of the water quality assessment findings is included in **Section 4.5.3**.

4.5.3 Water Quality Assessment

The assessment (refer to **Appendix F**) predicts a net decrease in total phosphorus and total nitrogen generated within the water management system capture area throughout the 30 year quarry life by up to 199 kg per year and 2.0 tonnes per year respectively. The assessment indicates a predicted net increase in generated total suspended solids within the water management system area for the early years of the proposed quarry, however, this initial calculation does not take into account the treatment effect of the sediment dams. The maximum modelled increase in sediment generation within the water management system is 19.7 tonnes per year (2%) for a wet rainfall year during Year 2 of operations. The increase in suspended solids is due to the increase in disturbed areas in the catchment and equates to a total suspended sediment generation of 990.7 tonnes within the water management system capture area during Year 2 of operations. These increases are predicted in runoff into the proposed sediment dam system and, as discussed above, do not take into account sediment retention or treatment in the sediment dam system.

The water balance modelling indicates that no overflows will occur from the water management system after Year 3 of the project during a dry rainfall year. The six sediment dams proposed for the project have a combined sediment storage capacity of 5862 m^3 (refer to **Table 4.14**). This equates to capacity to store approximately 12900 tonnes of sediment. As such, the sediment dams have sufficient sediment storage capacity for up to 13 years of sediment generation at the maximum predicted rate of 990.7 tonnes per year.

During average and wet rainfall years there is a predicted surplus of up to 421 ML/year of water that may overflow from the sediment dams. As such, 21.05 tonnes of sediment may be transported from the sediment dams with these overflows, based on a maximum suspended sediment load of 50 mg/L in overflows from the dams. As such, during these years the sediment dams will be required to capture up to 969.7 tonnes of sediment. This equates to a reduction in the sediment transported from the site of 969.7 tonnes per year.

Associated with the suspended sediment load in overflows from the sediment dams will be phosphorus that will be bound to the suspended sediment. Soil testing in the project area indicates that phosphorus levels in the overburden may range up to 200 mg/kg. On this basis a maximum of 4.21 kg of phosphorus will be released from the water management system bound to the 21.05 tonnes of suspended sediment. This phosphorus will be in particulate form, bound to the sediment particles and not readily available to plants. Based on the assessment there will be a net decrease in phosphorus generation of up to 2.0 tonnes per annum by Year 30 of the proposed quarry operation and as such it is considered that there will be no net increase in annual phosphorus loads from the project area.

In addition to the water quality controls for the water management system, improvements in water quality will be gained by rehabilitation and stabilisation works proposed over the balance of the project area outside the water management system. These works will be detailed in a Property Management Plan developed for the project area.

On this basis it is considered that overall, the project will have a beneficial effect on water quality in the downstream creeks and in the Wollondilly River. The beneficial effect is due to reduction of sediment, nitrogen and phosphorus loads leaving the project area by reuse of water in the plant and for dust suppression, and treatment of water prior to release from the water management system.

4.6 IMPACT ON EXISTING ENVIRONMENT

4.6.1 Joarimin Creek

Modelling indicates that during large storm events (i.e. 1:100 year or 1:20 year ARI storm events), if overflows occurred from the sedimentation dams, the impact on the downstream reaches of the creek in terms of peak discharge or flow velocity would not be increased from the current situation. Modelling indicates that there will be a reduced flooding impact on downstream areas of Joarimin Creek.

Space constraints regarding the placement of the rail loop and other quarry infrastructure will require two creek crossings and realignment of Joarimin Creek for approximately 180 metres. These works will result in decreases in peak flows and velocities during the 1:100 year and 1:20 year ARI storm events. This proposed realignment will not increase flood levels, flows or velocities downstream of the site.

Control of runoff within the proposed Year 30 quarry footprint of the nominated areas of Joarimin Creek catchment will reduce the annual volume of water that flows down the creek, however it is unlikely to have a sizeable impact on the frequency of flows within the system. Joarimin Creek is an intermittent stream and its natural condition exhibits prolonged periods without flow. During these periods aquatic habitat within Joarimin Creek is restricted to small permanent and semi-permanent water holes. As the volume of stored water in each of these holes is small, the volume of water stored in the system is small, as is the volume required to fill the holes. As a result, diversion of a section of the upstream catchment is unlikely to have a significant impact on the volume and quality of water that is ponded along Joarimin Creek, particularly due to the fact that stream flow is extremely intermittent and of short duration.

External supply of water from Johniefelds Dam, should this option be utilised, would be under an existing licence allocation and will not change impacts on Joarimin Creek downstream of the dam from those permitted under current licence conditions. Any allocation which Readymix purchases and transfers to the quarry and the associated pumping location will need to be done with the approval of DIPNR and impacts on the selected drainage will be assessed with any licence transfer applications.

The pH in the creek will remain unchanged from the present situation. A proportion of the project area, along the tributaries of Joarimin Creek, that currently exhibits erosion, is located within the perimeter of the proposed site water management system and runoff from these areas will now be treated. All runoff from the disturbed areas will be treated to achieve a design maximum of 50 mg/L of suspended sediment through the use of sediment dams and fences. The sediment dams will be constructed as a twin cell system allowing flocculation of sediment if required. Nitrogen and phosphorus loads from the site will be reduced. Application of fertilisers on rehabilitation areas will be closely monitored and limited to the minimum possible required to ensure growth. The proposed water quality management measures will also ensure that oil/fuel spillages are contained on site with no impact on water quality in the downstream creek.

Taking these matters into consideration, it is considered that the proposal will not have a significant adverse impact on hydrological aspects of the downstream Joarimin Creek ecosystem.

There are currently no surface water licences downstream of the project area on Joarimin Creek, until Johniefelds Dam (refer to **Figure 2.4**). Analysis indicates that the control of runoff from the Year 30 disturbance area, including reuse on site, will reduce overflows from Johniefelds Dam during a dry rainfall year by less than 6.5%. Analysis indicates that this reduction in downstream flow volumes will not decrease the frequency of overflows from that of the existing situation. It is considered that the size of Johniefelds Dam, estimated at 550 ML, will provide a further level of water quality control for flows into the Wollondilly River.

4.6.2 Lockyersleigh Creek

Modelling indicates that during large storm events (i.e. 1:100 year or 1:20 year ARI storm events), if overflows occurred from the sedimentation dams, the impact on the downstream reaches of the creek in terms of peak discharge or flow velocity would not be increased from the current situation.

Control of runoff within the proposed Year 30 quarry footprint of the impacted areas of Lockyersleigh Creek catchment will reduce the annual volume of water that flows down the creek. Lockyersleigh Creek is an intermittent stream and its natural condition exhibits prolonged periods without flow. During these periods, aquatic habitat within Lockyersleigh Creek is restricted to small permanent and semi-permanent water holes. As the volume of stored water in each of these holes is small, the volume of water stored in the system is small, as is the volume required to fill the holes. As a result, diversion of a section of the upstream catchment is unlikely to have a significant impact on the volume and quality of water that is ponded along Lockyersleigh Creek, particularly due to the fact that stream flow is extremely intermittent and of short duration.

Water released from the development will be treated to achieve a maximum total suspended solids concentration (TSS) of 50 mg/L by use sediment control measures, including sediment dams and fences, during both the construction and operational phases of the project. The sediment dams will be constructed as a twin cell system allowing flocculation of sediment if required. Nitrogen and phosphorus loads from the site will be reduced. Application of fertilisers on rehabilitation areas will be closely monitored and limited to the minimum possible required to ensure growth. It is considered that the pH of waters in Lockyersleigh Creek will not be altered from the existing situation by the proposal. The proposed water quality management measures will also ensure that oil/fuel spillages are contained on site with no impact on water quality in the downstream creek.

There are no surface water licences located in Lockyersleigh Creek catchment area. As such, downstream water users will be limited to those not requiring a licence for extraction and will therefore typically rely on the permanent and semi-permanent pools, which will not be significantly affected.

4.6.3 Marulan Creek

Modelling indicates that during large storm events some minor flooding impacts will occur. The majority of these impacts are contained within the site, however, modelling indicates that peak flood levels for the 20 year ARI storm event will increase immediately downstream of the project area by up to 6 mm after development.

Marulan Wastewater Treatment Plant is located within Marulan Creek catchment area (refer to **Figure 2.1**). Treated effluent from the plant is currently disposed of by irrigation of a dedicated area. External supply of water from the wastewater treatment plant to Lynwood Quarry will not impart any additional impacts on Marulan Creek downstream of the wastewater treatment plant.

A range of control measures, including limiting the disturbed area and sediment fences, will be in place to ensure that runoff from the project area is maintained with a design maximum of 50 mg/L of suspended solids. The proposed water quality management measures will also ensure that oil/fuel spillages are contained on site with no impact on water quality in the downstream creek.

Taking these matters into consideration, it is considered that the proposal will not have a significant adverse impact on hydrological aspects of the ecology of the downstream Marulan Creek ecosystem or on downstream water users.

5.0 CUMULATIVE IMPACTS

The proposed Lynwood Quarry will necessitate control of surface runoff from the site and water being imported to meet on-site needs. This will result in a decrease of annual flow volumes immediately downstream of the quarry on both Joarimin and Lockyersleigh Creeks. However, the required water management controls will not increase the flood flows, velocities or depths in Joarimin or Lockyersleigh Creeks from the existing situation. A slight increase in flood level immediately downstream of the project area of up to 6 mm during the 20 year ARI storm event is predicted to occur in Marulan Creek.

The realignment of Joarimin Creek immediately upstream of the Main Southern Railway will result in decreased peak flows and velocities in the reaches downstream of the realignment. The realignment will not cause any increase in flood flows, velocities or levels downstream of the site.

To meet on-site water requirements additional water will be imported from off site through the purchase/utilisation of existing licensed surface water allocations and treated effluent from Marulan Wastewater Treatment Plant.

Environmental flows, sufficient to ensure that similar volumes of water are stored in the small water holes that exist in the creek system will be maintained in the downstream reaches of Joarimin Creek. These flows will be maintained by the substantial catchment areas that will remain undisturbed and free flowing at the boundary of the project area.

As discussed, overflows from the quarry water management system will be managed in accordance with licence conditions for the site.

Runoff from all disturbed areas within the Year 30 quarry footprint will be controlled on site for treatment ensuring sediment transport off site is minimised and maintained below existing pollution loads. There will be a net reduction in pollutant loads from phosphorus and nitrogen from the project area by up to 2.0 tonnes per year and 199 kg per year respectively. In addition, import of treated effluent from Marulan Wastewater Treatment Plant, which is potentially high in nitrates and phosphates, for use within the quarry pit will assist in reducing potential water quality impacts downstream of the existing irrigation area used at the wastewater treatment plant. The proposed water quality management measures will also ensure that oil/fuel spillages are contained on site with no impact on water quality in the downstream creek.

Impacts on the Wollondilly River are estimated as a reduction in annual flow volumes of less than or equal to 0.1%. On this basis it is considered that the proposed development will not result in a significant adverse cumulative impact on water quality or quantity in the Wollondilly River system or the Warragamba Dam catchment.

Modelling undertaken by Peter Dundon and Associates (2005) indicates that the final void of the proposed quarry pit will become an evaporative sink with final water level unlikely to rise above temporary pools in the base of the quarry, which is 80 metres below the final “spill level” of approximately 640 mAHD. As a result, water quality in the final void has negligible potential to impact on water quality of the surrounding drainage system.

6.0 MONITORING, LICENSING AND REPORTING PROCEDURES

6.1 SURFACE WATER MONITORING

A surface water quality monitoring network has been established to provide data as a part of a baseline monitoring program. Surface water quality has been monitored at four locations on Joarimin Creek and two locations on Marulan Creek (shown on **Figure 2.2**) since July 2004, and one location on Lockyersleigh Creek since November 2004. These sites are monitored for flow (by way of comment as streams are ephemeral), pH, electrical conductivity, Total Dissolved Solids (TDS), sodium (Na), chloride (Cl), iron (Fe), manganese (Mn), arsenic (As), nitrite, nitrate, oxidised nitrogen, Total Kjeldahl Nitrogen (TKN), total nitrogen (total N), orthophosphate (ortho P), total phosphorous (total P), Total Petroleum Hydrocarbon (TPH), and Benzene, Toluene, Ethylbenzene, and Xzylene (BTEX).

The monitoring and reporting program will be continued during both the construction and operation phases of the project. Sedimentation basins used during the construction phase of the project will be monitored and inspected after storm events to ensure that they are operating in accordance with design principles.

Once operational, water storage dams and sediment dams will be monitored and metered to ensure that any overflows are to an appropriate standard and in accordance with licence conditions.

All monitoring results will be reported in the Lynwood Quarry annual reports and distributed to DIPNR, DEC and other relevant government agencies, as required by the development consent. All monitoring data will be retained in an appropriate database.

The results of the water quality monitoring will be used to review the effectiveness of the Lynwood Quarry water management systems on an ongoing basis.

Water usage, external sourcing, rainfall on site, dam volumes and overflows will also be monitored for the total operation to enable management of the water system.

6.2 CONTINGENCY MEASURES

The proposed Lynwood Quarry will be a net water user in dry years and potential net water source in average and wet years. As a consequence, there is considerable flexibility in managing the volume of water that is stored on the quarry site and that is imported to the site. There is also reasonable flexibility in where water to supply the needs of quarry operation is sourced providing a wide range of contingency measures that can be implemented. These include varying the rate that water is drawn from external supplies and, if necessary, purchasing additional surface water licences.

During wet rainfall years there is a potential for water to be released from the site. There are also several contingency options available regarding water quality treatment. If additional treatment of water is required either prior to reuse or discharge there is sufficient area able to be allocated on site to increase the treatment time/treatment area of site runoff. In addition, flocculation could be used to assist in settling clay particles prior to reuse or discharge of water.

Recent soil testing indicates that the soils are not dispersive. However, if surface stabilisation is required due to surface rilling, tilling with gypsum or lime and then vegetating may be implemented.

6.3 LICENSING REQUIREMENTS

6.3.1 Rivers and Foreshores Improvement Act 1948

Under the *Rivers and Foreshores Improvement Act* (RFIA) 1948 Part 3A, Protection of Rivers and Lakes, all works that require excavations or removal of material within protected lands or obstruction of flows within protected waters require a permit from DIPNR.

Protected land is land defined as the bank, shore or bed of protected waters, or land that is not more than 40 metres from the top of the bank of protected waters. Protected waters in terms of the proposal refers to any stream of water, whether perennial or intermittent, flowing in a natural channel, or in a natural channel artificially improved, or in an artificial channel which has changed the course of the stream of water.

As such all works within 40 metres of the top of bank of all defined creeklines will require a Part 3A Permit under the RFIA 1948. Proposed works that will be located within potential protected lands are shown on **Figure 6.1** and include realignment of creeks and creek crossings. As part of the development of the quarry all works, where possible, have been kept out of protected lands. A detailed assessment of each site will be undertaken as part of the Part 3A Permit Application.

6.3.2 Water Act 1912 and Water Management Act 2000

As yet no water management plans have been development for either the Wollondilly River or Shoalhaven River and as such the project area is governed by the *Water Act* 1912 until such plans are developed.

Surface water licences will be required as part of the water management system to import water to site. Negotiations regarding securing water licences are currently being undertaken by Readymix.

As groundwater that flows into the quarry pit will need to be dewatered, a licence under Part 5 of the *Water Act* 1912 will also be required for this extraction process.

6.3.3 Protection of the Environment Operations Act 1997

The proposed water management system will be licensed under the *Protection of the Environment Operations Act* 1997 Section 120.

The waters 3.5 kilometres upstream and 0.5 kilometres downstream of the Marulan Water Supply Pumping Station (refer to **Figure 2.1**) are classified as Class S – specially protected waters in the NSW Atlas of Classified Waters (1980). The confluence of Lockyersleigh Creek with the Wollondilly River is located 6.1 kilometres upstream of this zone and the confluence of Joarimin Creek with the Wollondilly River is located 5.3 kilometres downstream of this zone. As such, the receiving water of the Wollondilly River at the confluences of Lockyersleigh Creek and Joarimin Creek is classified as Class P – protected waters in the NSW Atlas of Classified Waters (1980). Joarimin and Lockyersleigh Creeks are not classified waters and therefore there is no constraint to granting of a licence in respect of these waters.

