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9. WATER RESOURCES

9.1. INTRODUCTION

This Section provides a description of the existing surface water and groundwater environments at the South Galilee Coal Project (SGCP) and surrounds. The Section identifies the potential impacts on water resources and discusses the water management measures required to appropriately mitigate the potential impacts identified.

9.2. METHODOLOGY

9.2.1. Surface Water Assessment

A surface water assessment of the SGCP was undertaken by WRM Water and Environment. The technical report produced by WRM has been included as **Appendix F—Surface Water**.

This surface water assessment covers:

- relevant legislation for surface water management
- the baseline (existing) surface water environment and associated environmental values
- the existing water users and uses
- the hydrology of the SGCP site including upstream and downstream conditions
- the known historical and modelled flooding characteristics of the site
- identification of potential impacts and impact assessment
- proposed site water management and mitigation measures.

As part of these studies, a conceptual Mine Water Management System (MWMS) and water balance was developed to control surface water flow at the site and to characterise the expected performance of the system. The MWMS is the control measure to manage surface water flows from all areas disturbed by mining and associated infrastructure and processing operations.

The surface water assessment was undertaken in the context of identifying applicable environmental values in accordance with *Environmental Protection (Water) Policy 2009 (EPP (Water))*, *Australian New Zealand Guidelines for Fresh and Marine Water Quality* (*ANZECC Guidelines*) (ANZECC & ARMCANZ, 2000) and the *Queensland Water Quality Guidelines 2009 (Version 3) (QWQG)* (DERM, 2009).

The methodology adopted for the surface water assessment included:

- identification of relevant environmental values applicable to water quality management
- assessment and preliminary description of the background surface water quality based on SGCP specific water quality sampling
- description of the features and activities of the SGCP relevant to the surface water quality impact assessment and description of potential impacts
- identification of mitigation strategies and measures required to manage the potential impacts on surface water
- identification of the potential residual impacts, following implementation of mitigation strategies and measures.

The conceptual MWMS was developed in accordance with the following objectives:

- development of surface water management system concepts at various phases through the SGCP life
- diversion of runoff from undisturbed catchments (clean water) around the SGCP area (i.e. bypassing the MWMS)
- segregation of waters within the SGCP site based on expected water quality
- reuse of saline and waste rock runoff water around site, with this water preferentially reused in the mine operations for coal processing
- determination of sufficient storage capacity within site dams for mine water containment
- preparation of a preliminary water balance of the SGCP site to estimate runoff volumes and simulate the balance of runoff (and other mine water generation) with mine water consumption to identify potential overflows and identify potential water deficits/surpluses over the mine life.

A surface water quality assessment was undertaken to assess the potential impacts of the SGCP on surface water quality in watercourses within and downstream from the SGCP area.

9.2.2. Groundwater Assessment

The groundwater assessment characterised the existing groundwater environment and estimated the potential impacts resulting from groundwater inflow into the proposed open-cut pit and underground longwall mine, and the impact of groundwater drawdown as a result of the proposed mining activities. The cumulative impact on the groundwater regime of mining the Galilee Coal Project , the Alpha Coal Project, the Kevin's Corner Coal Project together with the South Galilee Project was taken into account.

A comprehensive hydrogeological baseline assessment was undertaken for the SGCP, covering the coal seams and surrounding aquifers, both artesian and sub-artesian (including the Great Artesian Basin (GAB)), inter-aquifer connectivity, flow of water, recharge and discharge mechanisms, and hydrogeological processes at work.

The groundwater assessment involved:

- a review of existing data, previous groundwater investigations, and other EIS reports
- reviewing the regulatory framework as it relates to groundwater
- field work, including siting and construction of groundwater monitoring bores, installation of electronic data loggers, and undertaking a bore survey
- characterisation of the existing groundwater environment, such as aquifer types (including GAB aquifers to the west), groundwater levels, groundwater flow directions and aquifer interconnectivity, recharge and discharge processes, water quality, bore yields
- characterisation of the environmental values/uses of groundwater in the region
- development of conceptual and numerical groundwater models to assess the pre-mining, mining and post-mining groundwater environments and changes associated with each stage
- assessment of mine dewatering requirements in relation to the mining schedule
- assessment of the predicted impacts of the mine operation on the groundwater resource in terms of potential impacts on groundwater levels, quality and environmental values/uses, and outlining potential mitigation measures where appropriate
- assessment of the final open pit void effects in relation to predicting water levels and salinity
- development of monitoring and mitigation strategies for input into the Environmental Management Plan (EM Plan).