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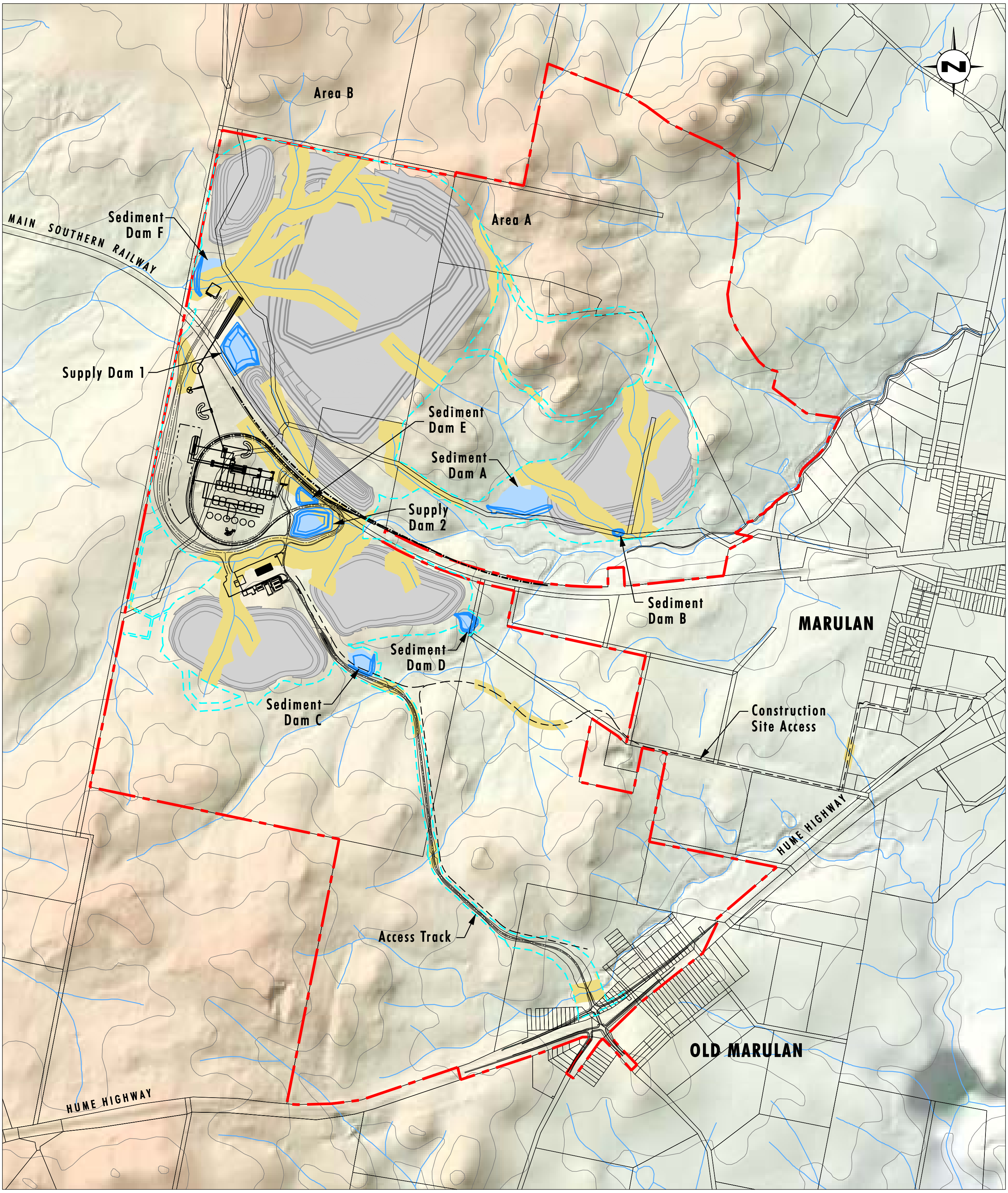

Base Source: LPI 2004, Readymix Holdings Pty Ltd

0 0.5 1 1.25km

Legend

- Project Area
- Approximate Disturbance Footprint
- Disturbed Areas Potentially in Protected Lands

FIGURE 6.1

Potential Part 3A Licensing Areas

7.0 REFERENCES

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Peter Dundon and Associates 2005. Proposed Lynwood Quarry, Marulan - Groundwater Impact Assessment Report prepared for Umwelt (Australia) Pty Ltd.

State Pollution Control Commission 1980. An Atlas of Classified Waters in NSW.

APPENDIX A

Water Quality Monitoring Results

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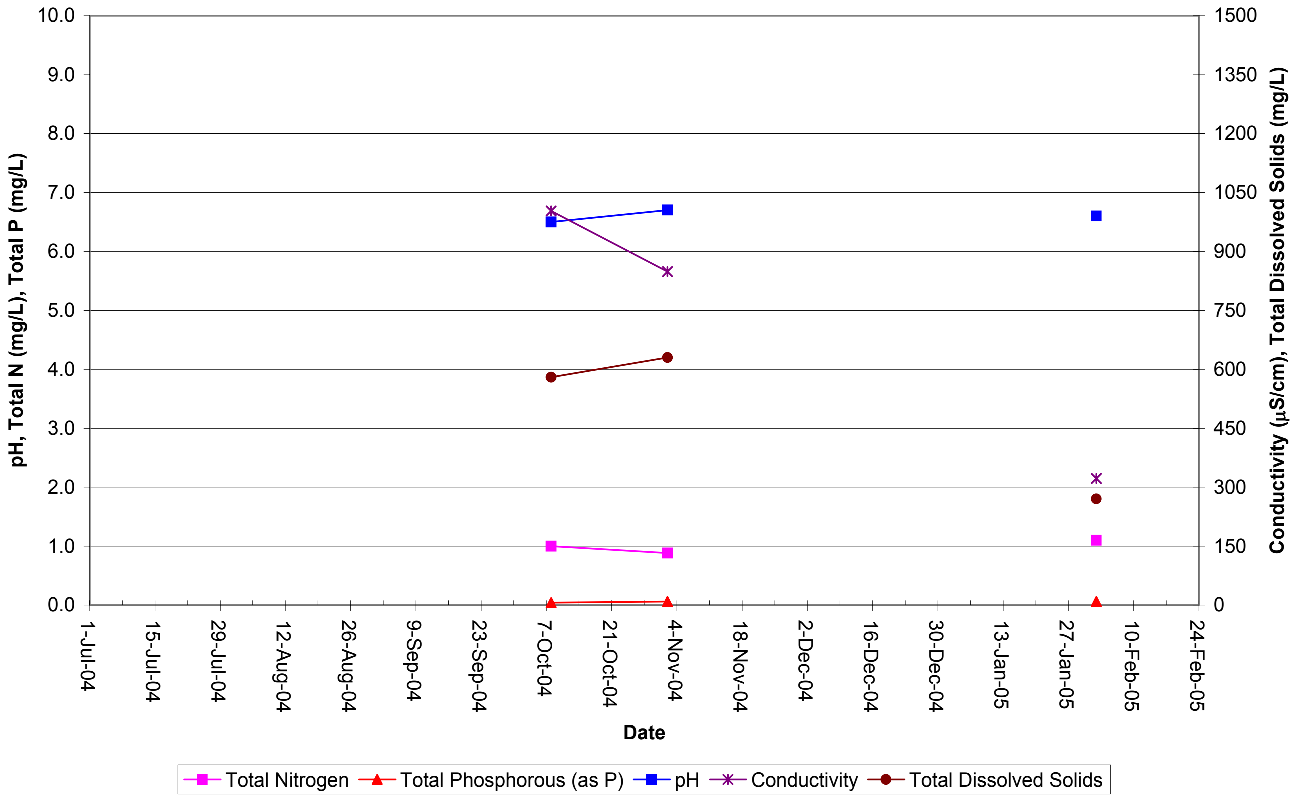
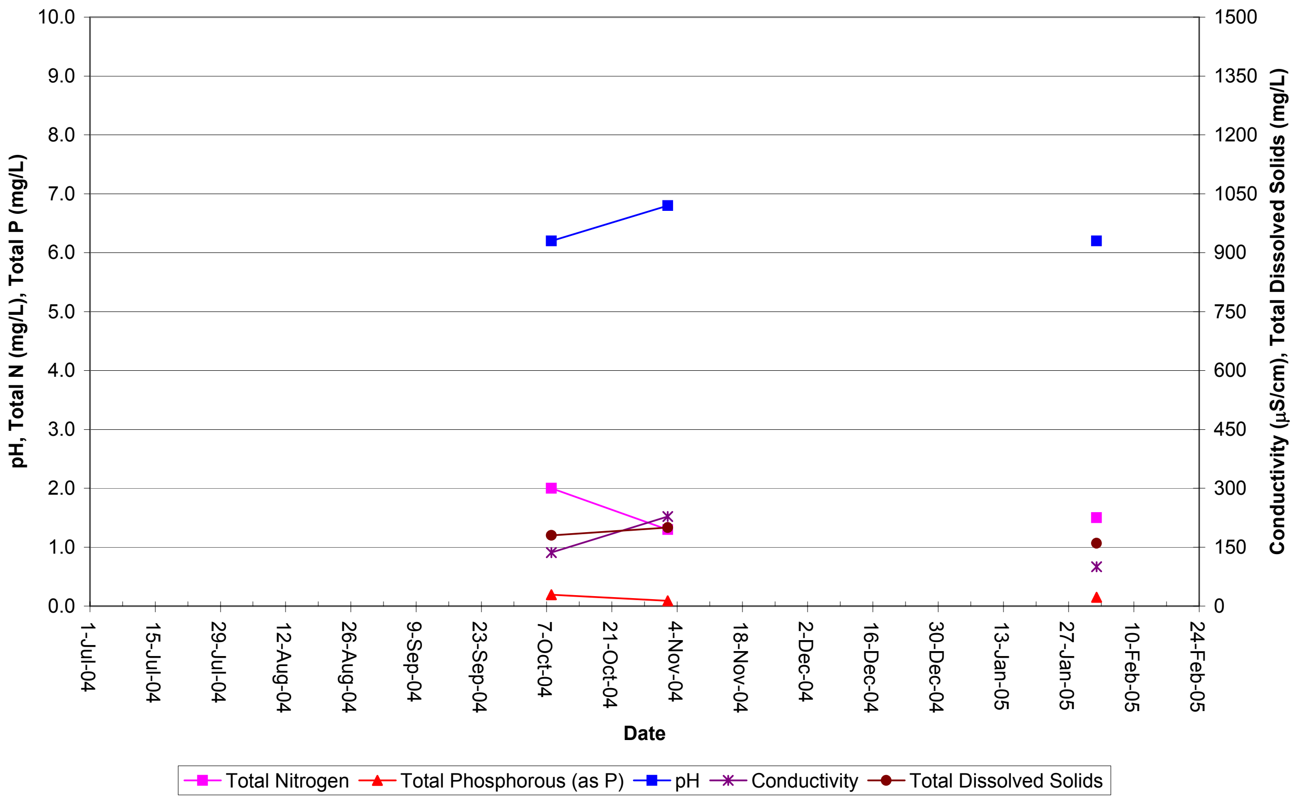


Location 1



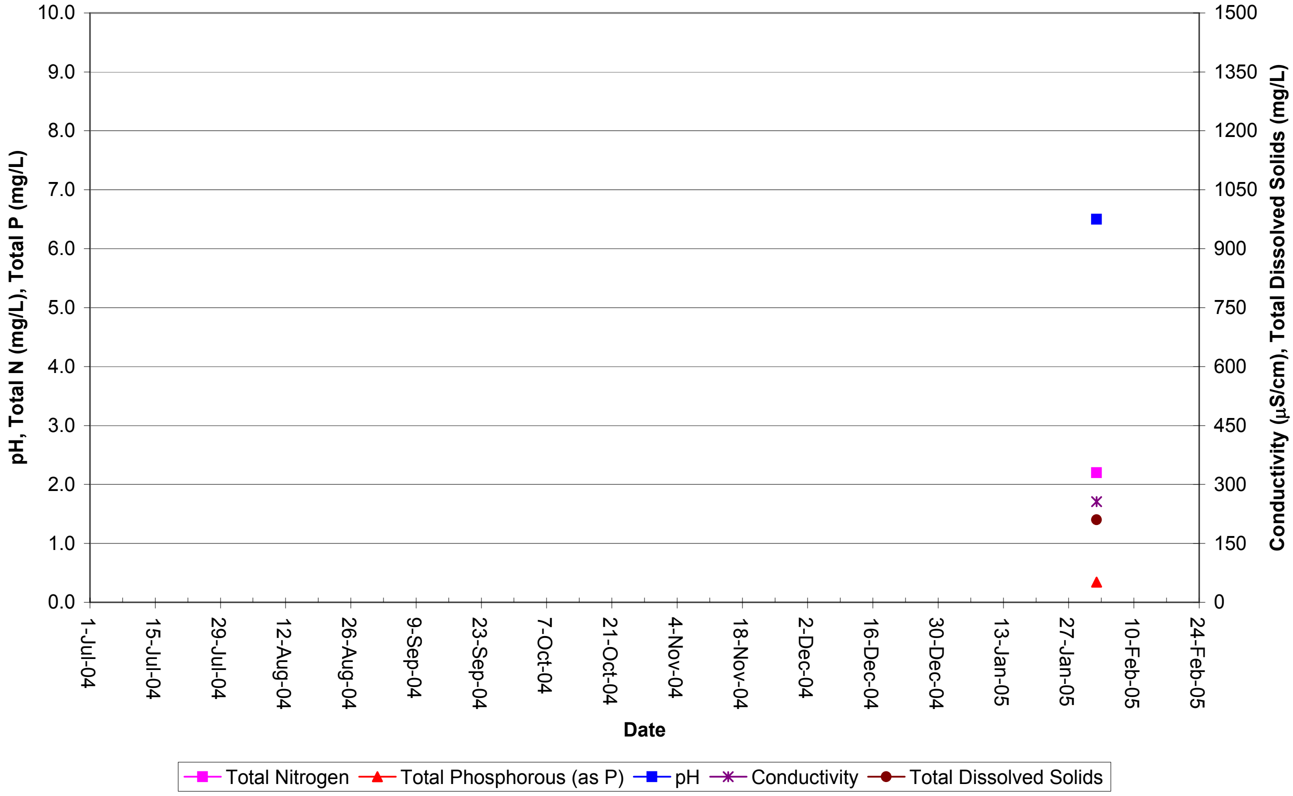
Location 2

FIGURE A1

Water Quality Data for Surface Water Monitoring Locations 1 and 2

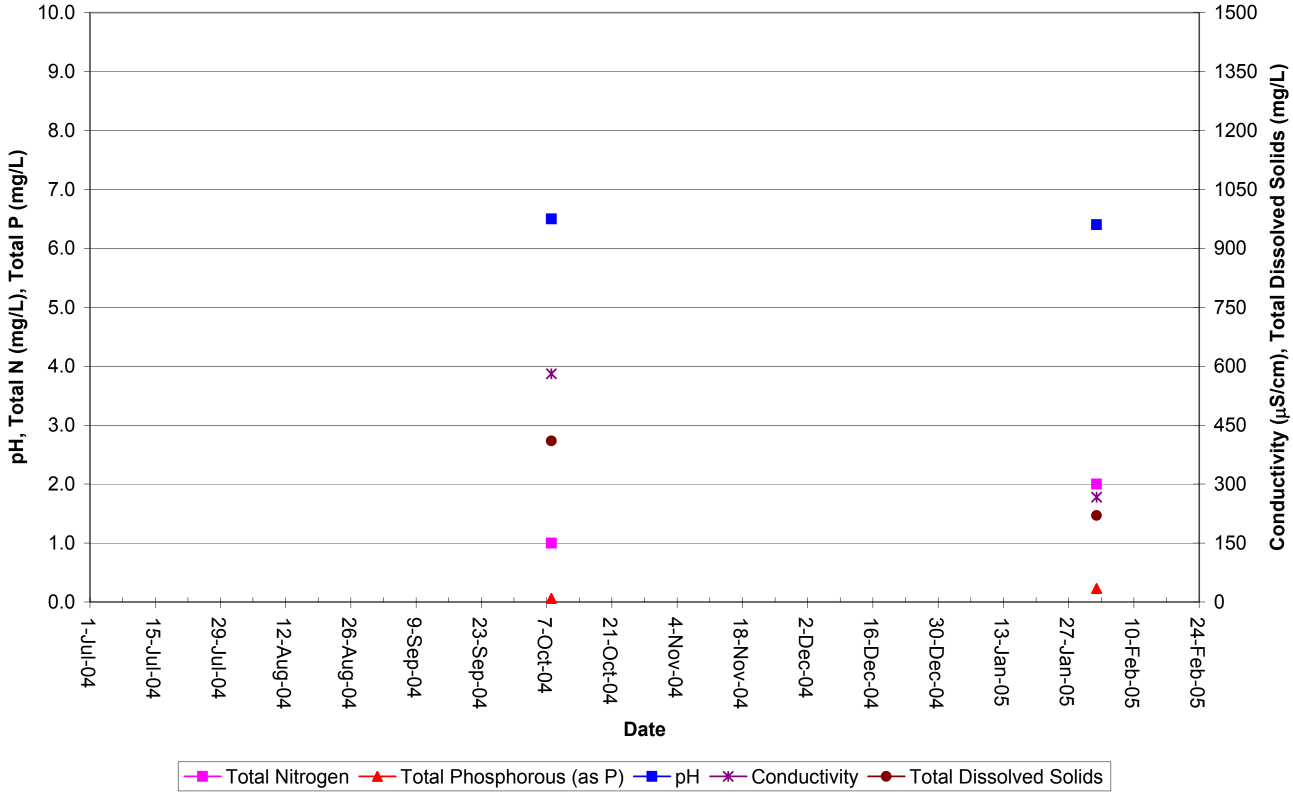
Source: Readymix Holdings Pty Ltd

File Name (A4): R04_V1/1829_116.dgn



Note: Only one data point available

Location 3



Note: Only two data points available

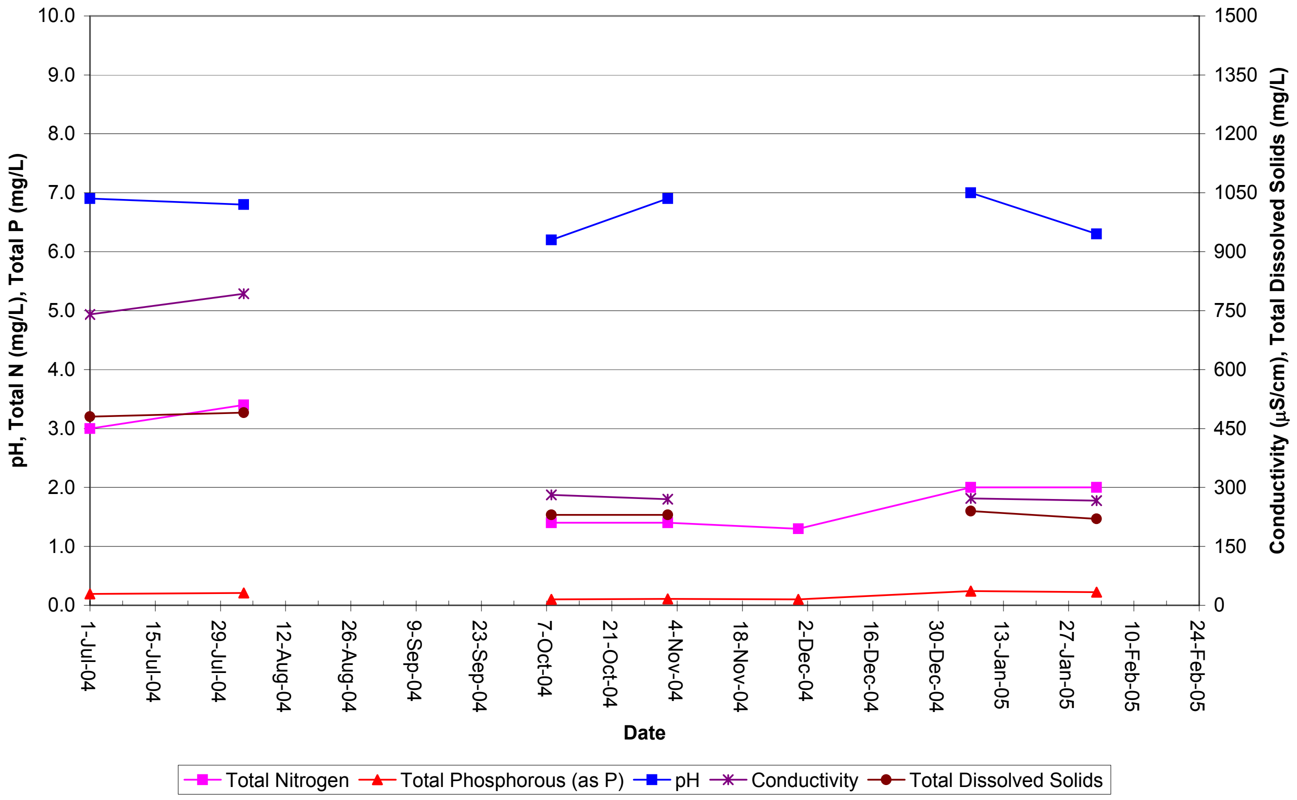
Location 4

FIGURE A2

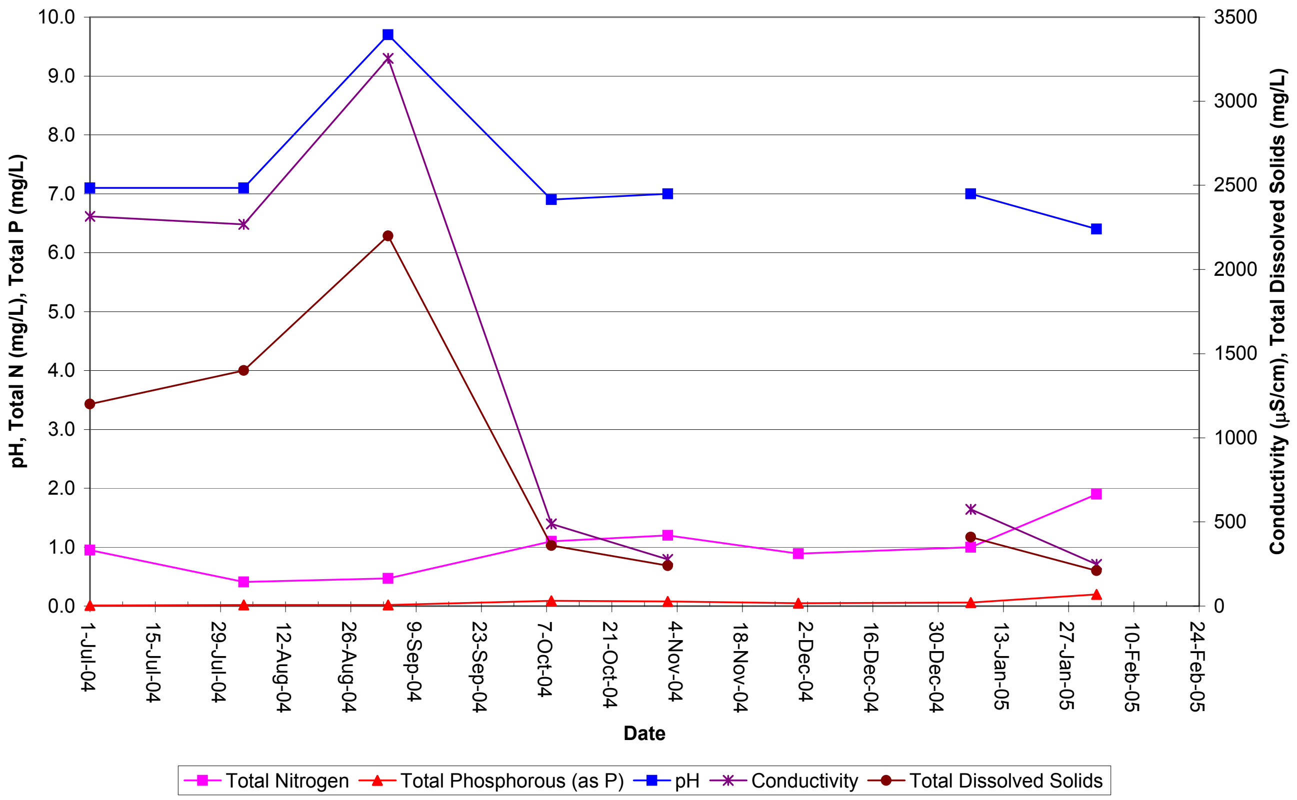
Water Quality Data for Surface Water Monitoring Locations 3 and 4

Source: Readymix Holdings Pty Ltd

File Name (A4): R04_V1/1829_117.dgn



Location 5



Location 6

FIGURE A3

Water Quality Data for Surface Water Monitoring Locations 5 and 6

Source: Readymix Holdings Pty Ltd

File Name (A4): R04_V1/1829_118.dgn

APPENDIX B

Water Licences

Appendix B - Licensed Water Users

Surface Water Licences

Licence	Purpose	Total
10SL004333	IRRIGATION	63
10SL012214	MINING	76
10SL012214	DOMESTIC	1
10SL012214	CONSERVATION OF WATER	0
10SL014105	IRRIGATION	10
10SL016682	IRRIGATION	39
10SL018354	IRRIGATION	133
10SL024070	INDUSTRIAL	5
10SL025561	MINING	10
10SL027862	STOCK	2
10SL031240	TOWN WATER SUPPLY	*
10SL031791	IRRIGATION	111
10SL032097	IRRIGATION	31
10SL033090	STOCK	2
10SL033090	DOMESTIC	1
10SL035365	IRRIGATION	372
10SL035365	CONSERVATION OF WATER	0
10SL035950	IRRIGATION	12
10SL037481	IRRIGATION	72
10SL037785	IRRIGATION	10
10SL040130	RECREATION - LOW SECURITY	4
10SL040558	IRRIGATION	18
10SL040655	IRRIGATION	60
10SL041577	IRRIGATION	39
10SL041875	IRRIGATION	6
10SL044098	IRRIGATION	102
10SL044191	IRRIGATION	90
10SL045364	IRRIGATION	52
10SL045649	IRRIGATION	12
10SL046984	IRRIGATION	18
10SL047157	RECREATION - LOW SECURITY	5
10SL047157	STOCK	3
10SL047157	INDUSTRIAL	2
10SL047157	IRRIGATION	5
10SL047910	IRRIGATION	5
10SL048321	IRRIGATION	12
10SL050270	IRRIGATION	40
10SL055317	DOMESTIC	1
10SL055317	STOCK	2
10SL055317	CONSERVATION OF WATER	0
10SL055383	CONSERVATION OF WATER	0

Licence	Purpose	Total
10SL055383	IRRIGATION	2
10SL055619	IRRIGATION	15
10SL055762	CONSERVATION OF WATER	0
10SL055762	IRRIGATION	240
10SL055763	CONSERVATION OF WATER	0
10SL055763	STOCK	21
10SL055763	DOMESTIC	5
10SL055763	IRRIGATION	410
10SL055770	DOMESTIC	1
10SL055806	IRRIGATION	*
10SL055806	CONSERVATION OF WATER	0
10SL055840	IRRIGATION	81
10SL055907	IRRIGATION	*
10SL055907	CONSERVATION OF WATER	0
10SL055945	DOMESTIC	1
10SL055945	CONSERVATION OF WATER	0
10SL056163	IRRIGATION	51
10SL056163	INDUSTRIAL	74
10SL056163	FARMING	5
10SL056169	IRRIGATION	15
10SL056169	DOMESTIC	1
10SL056169	STOCK	4.5

Groundwater Licences

Licence	Purpose	Allocation(ML/yr)
10BL011335	COMMERCIAL	0
10BL012422	DOMESTIC WASTE DISPOSAL	1
10BL014463	WASTE DISPOSAL	0
10BL018029	WASTE DISPOSAL	0
10BL021977	DOMESTIC IRRIGATION	1
10BL024139	STOCK DOMESTIC	3
10BL024589	STOCK DOMESTIC	3
10BL029626	STOCK DOMESTIC	3
10BL029698	STOCK DOMESTIC	3
10BL100826	STOCK DOMESTIC	3
10BL101911	STOCK DOMESTIC	3
10BL102302	STOCK DOMESTIC	3
10BL102309	DOMESTIC STOCK	3
10BL108985	STOCK DOMESTIC	3
10BL110979	DOMESTIC	1
10BL111562	DOMESTIC	1
10BL111839	STOCK IRRIGATION DOMESTIC	19
10BL112564	STOCK DOMESTIC	3
10BL117632	STOCK DOMESTIC	3

Licence	Purpose	Allocation(ML/yr)
10BL120421	STOCK DOMESTIC	3
10BL121918	STOCK	2
10BL123175	STOCK DOMESTIC	3
10BL123837	STOCK	2
10BL125059	STOCK DOMESTIC	3
10BL126584	STOCK DOMESTIC	3
10BL128517	STOCK DOMESTIC	3
10BL130619	DOMESTIC	1
10BL132204	INDUSTRIAL	19
10BL133477	DOMESTIC FARMING	6
10BL133999	STOCK DOMESTIC	3
10BL135042	STOCK DOMESTIC	3
10BL135898	STOCK IRRIGATION DOMESTIC	26
10BL138974	RECREATION (GROUNDWATER)	15
10BL139804	STOCK DOMESTIC	3
10BL140325	STOCK DOMESTIC	3
10BL141598	STOCK DOMESTIC	3
10BL142688	DOMESTIC	1
10BL142752	DOMESTIC	1
10BL143732	STOCK DOMESTIC	3
10BL156074	STOCK DOMESTIC	3
10BL156152	DOMESTIC STOCK	3
10BL156416	STOCK DOMESTIC	3
10BL156499	STOCK DOMESTIC	3
10BL156512	DOMESTIC STOCK	3
10BL156601	DOMESTIC STOCK	3
10BL156602	DOMESTIC STOCK	3
10BL156656	STOCK DOMESTIC	3
10BL157290	DOMESTIC	1
10BL157417	DOMESTIC	1
10BL157712	DOMESTIC STOCK	3
10BL157790	MONITORING BORE	0
10BL157791	MONITORING BORE	0
10BL157816	STOCK DOMESTIC	3
10BL158496	DOMESTIC	1
10BL159086	STOCK DOMESTIC	3
10BL159259	IRRIGATION DOMESTIC	10
10BL159307	STOCK DOMESTIC	3
10BL159324	STOCK DOMESTIC	3
10BL159492	TEST BORE	0
10BL159521	STOCK DOMESTIC	3
10BL159678	STOCK DOMESTIC	3
10BL159860 10BL159341	INDUSTRIAL TEST BORE	15
10BL159937	STOCK DOMESTIC INDUSTRIAL	2

Licence	Purpose	Allocation(ML/yr)
10BL159996	STOCK DOMESTIC	3
10BL160005	STOCK DOMESTIC	3
10BL160028	STOCK DOMESTIC	3
10BL160031	STOCK DOMESTIC	3
10BL160069	STOCK DOMESTIC	3
10BL160131	STOCK DOMESTIC	3
10BL160134	STOCK DOMESTIC	3
10BL160140	STOCK DOMESTIC	3
10BL160459	STOCK DOMESTIC	3
10BL160467 10BL160126	IRRIGATION TEST BORE	0
10BL160468	STOCK DOMESTIC	3
10BL160498	DOMESTIC	1
10BL160505	STOCK DOMESTIC	3
10BL160520	STOCK DOMESTIC	3
10BL160565	STOCK DOMESTIC	3
10BL160596	STOCK DOMESTIC	3
10BL160598	STOCK DOMESTIC	3
10BL160599	STOCK DOMESTIC	3
10BL160628	DOMESTIC	1
10BL160674	STOCK DOMESTIC	3
10BL160765	STOCK DOMESTIC	3
10BL160771	STOCK DOMESTIC	3
10BL160779	STOCK DOMESTIC	3
10BL160846	STOCK DOMESTIC	3
10BL160876	STOCK DOMESTIC	3
10BL161112	STOCK DOMESTIC	3
10BL161113	STOCK DOMESTIC	3
10BL161204	STOCK DOMESTIC	3
10BL161231	STOCK DOMESTIC	3
10BL161287	STOCK DOMESTIC	3
10BL161326	STOCK DOMESTIC	3
10BL161354	DOMESTIC	1
10BL161359	STOCK DOMESTIC	3
10BL161453	STOCK DOMESTIC	3
10BL161558	STOCK	2
10BL161561	DOMESTIC	1
10BL161571 10BL159314	DOMESTIC FARMING INDUSTRIAL INDUSTRIAL DOMESTIC FARMING	14
10BL161595	STOCK DOMESTIC	3
10BL161667	STOCK DOMESTIC	3
10BL161804	STOCK DOMESTIC	3
10BL162379	STOCK DOMESTIC	3
10BL162481	TEST BORE	0
10BL162491	STOCK DOMESTIC	3
10BL162565	STOCK DOMESTIC	3

Licence	Purpose	Allocation(ML/yr)
10BL162573	STOCK DOMESTIC	3
10BL162704	DOMESTIC	1
10BL162783	STOCK DOMESTIC	3
10BL162789	DOMESTIC STOCK	3
10BL162935 10BL162827	IRRIGATION INDUSTRIAL STOCK DOMESTIC TEST BORE	10
10BL163278	STOCK DOMESTIC	3
10BL163413	STOCK DOMESTIC	3
10BL163447	STOCK DOMESTIC	3
10BL163545	TEST BORE	0
10BL163562	DOMESTIC	1
10BL163570	STOCK DOMESTIC	3
10BL163624	DOMESTIC	1
10BL163720	STOCK DOMESTIC	3
10BL163796	STOCK DOMESTIC	3
10BL163815	STOCK	2
10BL163959	TEST BORE	0
10BL164123	STOCK DOMESTIC	3
10BL164413	STOCK DOMESTIC	3
10BL164515	MONITORING BORE	0
10BL164685	STOCK DOMESTIC	3
10BL164788	TEST BORE	0
10BL164822	TEST BORE	0
40BL003263	STOCK	2
40BL006368	STOCK	2
40BL006955	STOCK	2
40BL025587	STOCK	2
40BL025588	STOCK	2

* Allocation not provided by DIPNR

APPENDIX C

Water Balance Calculations

Appendix C – Water Balance Calculations

C.1 Meteorology

To explore the water balance at Lynwood Quarry over a range of climatic conditions, daily rainfall for Goulburn for the period 1886 to 2004 was used in conjunction with derived daily evaporation data based on evaporation data from Station 70263. From an analysis of historical rainfall data, the annual rainfall years shown in **Table C.1** were chosen to represent dry, average and wet years.

Table C.1 – Selected Rainfall Years

Rainfall Condition	Representative Calendar Year	Annual Rainfall (mm)
Dry (10th Percentile)	1967	407
Average (50th Percentile)	1923	607
Wet (90th Percentile)	1887	872

In the modelling undertaken quarry operations were simulated without water being imported to the site or discharged from the site. The requirements to import or discharge water to or from the proposed Lynwood Quarry have been addressed after determining the water balance on site without these transfers.

C.2 Water Storages

The modelled water storage and sedimentation dams identified have been derived from the concept designs of these dams.

C.3 Sources

There are three sources for the water balance at the proposed Lynwood Quarry:

- runoff from local catchments;
- groundwater; and
- external water.

As discussed above, external water sourcing has not been included in the initial water balance calculations so that an assessment of the requirement for external sources and potential discharges off site can be made.

The catchment area of the proposed water management system is 436 hectares which will consist of areas including:

- quarry pit;
- haul roads;
- crushing and screening plant;
- support infrastructure;

- overburden emplacement and excess product emplacement areas; and
- sediment dams.

The area of the water management system is proposed to remain static over the proposed 30 year life of the quarry.

Groundwater inflows have been determined based on the Proposed Lynwood Quarry, Marulan - Groundwater Impact Assessment Report prepared by Peter Dundon and Associates. Groundwater inflows predictions for the proposed Year 30 quarry life are shown on **Figure C.1**.

C.4 Sinks

As the proposed quarrying operations progress, the haul road requirements for the operation will also change. Haul road positions have been determined for the future quarry landforms from the staged quarry plans. Typical future dust suppression requirements have been derived based on effective evaporation rates, days of operation and consideration of haul road lengths. Predicted dust suppression requirements for the quarry are shown on **Figure C.2**.

The length of haul road for dust suppression does not include the access road from the infrastructure area to the Hume Highway. This road will be sealed and as such will only require dust suppression during construction.

Water usage in the crushing and screening plant will vary with changing production rates. Taking into account planned production rates, the calculated future net water usage rates for the plant are outlined in **Table C.2**.

Table C.2 - Predicted Plant Water Demand

Year of Operation	Plant Water Demand (ML/year)
1	63
2	87
3 to 30	125

After Year 3 it is considered that the plant will run at full capacity, i.e. 5 Mpta, for the remainder of the proposed 30 year life of the quarry.