The hydrogeological assessment includes data extrapolated by modelling simulations and monitoring data validation. Supporting literature includes geological and hydrogeological studies for the SGCP and immediate surrounds. Cumulative impact assessment included model validation for neighbouring mines and included the township of Alpha. Modelling results are summarised from the groundwater technical report completed by RPS Aquaterra (refer to **Appendix G—Groundwater**).

9.2.3. Subsidence Assessment

The subsidence assessment for the SGCP aims to determine the potential surface impacts caused by potential subsidence from underground mining, as well as potential impacts on surface and groundwater flows and quality.

Results are summarised from the subsidence technical report completed by Seedsman Geotechnics Pty Ltd (refer to **Appendix H—Subsidence**).

9.3. LEGISLATIVE FRAMEWORK

The Final Terms of Reference (ToR) for the SGCP indicate a number of legislated Acts, regulatory guidelines and other water management documents that are required to be addressed as part of this Environmental Impact Statement (EIS). A summary of the relevant documents is provided in this Section. The relevant requirements of these documents have been reviewed and incorporated into the surface water and groundwater assessments for the SGCP.

9.3.1. *Water Act 2000*

The *Water Act 2000* (*Water Act*) vests the use and control of all of the State's water to the Queensland Government. The *Act* is the primary statutory document that establishes a system for the planning, allocation and use of non-tidal water. In Queensland, the *Act* is administered by Department of Natural Resources and Mines (DNRM). The *Act* prescribes the process for preparing Water Resource Plans (WRPs) and Resource Operation Plans (ROPs) for specific catchments within Queensland. Under this process, WRPs are prepared to identify a balance between waterway health and community needs, and to set allocation and management objectives. The ROPs provide the operational details on how this balance can be achieved.

The WRPs and ROPs determine conditions for granting water allocation licences, permits and other authorities, as well as rules for water trading and sharing. The WRP sets Environmental Flow Objectives (EFOs) to protect waterway health, and Water Allocation Security Objectives (WASOs) to maintain community water supplies. The nearest WRP node of relevance for assessing EFOs and WASOs are well downstream of SGCP, at the Suttor and Belyando River confluence.

The *Act* provides a legislative basis for the sustainable planning and management of Queensland's water resources. It establishes the relevant Water Authorities and their responsibilities, including regulation of water allocations, water usage criteria, and also sets the standards for water bore drilling and water bore licensing requirements. A water licence is required for the taking of and using water or interfering with the flow of water. Water licences are tied to the land, and are not tradable.

Under the *Water Act*, the preparation of land and water management plans may be required in specific areas. DNRM has advised that there are no land and water management plans in place in the vicinity of the SGCP.

There is provision in the WRPs for the taking of overland flow water to satisfy the requirements of an Environmental Authority (EA) issued under the *Environmental Protection Act 1994* (*EP Act*). This provision is likely to apply to surface water intercepted by the MWMS to protect downstream water quality.

Overland flow is defined in the *Water Act* as follows:

> *"water, including floodwater, flowing over land, otherwise than in a watercourse or lake:*
> *(a) after having fallen as rain or in any other way; or*
> *(b) after rising to the surface naturally from underground.*

> *It excludes:*
> *(a) water that has naturally infiltrated the soil in normal farming operations, including infiltration that has occurred in farming activity such as clearing, replanting and broadacre ploughing; or*
> *(b) tailwater from irrigation if the tailwater recycling meets best practice requirements; or*
> *(c) water collected from roofs for rainwater tanks."*

Where the bed and banks of watercourses are to be disturbed by proposed works, licensing will be required under the *Water Act*. Once design of these structures is finalised, they will be submitted to DNRM with an application for a Riverine Protection Permit and/or Water Licence application.

The EIS identifies a number of proposed levees for flood protection. The authorisation of levee banks on mining tenements falls under the jurisdiction of the *EP Act*. However where they form plugs for the existing watercourses, some levees may be incorporated into the licensing of the watercourse diversions, and would be assessed under the *Water Act*, in negotiation with DNRM.