It is considered that 11 ML/year for dust suppression on stockpiles will be required throughout the proposed 30 year life of the quarry.

Potable water has not been included as a sink in the water balance calculations. It is assumed that potable water will be sourced from Marulan town water supply.

C.5 Preliminary Water Demand

A preliminary water demand analysis was undertaken based on the above identified inputs. The preliminary water balance does not include allowances for evaporation from dam surfaces, capture of surface runoff or external supply sources. This assessment was undertaken to understand the potential changes in the water demand from year to year of operations. The assessment forms a tool to highlight which years of the operation should be considered in detail to assess the variability in water demand for the proposed project over the life of the operations.

From a review of the preliminary water balance, refer to **Figure C.3**, it can be seen that an assessment of the water balance for Years 1, 5, 12, 20 and 30 of operations should be undertaken. Analysis of these years of operation will allow the potential extremes of the water balance over the quarry life to be assessed.

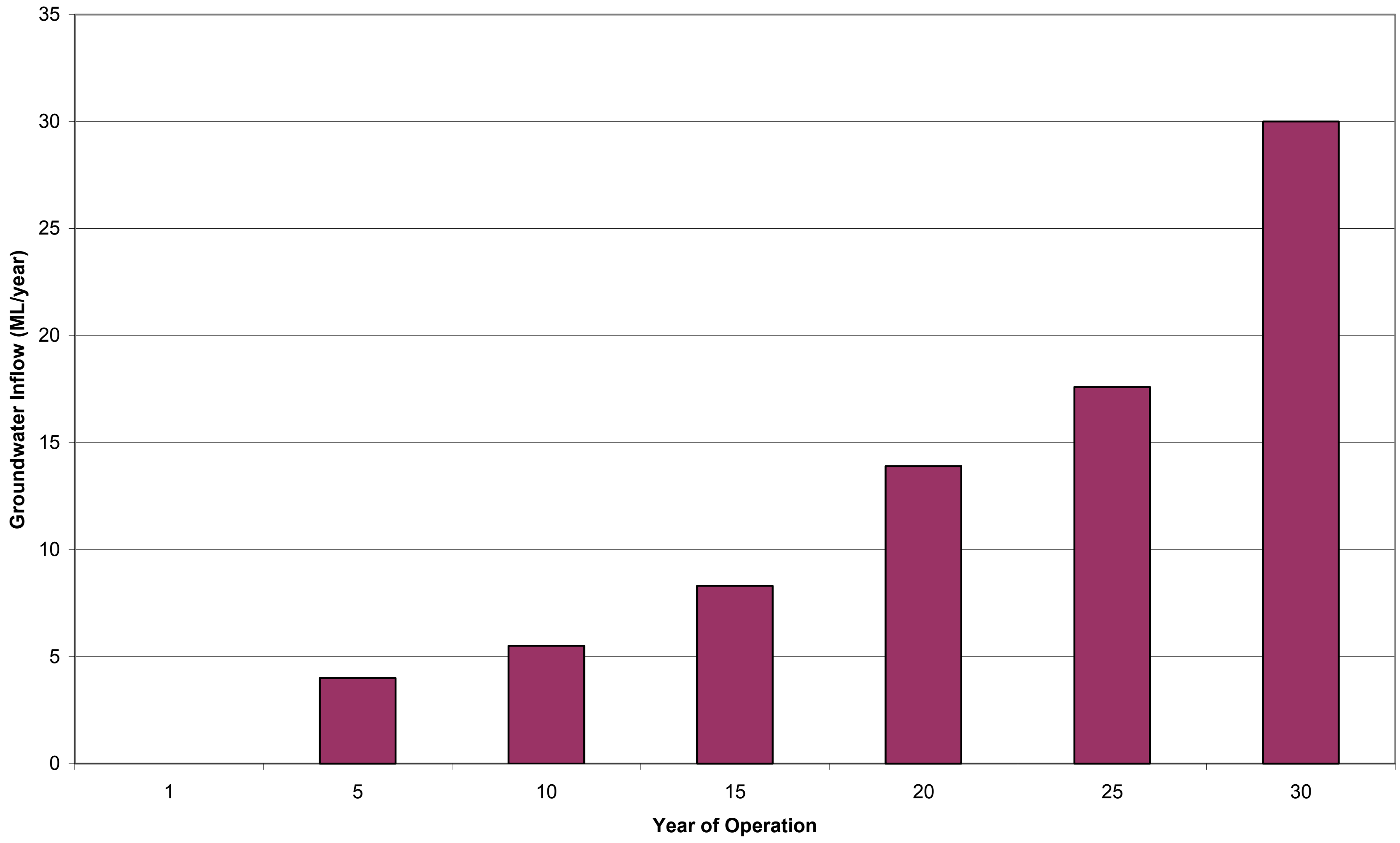
C.6 Predicted Water Balance

All future quarry development scenarios were modelled using the water model described in the main report and based on the assumptions outlined above. It was assumed in the modelling that there is no externally sourced water or discharges off site. These assumptions enable the total volume of water that will be required to be imported to site or discharged off site to be determined.

Modelled water balances for the proposed Lynwood Quarry for Years 1, 5, 12, 20 and 30 for wet, dry and average years are listed in **Table C.3** and shown on **Figure C.4**.

Table C.3 - Predicted Lynwood Water Balance

Rainfall Condition	Annual Rainfall (mm)	Water Balance (ML/Year)				
		Year 1	Year 5	Year 12	Year 20	Year 30
Dry Year (10th percentile)	407	51	-70	-83	-65	-48
Average Year (50th percentile)	607	193	69	54	80	93
Wet Year (90th percentile)	872	421	297	283	303	320



Source: Peter Dundon and Associates

FIGURE C1

Groundwater Inflows

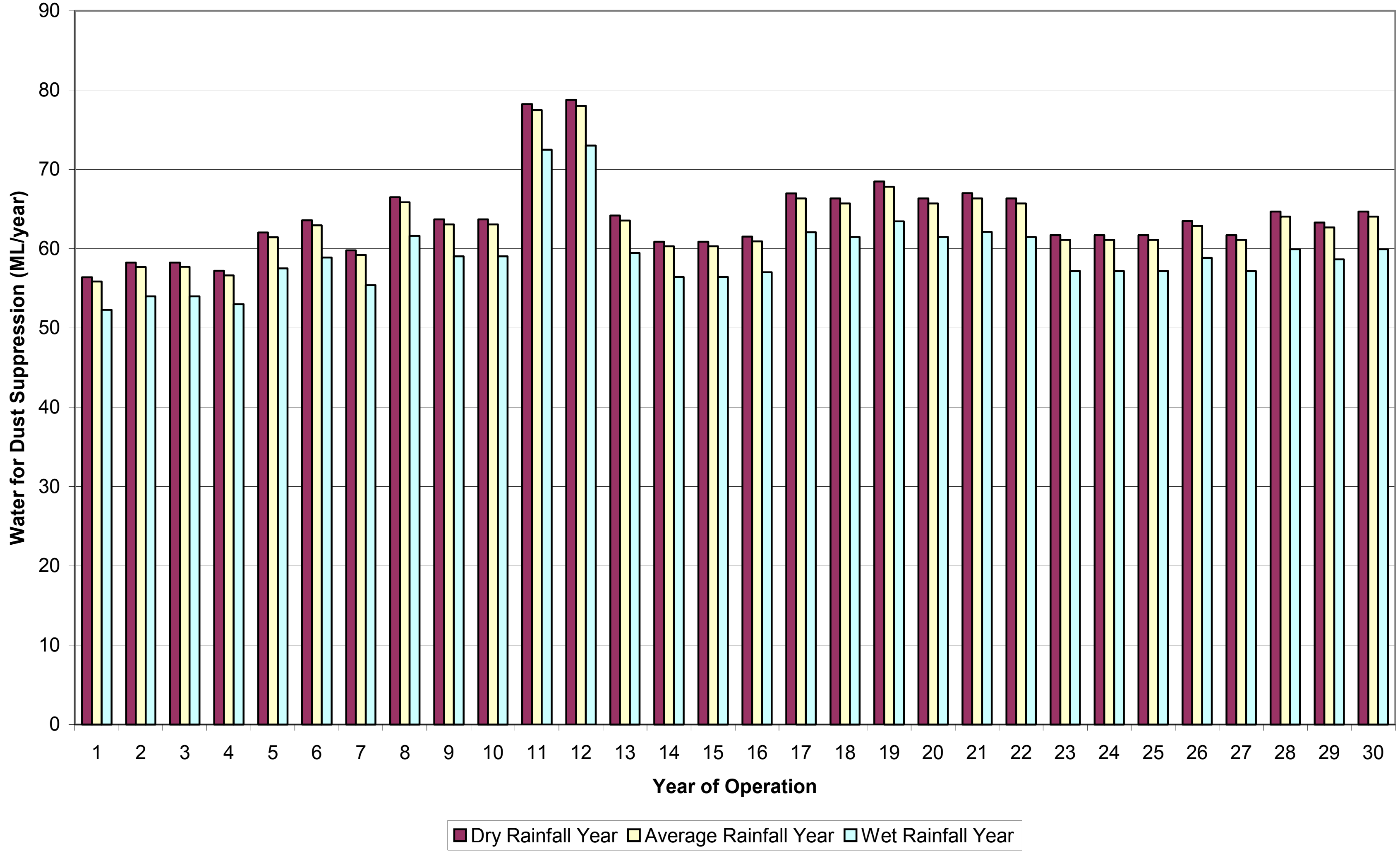


FIGURE C2

Haul Road Dust Suppression Water Demand

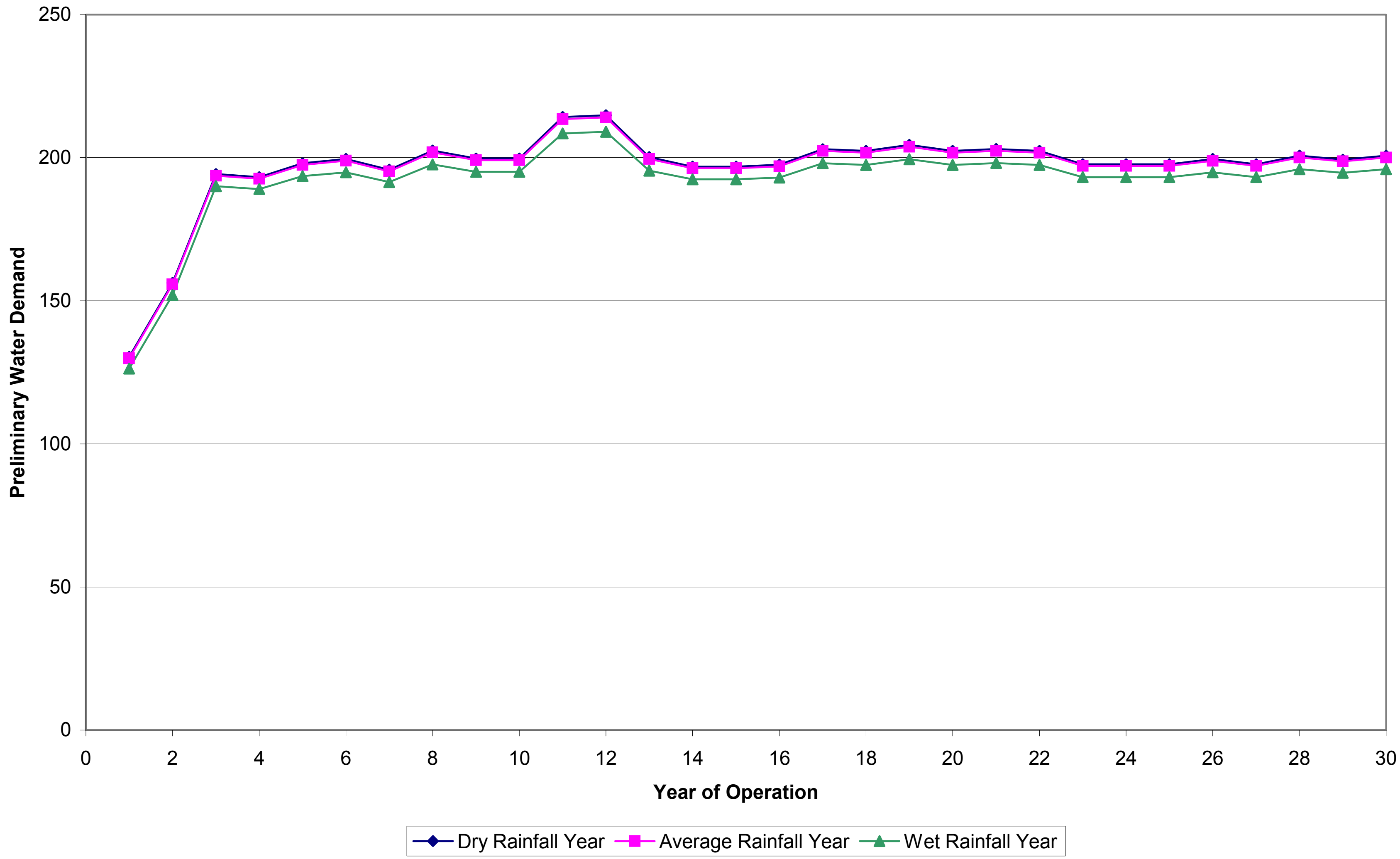


FIGURE C3

Preliminary Water Demand

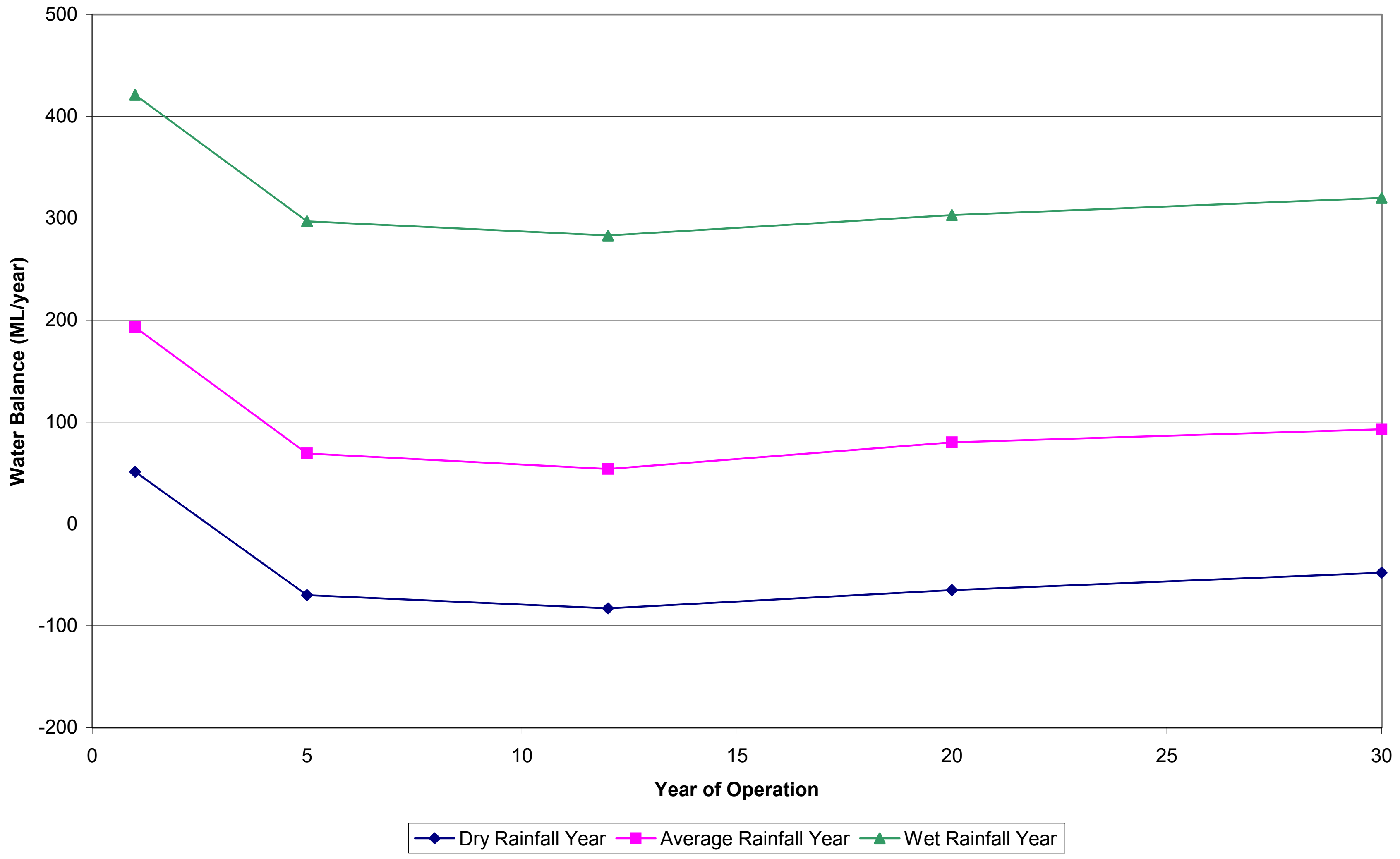
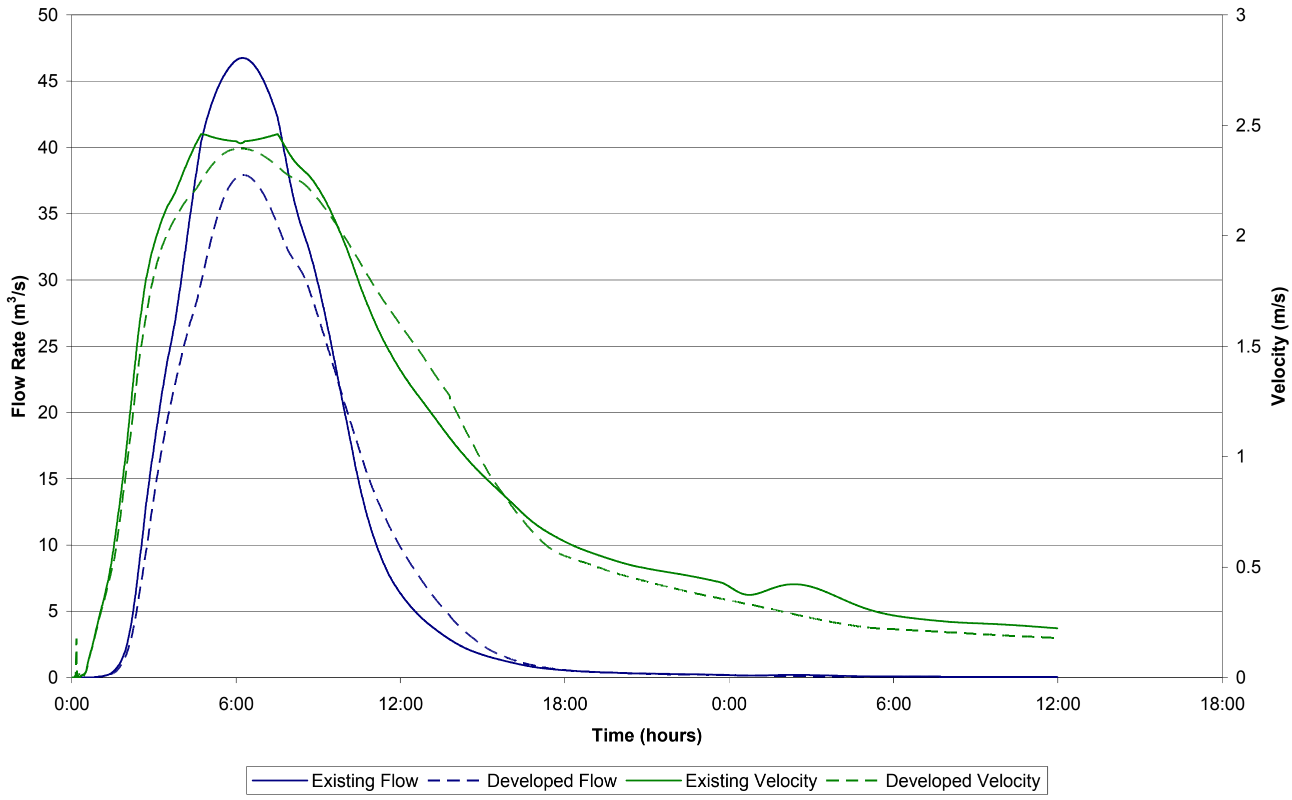


FIGURE C4

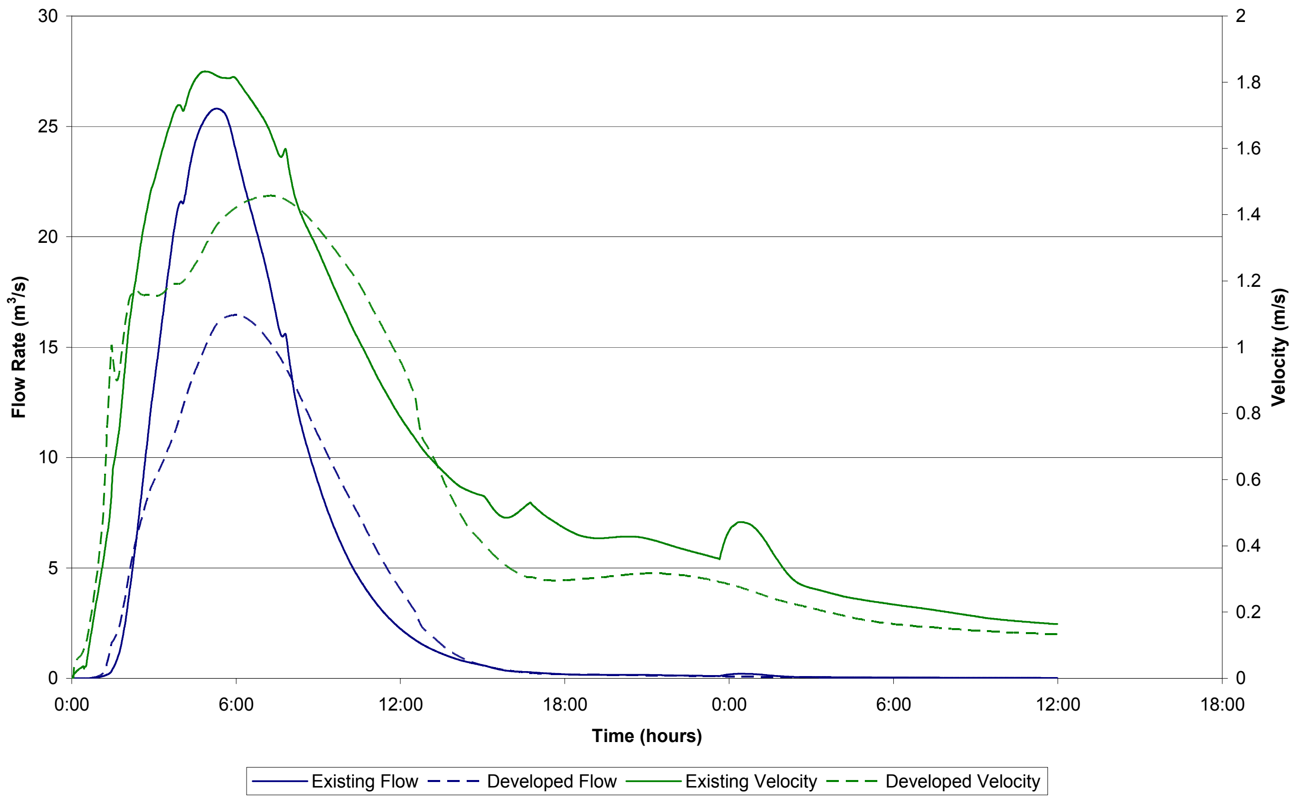
Proposed Lynwood Quarry Water Balance

APPENDIX D

Flood Hydrographs



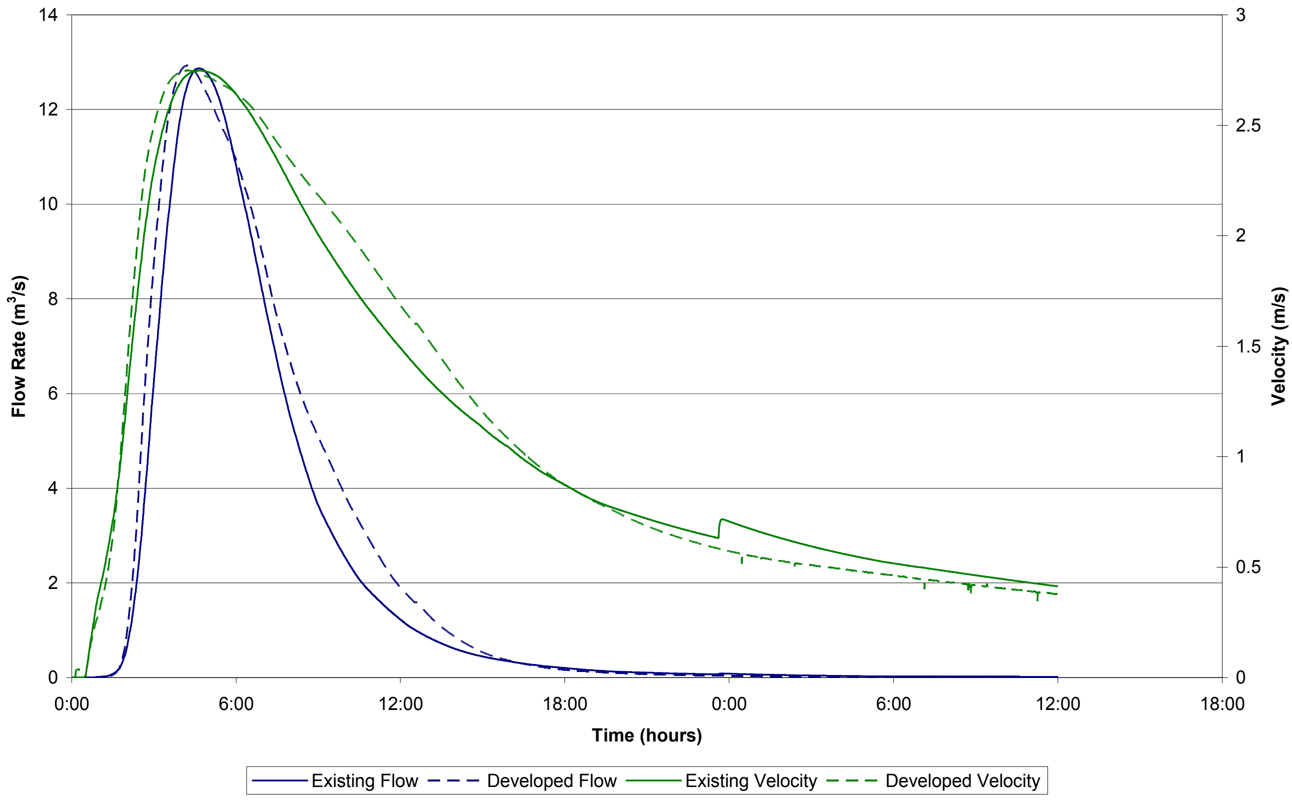
Node 1



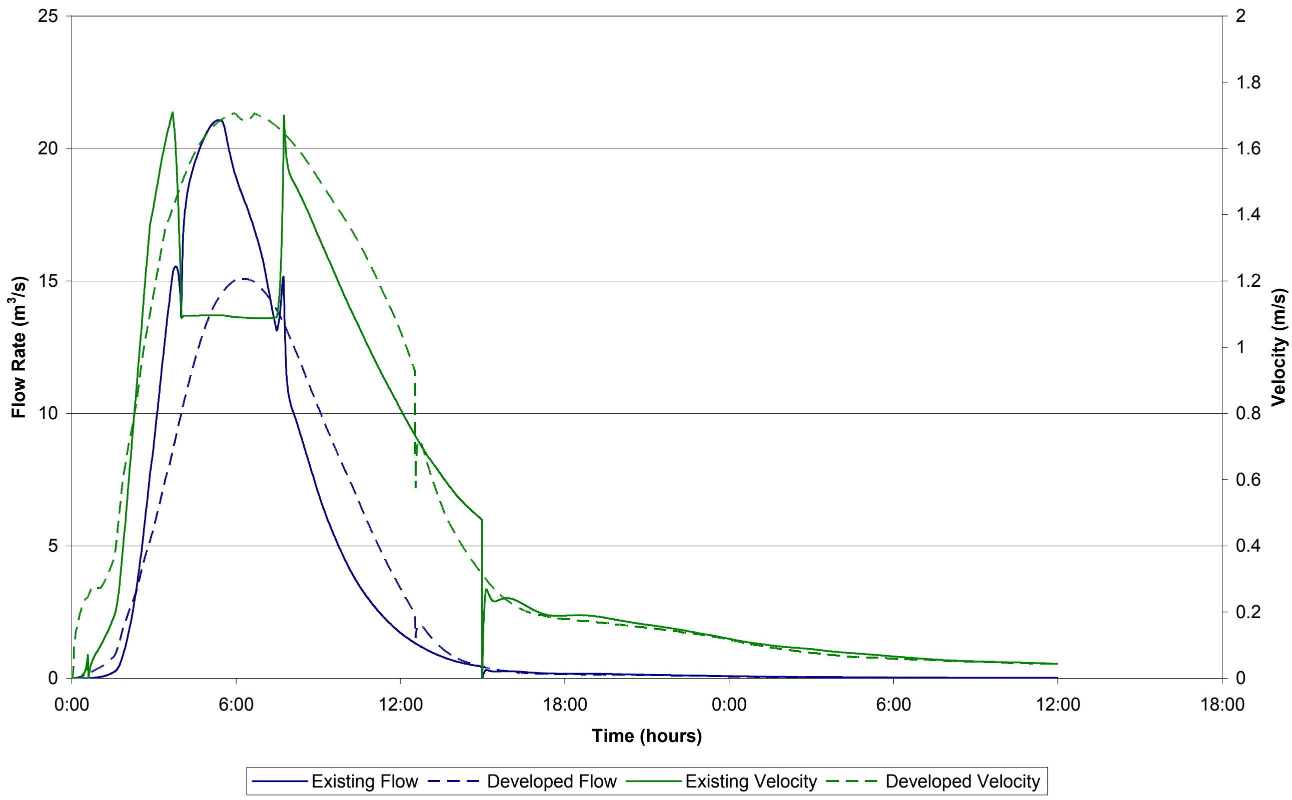
Node 4

FIGURE D1

Joarimin Creek - 100 Year ARI Storm Event - Nodes 1 and 4



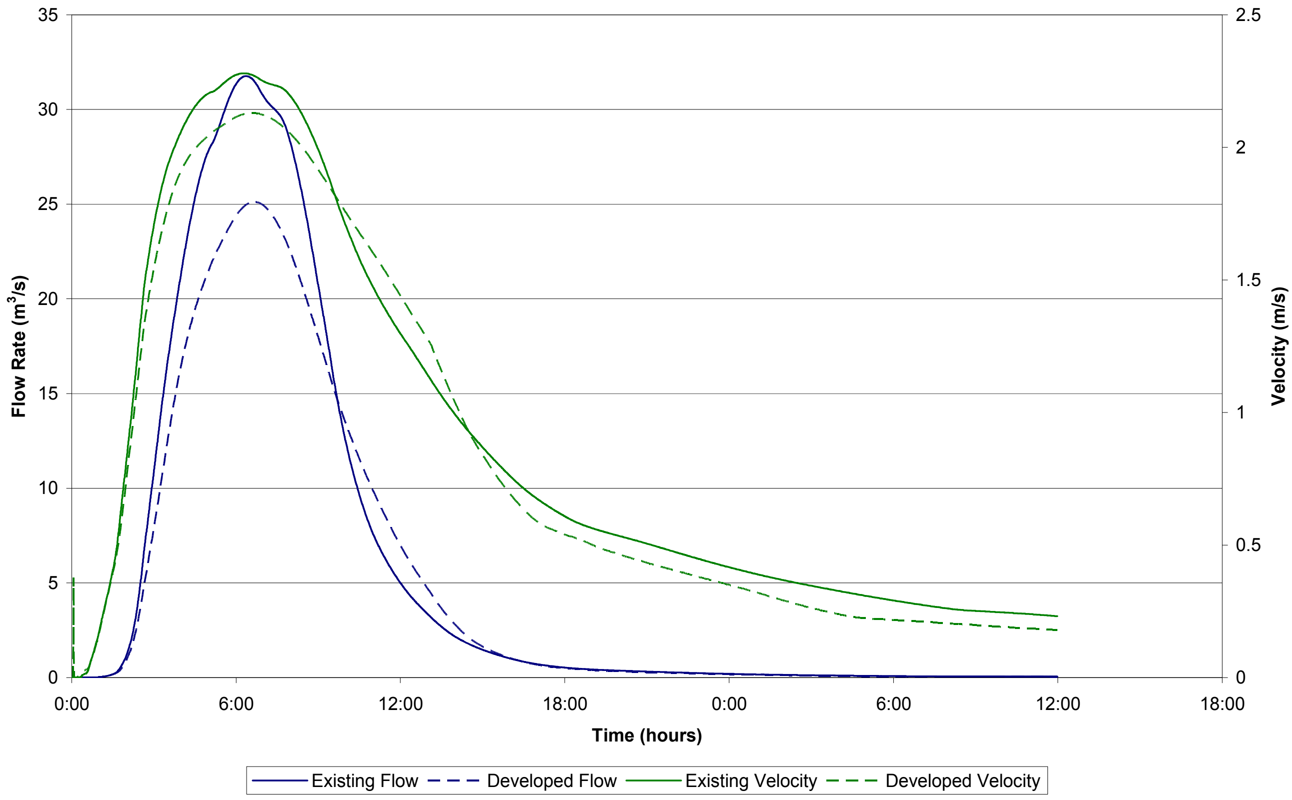
Node 4.2 (Tributary)