9.3.2. Water Regulation 2002

The *Water Regulation 2002* lists current subartesian areas in Queensland. The schedule also lists the bore types (e.g. stock or domestic) for which a water entitlement or permit is not required, and the bore types which are not assessable. Where authority is required to take or interfere with water, a development permit is required for bore drilling and construction. Authority to take or interfere with groundwater may be in the form of a Permit to Take Water (where the activity is of a temporary nature) or a Water Licence (where the taking of or interference with groundwater is of a longer-term nature).

9.3.3. Environmental Protection Act 1994

The *EP Act* promotes ecologically sustainable development, and has the stated objective "to protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends". The Proponent is aware of the Standard Criteria set out in the *EP Act* (Schedule 4), which includes the requirement to consider the principles of the National Strategy for Ecologically Sustainable Development (ESD) including the Precautionary Principle in decision making.

Chapter 5 of the *EP Act* establishes a process for obtaining an EA for mining activities. A Level 1 EA (mining activities) is applicable to the SGCP. In addition, an Environmental Management Plan (EM Plan) is also required under Section 201 of the *EP Act*. The Department of Environment and Heritage Protection (DEHP) is the regulatory authority with responsibility for granting the EA under the *EP Act*, as well as compliance, auditing and monitoring of the SGCP environmental management activities. Surface water management is regulated through this process.

The *EP Act* regulates mining activities and associated Environmentally Relevant Activities (ERAs) through the EM Plan and EA conditions. These mechanisms will be utilised to regulate surface water management for the SGCP. Dams containing hazardous waste (including tailings storage facilities and mine water dams) that are not Referable Dams under the *Water Supply Safety and Reliability Act 2008* are regulated through EA conditions. Potential controlled releases of mine affected water from the SGCP and associated surface water monitoring will also regulated with EA conditions.

Conceptual details and design criteria of the water management systems for the SGCP are described in the following Sections, with this information contributing to proposed EA conditions within the EM Plan for the SGCP. The *EP Act* also permits DEHP to prepare Environmental Protection Policies (EPPs). EPPs are subordinate legislation which contain detailed requirements for protecting a part of the environment or controlling a type of activity. These are intended to complement the more general provisions in the *EP Act*. This includes the *Environmental Protection (Water) Policy 2009* (*EPP (Water))*.

9.3.4. Environmental Protection (Water) Policy 2009

The *EPP (Water)* seeks to seek to protect Queensland's waters while allowing for development that is ecologically sustainable. The *EPP (Water)* is subordinate legislation under the *EP Act*. Under the *EPP (Water)*, water quality must be assessed against established *QWQG*, however as the SGCP falls within the headwaters of the Central Coast Region where the *QWQG* are not complete, the use of the *ANZECC Guidelines* is acceptable. Queensland waters include water in rivers, streams, wetlands, lakes, aquifers, estuaries and coastal areas.

This purpose is achieved within a framework that includes:

- identifying environmental values for aquatic ecosystems and for human uses (e.g. water for drinking, farm supply, agriculture, industry and recreational use)
- determining water quality guidelines (WQGs) and water quality objectives (WQOs) to enhance or protect the environmental values.

The processes to identify environmental values and to determine WQGs and WQOs are based on the National Water Quality Management Strategy (NWQMS, 2000). Environmental values and WQOs that are adopted for particular waters are included in Schedule 1 of the *EPP (Water)*. Streams in the Burdekin Basin will not be scheduled until late 2013.

In the absence of scheduled environmental values, the following have been adopted for the area within and downstream of the SGCP:

- protection of aquatic ecosystems
- suitability for recreational use and aesthetics, including fishing activities
- cultural and spiritual values
- suitability for primary industrial uses, including irrigation and stock drinking water.

9.3.5. *Water Supply (Safety and Reliability) Act 2008*

The *Water Supply (Safety and Reliability) Act 2008* contains certain regulatory provisions from the *Water Act* 2000 and, to protect public health, introduce requirements relating to recycled water and drinking water. It regulates infrastructure management and service provision by water and sewerage service providers, including asset management, customer standards and water conservation, the supply of drinking water by water service providers, the production and supply of recycled water in certain circumstances, including augmenting drinking water supplies, and dam safety, including dam failure risk assessment and flood mitigation plans.

Referable dams are also legislated under the *Act*. The exact number and design details of referable dams (including levees) will not be finalised until the detailed design stage and during operations of the SGCP. A "population at risk" assessment will be carried out for each dam (which does not contain hazardous waste) to determine if it meets the criteria for referable dams.

9.3.6. Water Resource (Burdekin Basin) Plan 2007

Section 38 of the *Water Act 2000* provides for the Minister to prepare a water resource plan for any part of Queensland to advance the sustainable management of water. The objective of the plan is to provide a framework for the allocation and sustainable management of surface and overland flow water in the plan area to meet future water requirements, including the protection of natural ecosystems and security of supply to water users. The plan area includes the Burdekin and Haughton Rivers and their tributaries. The WRP provides a framework for managing and taking water, and establishing water allocations. The WRP applies to:

- water in a watercourse or lake
- water in springs not connected to:
    - artesian water
    - subartesian water connected to artesian water.
- overland flow water, other than water in springs connected to:
    - artesian water
    - subartesian water connected to artesian water.

The plan will eventually convert existing water authorisations to tradable volumetric water allocations. Unlike water licences, water allocations are not subject to periodic renewal and will endure beyond the 10 year life of the WRP. The rules under which water allocations will be traded will be established in the Burdekin Basin ROP.

The SGCP site is located within the Belyando-Suttor sub-catchment area of the WRP. The SGCP is not part of the declared Water Management Areas. The WRP identifies over 543,000 megalitres (ML) of unallocated water that may be made available in the plan area. In addition to water that may be granted from the unallocated water reserves, permits may be issued for water required for short-term projects such as the construction and maintenance of roads and bridges.

9.3.7. Burdekin Basin Resource Operations Plan 2009

The *Burdekin Basin Resource Operations Plan 2009* implements the *Water Resource (Burdekin Basin) Plan 2007*. The plan sets out the rules and requirements that guide the day-to-day management of stream flows and water infrastructure to achieve the objectives of the *Water Resource (Burdekin Basin) Plan 2007*.

The *Water Act* states that all rights to the use, flow and control of all water in Queensland are vested in the State. Water cannot be legally taken or used unless it is authorised under a water entitlement (a water allocation or licence). The Burdekin Basin ROP sets the rules by which water allocations and licences may be granted. A water allocation is defined under the *Act* as follows: "*An authority to take water granted under Section 121 or 122 of the Water Act 2000. A water allocation can only be issued under an approved resource operations plan.*"

Unsupplemented water is water taken under a water allocation or water licence that is not managed under a Resource Operations Licence (ROL) or Interim Resource Operations Licence (IROL). All potential surface water supplies on watercourses in the immediate vicinity of the SGCP site are unsupplemented.

Unsupplemented water management relates to:

- taking water under high stream flow conditions (water harvesting) within the bounds of a water supply scheme
- taking water under any flow conditions outside of the bounds of a water supply scheme.

For unsupplemented water, a water allocation may be specified in terms of:

- the nominal volume of water for the allocation
- the volumetric limit for the allocation
- the location from which the water may be taken under the allocation
- the purpose for which water may be taken under the allocation
- the maximum rate for taking water
- the flow conditions under which water may be taken
- the water allocation group to which the allocation belongs.

There is no proposal to take water for the SGCP from a watercourse. However, there is potential for the SGCP to impact on the reliability of supplies for licence holders downstream of the SGCP. There may also be other users who take unsupplemented water for stock or domestic purposes.

9.3.8. Water Resources (Great Artesian Basin) Plan 2006

The *Water Resources (Great Artesian Basin) Plan 2006* is the primary legislation for groundwater management of the GAB in Queensland. There are no artesian bores located in or near the SGCP area. The SGCP is just outside the eastern limit of the GAB. The SGCP area does fall within the Highlands Subartesian Area which is regulated under the *Water Regulations 2002*. Authority is required under these regulations to take or interfere with groundwater for any purpose, other than stock and domestic use, including mine water supply bores and mine dewatering bores.

9.3.9. Sustainable Planning Act 2009

The *Sustainable Planning Act 2009* (*SPA*) seeks to continue the coordination and integration of planning at the local, regional and State levels. The *SPA* provides the mechanism (via the Integrated Development Assessment System, or IDAS), through which assessment of a proposed development is undertaken, and under which a Development Permit is granted. Thus the SGCP will require Development Permits for all groundwater bores that are drilled and constructed within the Mining Lease Application (MLA), for purposes other than stock or domestic use, or construction of groundwater monitoring bores.

9.3.10. Fisheries Act 1994

The main purpose of this *Act* is to provide for the use, conservation and enhancement of the community's fisheries resources and fish habitats in a way that seeks to:

(a) apply and balance the principles of ESD

(b) promote ESD.