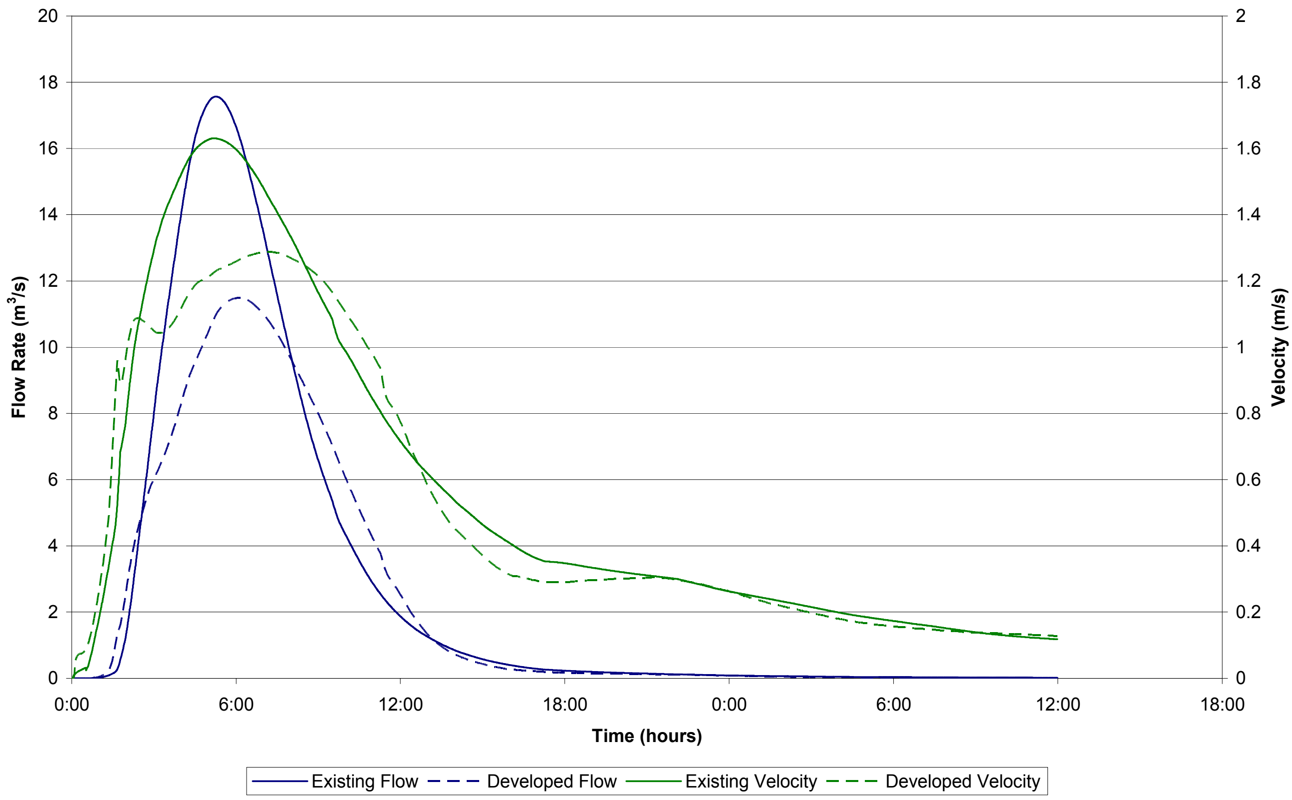
Node 7

FIGURE D2

Joarimin Creek - 100 Year ARI Storm Event - Nodes 4.2 (Tributary) and 7



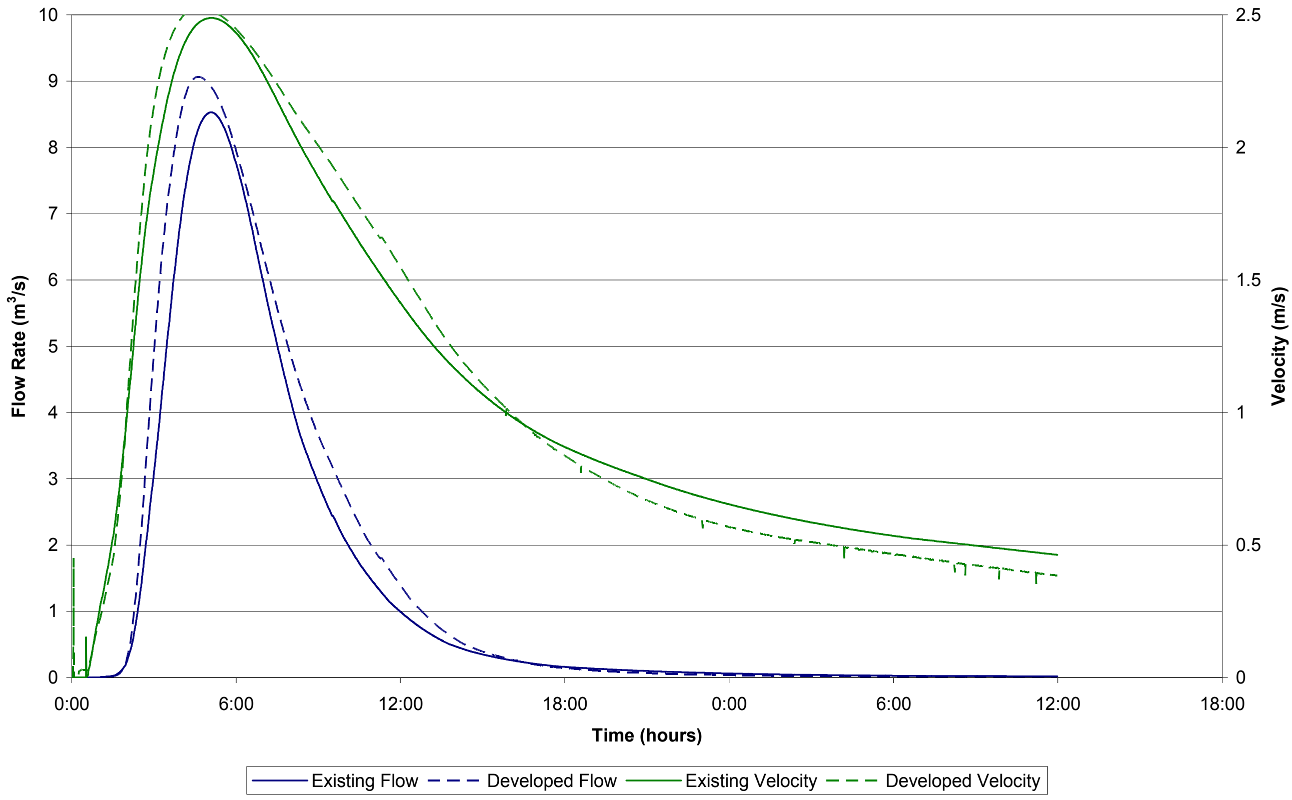
Node 1



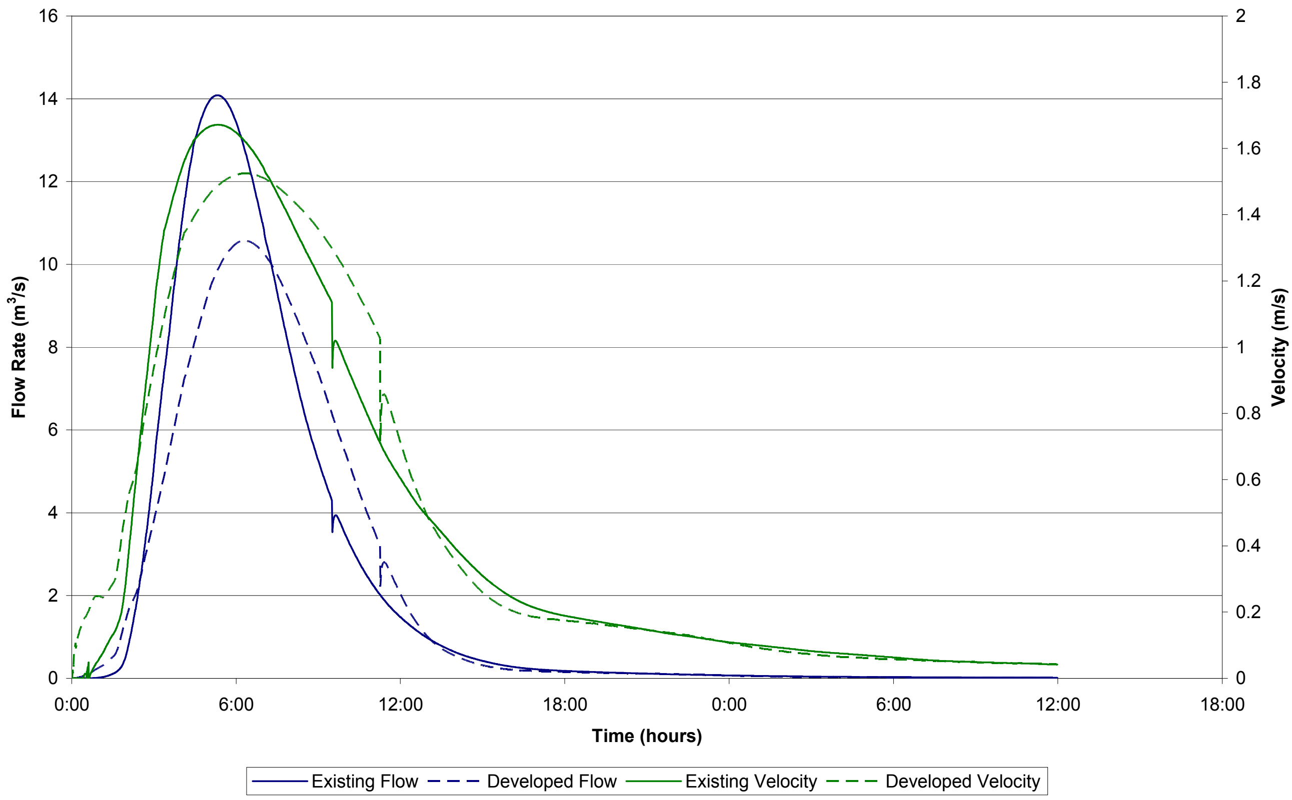
Node 4

FIGURE D3

Joarimin Creek - 20 Year ARI Storm Event - Nodes 1 and 4



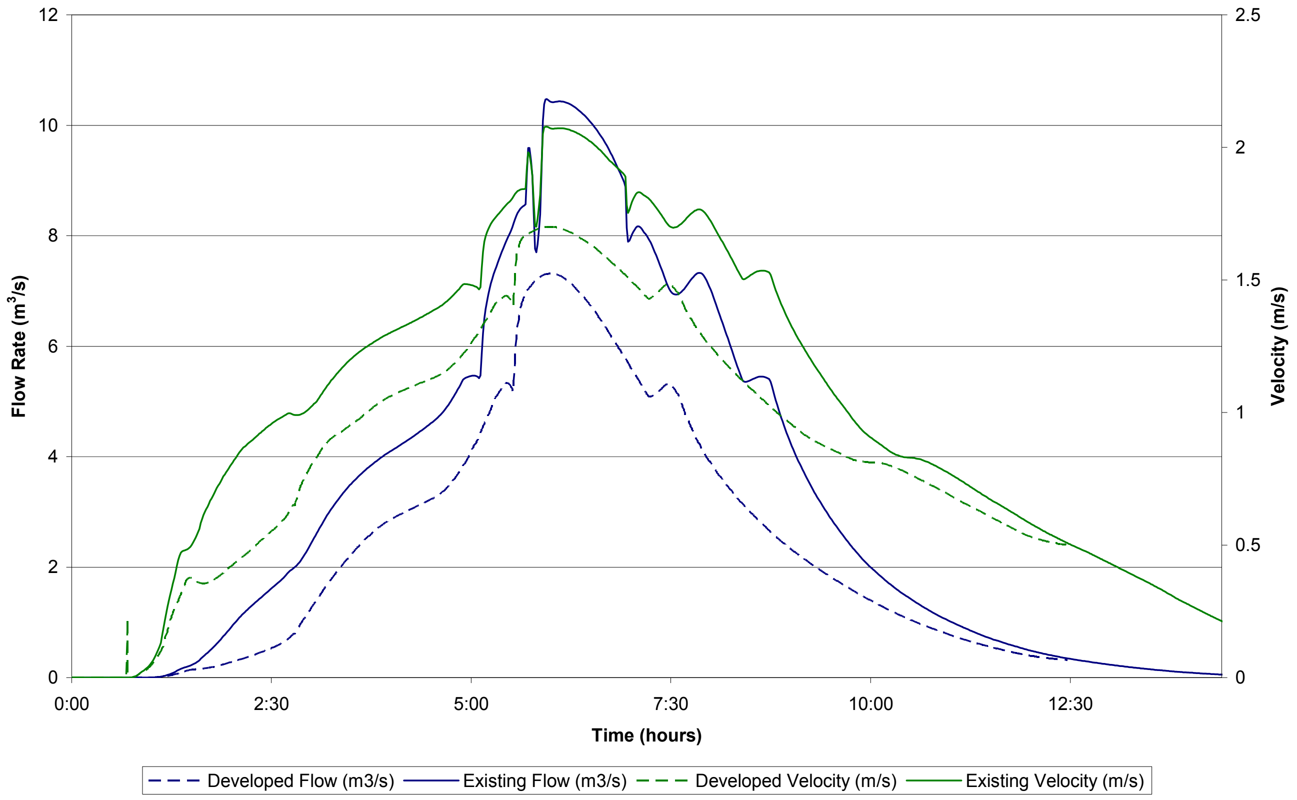
Node 4.2 (Tributary)



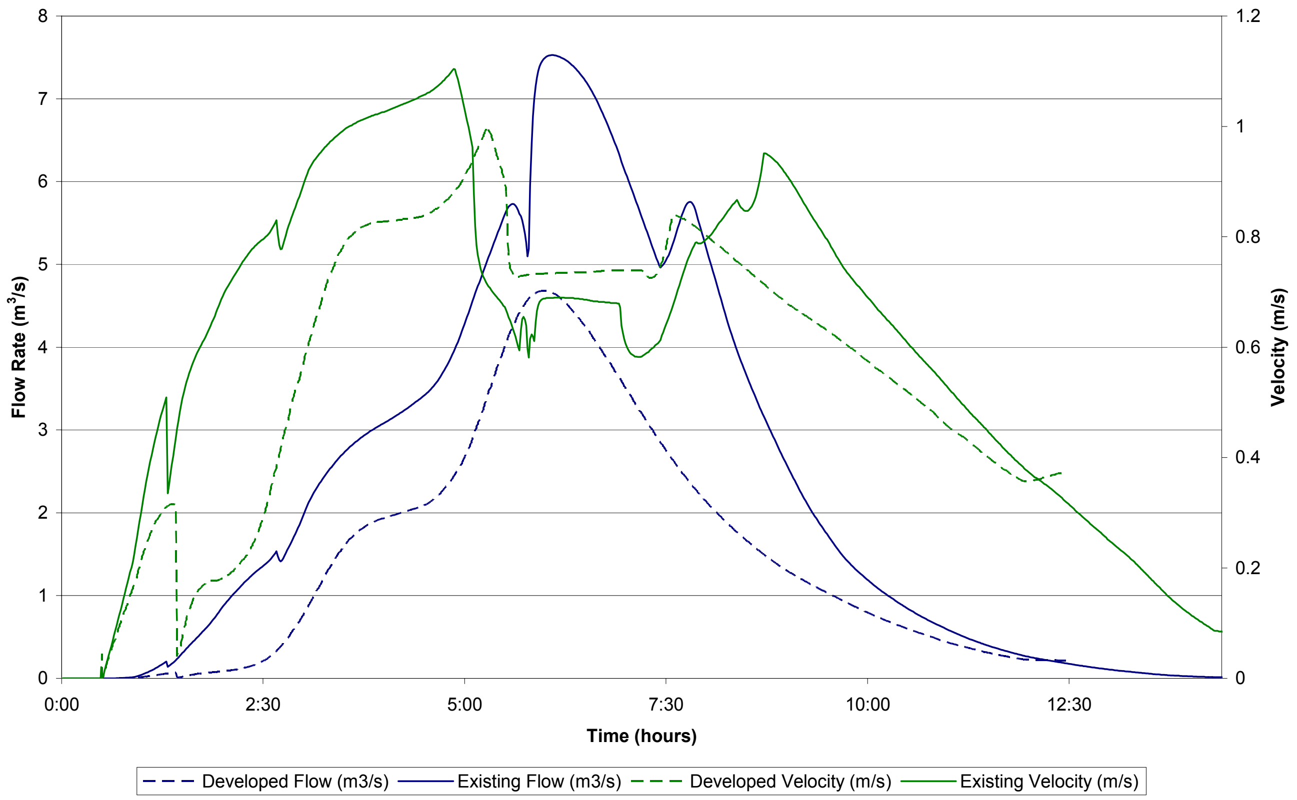
Node 7

FIGURE D4

Joarimin Creek - 20 Year ARI
Storm Event - Nodes 4.2 (Tributary) and 7



Node 1



Node 1.1

FIGURE D5

Lockyersleigh Creek - 100 Year ARI Storm Event - Nodes 1 and 1.1

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Environmental Consultants

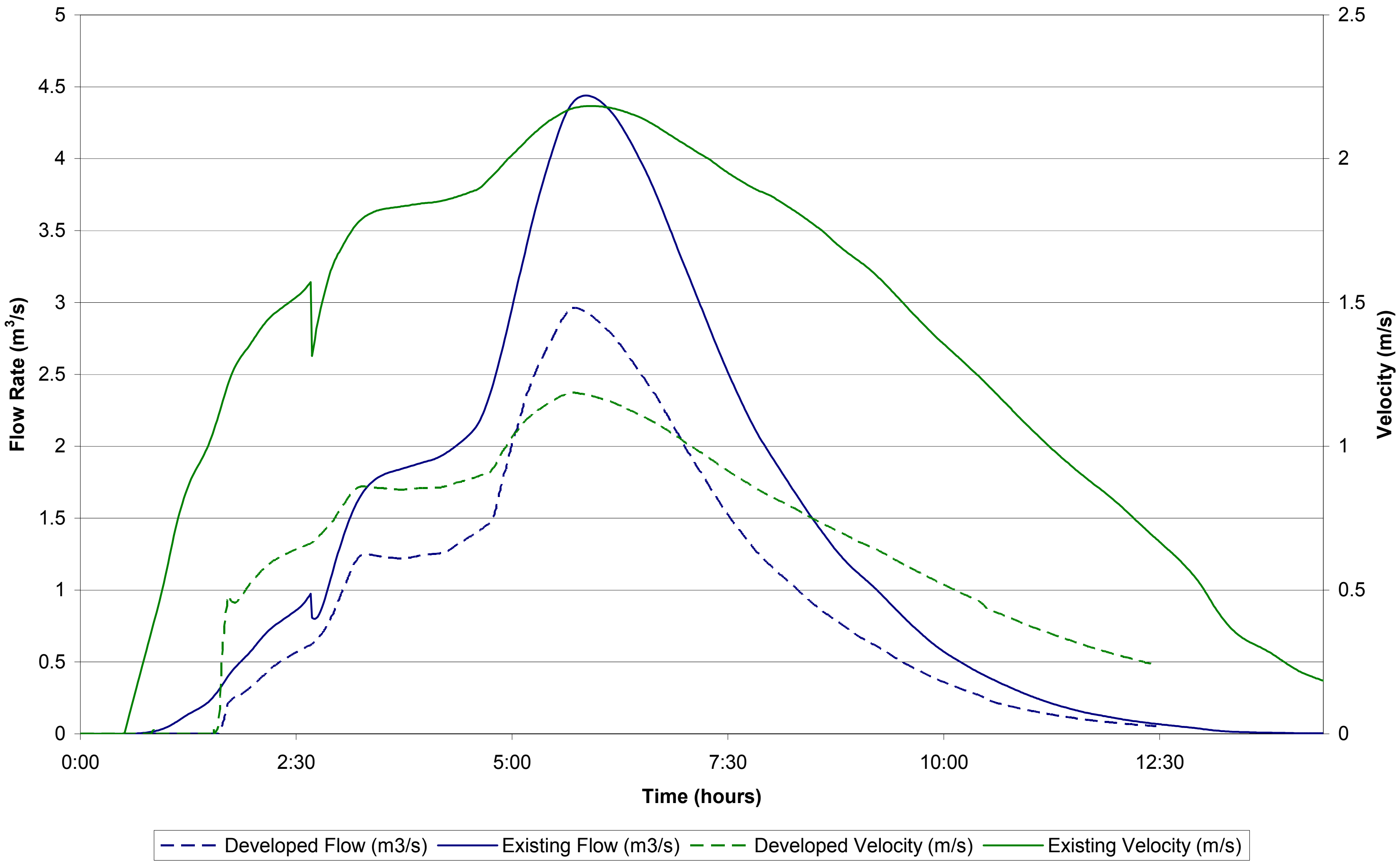
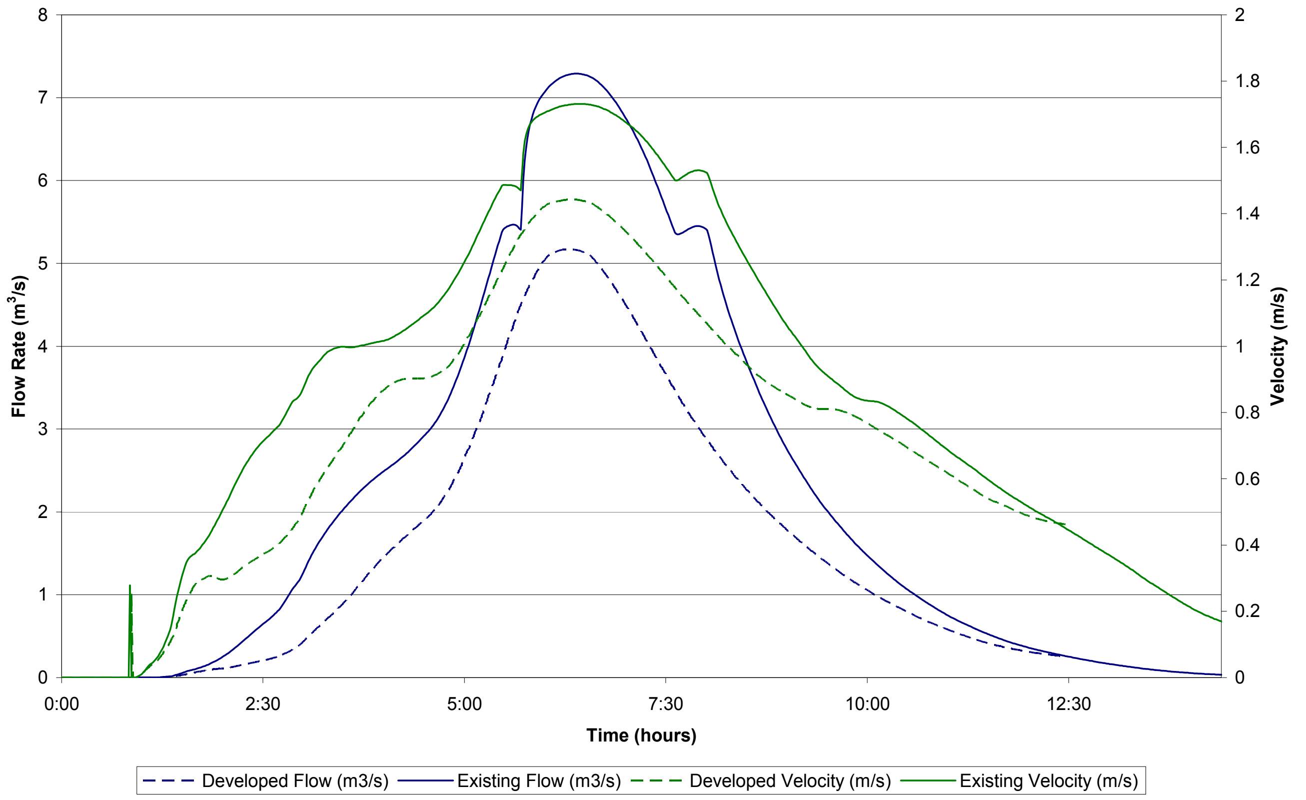
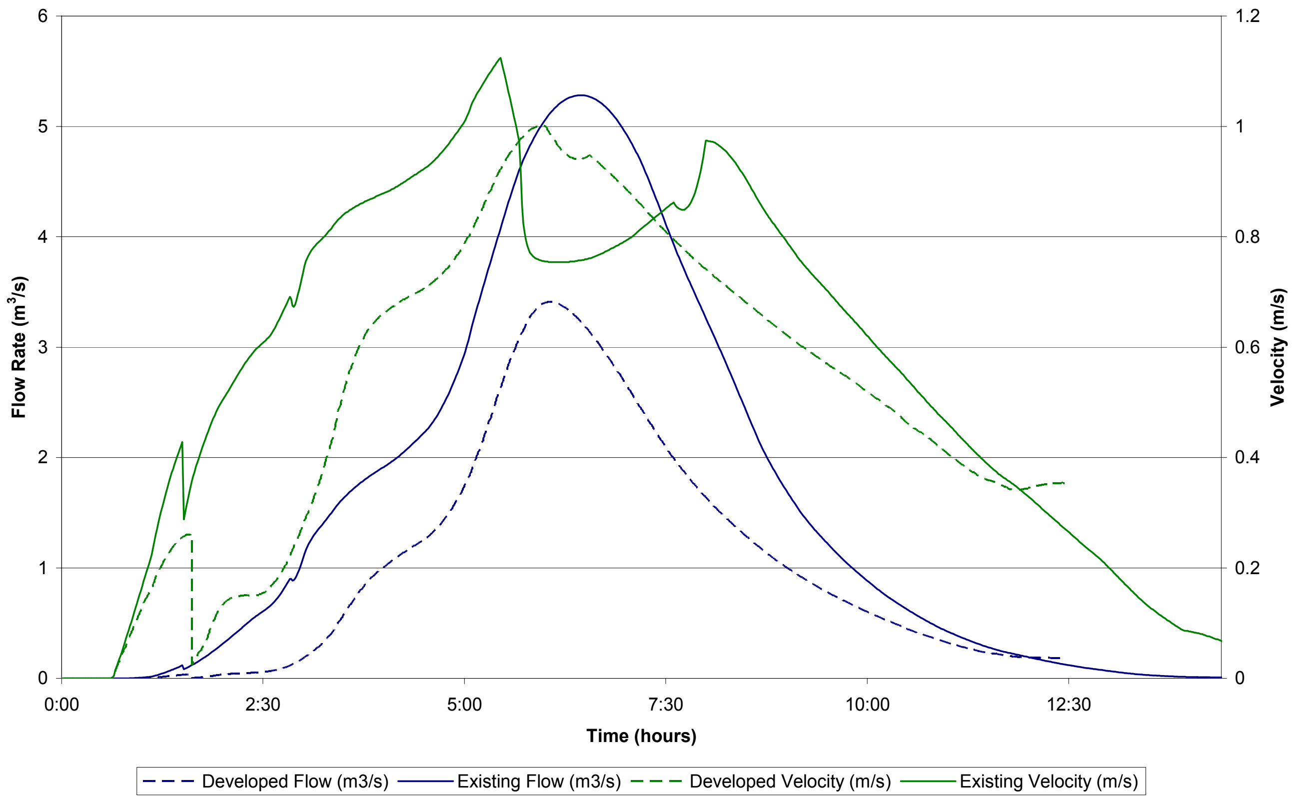


FIGURE D6

Lockyersleigh Creek - 100 Year ARI Storm Event - Node 1.4



Node 1



Node 1.1

FIGURE D7

Lockyersleigh Creek - 20 Year ARI Storm Event - Nodes 1 and 1.1

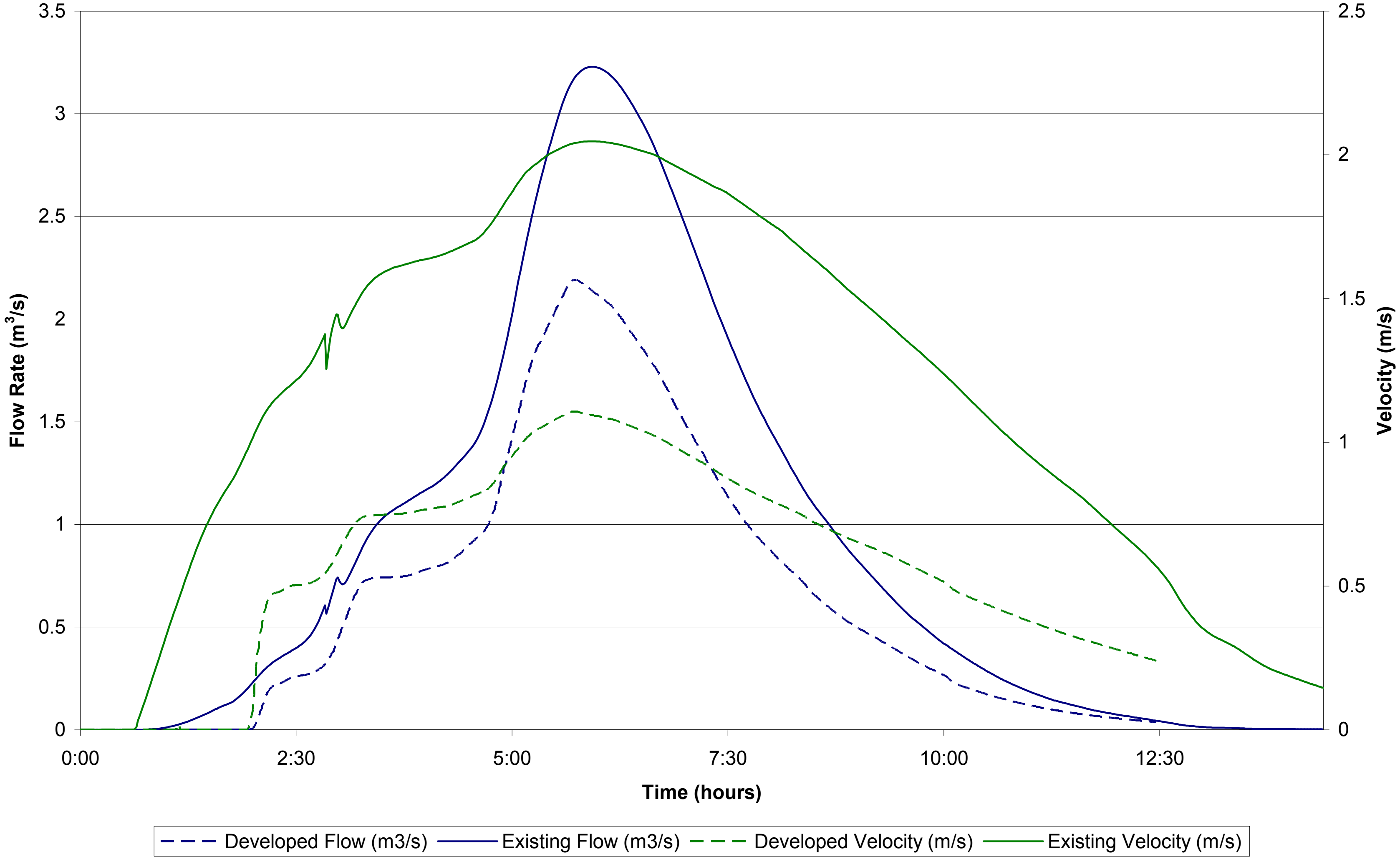
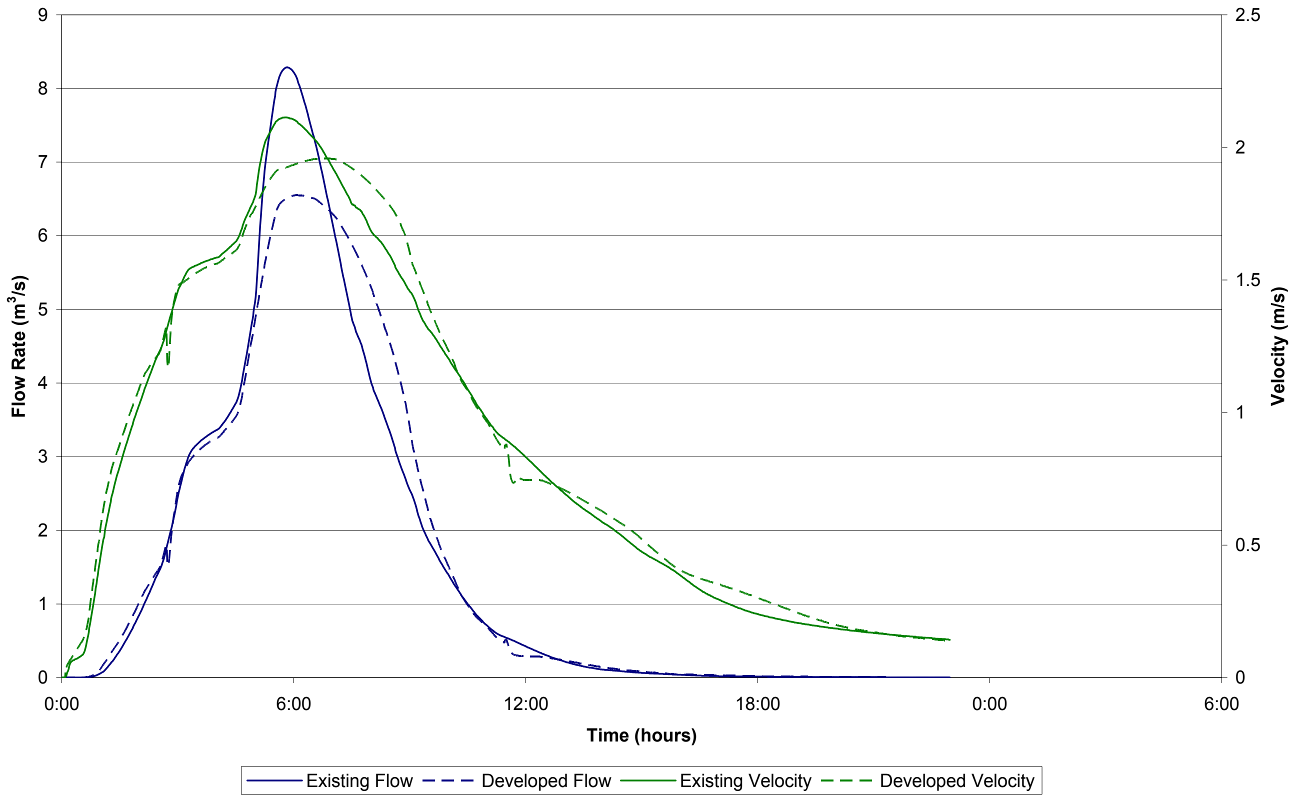
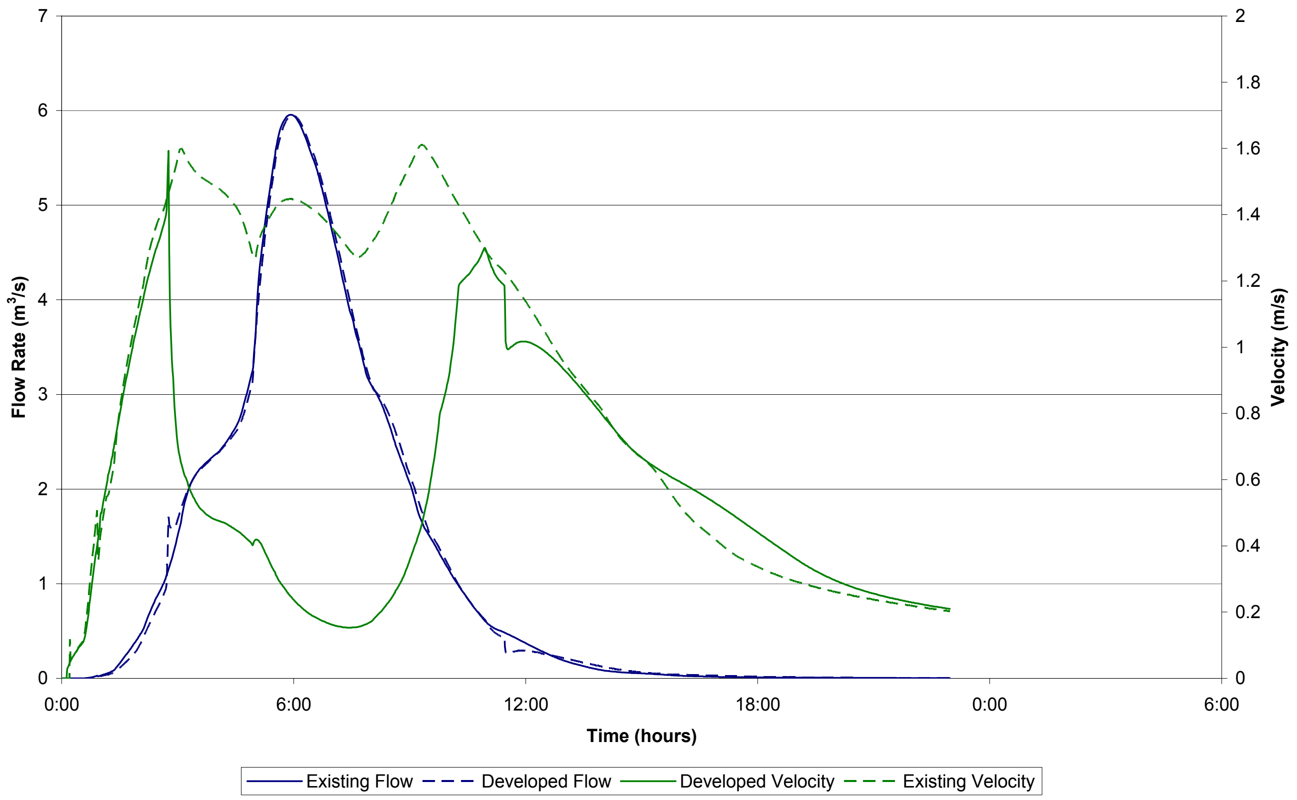


FIGURE D8

Lockyersleigh Creek - 20 Year ARI
Storm Event - Node 1.4



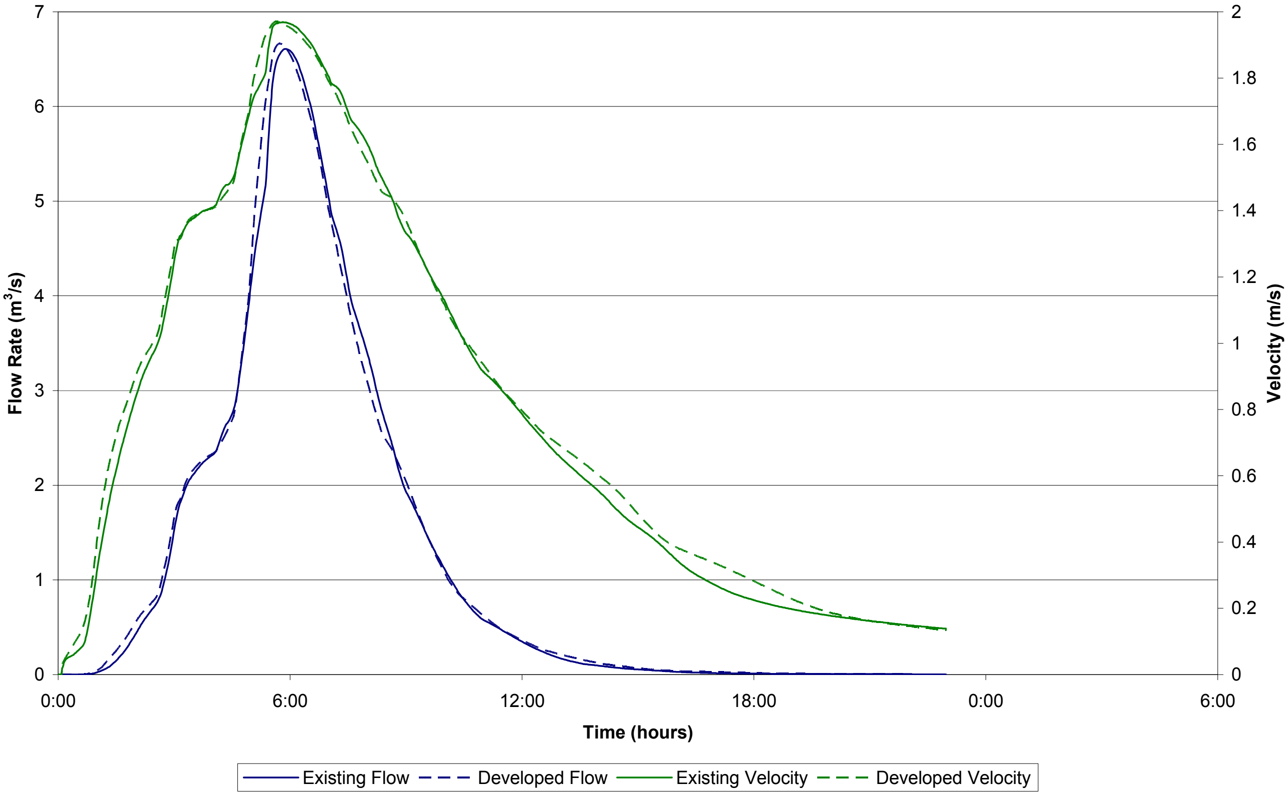
Node 2



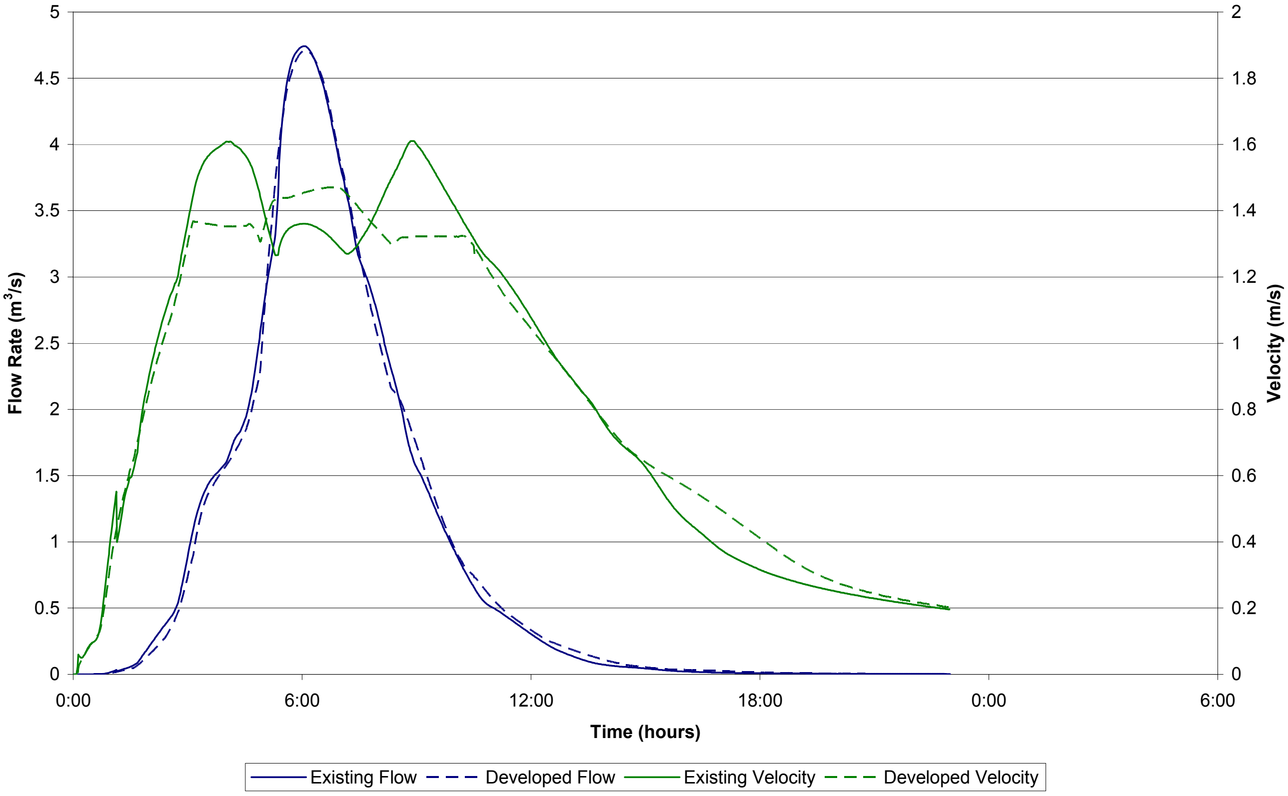
Node 4

FIGURE D9

Marulan Creek - 100 Year ARI Storm Event - Nodes 2 and 4



Node 2



Node 4

FIGURE D10

Marulan Creek - 20 Year ARI Storm Event - Nodes 2 and 4

APPENDIX E

Drainage Design Specifications

Appendix E - Water Management Design Specifications

Catch Drains	Base Width (m)	Grade (%)	Peak Discharge (m^3/s)	Peak Velocity (m/s)	Maximum Flow Depth (m)
A	2	1.9%	1.06	0.86	1.13
B	3	1.1%	1.95	1.28	0.37
C	0.5	2.1%	0.06	0.72	0.10
D	15	0.5% *	3.30	1.22	0.25
E	4	0.8%	2.54	0.83	0.69
F	3	1.6%	2.17	1.05	1.34
G	10	1.0% *	2.96	1.22	0.25
H	3	1.0 % *	1.21	1.21	0.32

* Drop structures required along channel

Culvert Number	Size
1	1 x 825 mm diameter pipe
2	2 x 1050 mm diameter pipes
3	2 x 1350 mm diameter pipes
4	2 x 1.8 m x 2.4 m box culverts*
5	2 x 1.8 m x 2.1 m box culverts*
6	2 x 1050 mm diameter pipes
7	2 x 1050 mm diameter pipes
8	2 x 1050 mm diameter pipes
9	2 x 1050 mm diameter pipes
10	2 x 1050 mm diameter pipes
11	2 x 1050 mm diameter pipes
12	2 x 600 mm diameter pipes
13	2 x 1.8 m x 1.2 m box culverts
14	2 x 675 mm diameter pipes
15	2 x 675 mm diameter pipes
16	2 x 675 mm diameter pipes
17	1 x 600 mm diameter pipe
18	3 x 900 mm diameter pipes
19	3 x 825 mm diameter pipes
20	1 x 450 mm diameter pipe
21	2 x 675 mm diameter pipes
22	1 x 1.8 m x 1.2 m box culvert*
23	1 x 1.8 m x 1.2 m box culvert

* Base of Culvert to be placed 300 mm below finished bed level

Appendix E - Emplacement Area Catch Drain Design Specifications

Rail Overburden Emplacement Area

Drain Name	Base Width (m)	Grade (%)	Pre-Vegetated			Post-Vegetated		
			Peak Discharge (m^3/s)	Peak Velocity (m/s)	Maximum Flow Depth (m)	Peak Discharge (m^3/s)	Peak Velocity (m/s)	Maximum Flow Depth (m)
RC1	2	1.6%	1.51	1.43	0.35	0.74	1.16	0.24
RC2	2	1.8%	0.79	1.24	0.24	0.39	0.99	0.16
RC3	2	1.6%	1.51	1.44	0.35	0.74	1.16	0.24
RC4	2	1.8%	0.79	1.24	0.24	0.39	0.99	0.16
RC5	1	6.3%	1.41	2.02	0.34	0.69	1.67	0.24

Eastern Overburden Emplacement Area

Drain Name	Base Width (m)	Grade (%)	Pre-Vegetated			Post-Vegetated		
			Peak Discharge (m^3/s)	Peak Velocity (m/s)	Maximum Flow Depth (m)	Peak Discharge (m^3/s)	Peak Velocity (m/s)	Maximum Flow Depth (m)
EC3	2	1.0%	2.30	1.35	0.49	1.13	1.10	0.34
EC4	2	1.0%	0.73	0.97	0.27	0.36	0.78	0.18
EC5	1	0.7%	0.33	0.53	0.32	0.16	0.44	0.22
EC7	2	1.5%	1.16	1.31	0.30	0.57	1.06	0.21
EC8	2	0.8%	1.89	1.18	0.47	0.93	0.96	0.32
EC9	2	1.7%	1.45	1.45	0.33	0.71	1.17	0.23
EC10	2	1.2%	1.32	1.25	0.35	0.65	1.01	0.24
EC11	4	3.8%	5.61	2.63	0.41	2.77	2.09	0.27
EC12	1	1.3%	0.50	1.04	0.27	0.25	0.85	0.19
EC13	1	1.1%	0.48	0.95	0.28	0.24	0.78	0.19
EC14	1	2.3%	0.53	1.29	0.24	0.26	1.05	0.17
EC15	1	17.8%	0.71	2.93	0.16	0.35	2.37	0.11

Western Overburden Emplacement Area

Drain Name	Base Width (m)	Grade (%)	Pre-Vegetated			Post-Vegetated		
			Peak Discharge (m^3/s)	Peak Velocity (m/s)	Maximum Flow Depth (m)	Peak Discharge (m^3/s)	Peak Velocity (m/s)	Maximum Flow Depth (m)
WC1	2	1.3%	0.51	0.97	0.20	0.25	0.77	0.13
WC2	2	1.2%	0.98	1.14	0.30	0.48	0.92	0.20
WC3	2	2.6%	0.66	1.33	0.19	0.33	1.06	0.13
WC4	2	1.3%	0.55	0.98	0.21	0.27	0.78	0.14
WC5	2	1.6%	0.88	1.23	0.26	0.44	0.99	0.18
WC6	2	3.1%	0.45	1.25	0.15	0.22	0.98	0.10
WC7	4	8.3%	2.40	2.19	0.23	1.18	1.71	0.15

Western Excess Product Emplacement Area

Drain Name	Base Width (m)	Grade (%)	Pre-Vegetated			Post-Vegetated		
			Peak Discharge (m^3/s)	Peak Velocity (m/s)	Maximum Flow Depth (m)	Peak Discharge (m^3/s)	Peak Velocity (m/s)	Maximum Flow Depth (m)
PC1	1	0.8%	1.39	1.15	0.49	0.69	0.95	0.35
PC2	1	0.5%	1.42	0.92	0.57	0.70	0.77	0.41
PC3	1	0.9%	2.11	1.33	0.58	1.04	1.11	0.42
PC4	1	0.8%	2.00	1.26	0.58	0.98	1.05	0.42
PC5	1	0.5%	2.13	1.10	0.65	1.05	0.92	0.47
PC6	1	2.8%	0.19	1.04	0.13	0.09	0.82	0.09
PC7	2	24.3%	6.64	4.84	0.42	3.27	3.95	0.29
PC8	1	1.0%	0.19	0.60	0.20	0.09	0.48	0.13

Eastern Excess Product Emplacement Area

Drain Name	Base Width (m)	Grade (%)	Pre-Vegetated			Post-Vegetated		
			Peak Discharge (m^3/s)	Peak Velocity (m/s)	Maximum Flow Depth (m)	Peak Discharge (m^3/s)	Peak Velocity (m/s)	Maximum Flow Depth (m)
SC1	2	0.8%	1.35	1.08	1.25	0.66	0.88	0.27
SC2	2	1.5%	2.17	1.55	1.40	1.07	1.26	0.29
SC3	3	1.5%	1.13	1.22	0.92	0.56	0.97	0.17
SC4	2	1.1%	1.62	1.28	1.26	0.80	1.04	0.27
SC5	2	1.0%	1.94	1.29	1.50	0.96	1.06	0.31
SC6	2	1.2%	0.59	0.98	0.60	0.29	0.78	0.15
SC7	3	1.3%	1.07	1.14	0.25	0.53	0.90	0.17
SC8	3	3.1%	5.27	2.32	0.50	2.60	1.70	0.37
SC9	1	1.4%	0.19	0.67	0.18	0.09	0.54	0.12

APPENDIX F

Predicted Pollutant Generation for the Water Management System Area

Table 1 -Predicted Year 2 Pollutant Generation for Water Management System Area

Pollutant	Dry Rainfall Year	Average Rainfall Year	Wet Rainfall Year
Total Phosphorus (kg)	269	384	692
Total Nitrogen (kg)	3,075	4,228	7,304
Total Suspended Solids (kg)	50,702	596,175	990,487

Table 2 -Predicted Year 5 Pollutant Generation for Water Management System Area

Pollutant	Dry Rainfall Year	Average Rainfall Year	Wet Rainfall Year
Total Phosphorus (kg)	253	361	651
Total Nitrogen (kg)	2,891	3,975	6,867
Total Suspended Solids (kg)	48,163	561,638	935,031

Table 3 -Predicted Year 10 Pollutant Generation for Water Management System Area

Pollutant	Dry Rainfall Year	Average Rainfall Year	Wet Rainfall Year
Total Phosphorus (kg)	232	331	596
Total Nitrogen (kg)	2,647	3,640	6,287
Total Suspended Solids (kg)	48,628	524,618	890,983

Table 4 -Predicted Year 15 Pollutant Generation for Water Management System Area

Pollutant	Dry Rainfall Year	Average Rainfall Year	Wet Rainfall Year
Total Phosphorus (kg)	211	301	542
Total Nitrogen (kg)	2,407	3,310	5,717
Total Suspended Solids (kg)	41,554	470,949	789,695

Table 5 -Predicted Year 20 Pollutant Generation for Water Management System Area

Pollutant	Dry Rainfall Year	Average Rainfall Year	Wet Rainfall Year
Total Phosphorus (kg)	210	300	541
Total Nitrogen (kg)	2,402	3,303	5,706
Total Suspended Solids (kg)	40,238	467,183	778,624

Table 6 -Predicted Year 25 Pollutant Generation for Water Management System Area

Pollutant	Dry Rainfall Year	Average Rainfall Year	Wet Rainfall Year
Total Phosphorus (kg)	211	302	544
Total Nitrogen (kg)	2,416	3,322	5,738
Total Suspended Solids (kg)	41,197	471,505	788,664

Table 7 -Predicted Year 30 Pollutant Generation for Water Management System Area

Pollutant	Dry Rainfall Year	Average Rainfall Year	Wet Rainfall Year
Total Phosphorus (kg)	212	302	544
Total Nitrogen (kg)	2,418	3,325	5,744
Total Suspended Solids (kg)	38,324	465,296	767,022