The *Fisheries Act 1994* is relevant to the SGCP in relation to any potential impediments or crossings of recognised creeks and waterways as a result of the SGCP.

9.3.11. Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & *ARMCANZ*, 2000)

The primary objective of the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, developed by the Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ), is: "To provide an authoritative guide for setting water quality objectives required to sustain current, or likely future, environmental values (uses) for natural and semi-natural water resources in Australia and New Zealand."

These guidelines play a vital role in the management of water quality in both New Zealand and Australia. They provide methods for setting limits on pollutant concentrations in freshwater, coastal and marine environments.

9.3.12. National Water Quality Management Strategy

The *NWQMS* provides a national approach to improving water quality in Australia's waterways. Through the application of the *NWQMS* the Australian Government is working in collaboration with States and Territories to reduce pollution being released into aquatic ecosystems with high ecological, social and/or recreational values across the country. Participants in *NWQMS* are working to protect the nation's water resources by improving their quality, reducing pollutants and at the same time supporting the businesses, industry and communities that depend on water for their continued development.

9.3.13. Queensland Water Quality Guidelines 2009 (DERM, 2009)

The *QWQG* are intended to address the need identified in the *ANZECC Guidelines* by:

- providing guideline values (numbers) that are tailored to Queensland regions and water types
- providing a process/framework for deriving and applying more locally specific guidelines for waters in Queensland.

9.3.14. Guideline: Establishing draft environmental values and water quality objectives (DERM, 2011)

This guideline sets out the processes for establishing draft environmental values and draft water quality objectives for specific waterways in line with the *ANZECC Guidlines* and the *EPP (Water).*

9.3.15. Australian Drinking Water Guidelines (NHMRC, 2011)

The Australian Drinking Water Guidelines were revised by the National Health and Medical Research COuncil in 2011 to provide information on acceptable water quality for human consumption and to offer information on measures to ensure their safety. It provides a framework for identifying acceptable water quality and is intended for use by the Australian community and all agencies with responsibilities associated with the supply of drinking water. These guidelines are relevant for the provision of potable water at the SGCP.

9.3.16. Groundwater Flow Modelling Guidelines

Guidelines were developed by the Murray Darling Basin Commission (MDBC) (Middlemis, 2001) for groundwater flow modelling projects in the Murray-Darling Basin, although they are suitable for modelling projects generally.

In 2012, the National Water Commission developed the Australian Groundwater Modelling Guidelines (AGMG) (Barnett et al., 2012), which build on the MDBC guidelines, have substantial consistency in the model conceptualisation, design, construction and calibration principles, and performance and review criteria. They are designed to promote transparency in modelling methodologies and encouraging consistency and best practice.

9.4. EXISTING SURFACE WATER ENVIRONMENT

9.4.1. Environmental Values

Environmental values for surface water relevant to the SGCP and associated infrastructure area are set and described under various documents, including the:

- Guideline: Establishing draft environmental values and water quality objectives (DERM Guideline)
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ, 2000) (ANZECC Guidelines)
- EPP (Water).

The environmental values for surface water in the SGCP area remain relatively consistent between the documents, as shown in **Table 9-1**.

Table 9-1 SGCP Environmental Values - Water

DERM Guideline	ANZECC Guidelines	EPP (Water)
• Aquatic—Slightly to Moderately disturbed (SMD) system. • Primary Industries—Stock watering. • Cultural and spiritual.	• 'Environmental values' of receiving waters as those values or uses of water that the community believes are important for a healthy ecosystem. • The receiving waterways relevant for the SGCP are classed as SMD	• Under Section 7 of the EPP (Water), there are no particular environmental values attributed to the specific waterways located within the SGCP as they are not listed in Schedule 1. • Section 7 (2) however, assigns the environmental values in the receiving water to be protected under the category 'other waters' as: • ecosystem protection (Level 2—disturbed ecosystems, QWQG • agricultural uses (Irrigation and Stock Watering).

Environmental values must consider that the catchment has seen significant changes in land use over the past 150 years, with rapid changes in the last 50. Widespread land clearing for agricultural use has occurred throughout much of the receiving water catchments.

9.4.2. Catchment Context

9.4.2.1. Water Courses

9.4.2.1.1. Regional Drainage Basin Characteristics

The SGCP is located in the upper catchment of the Burdekin River Basin. With a catchment area of approximately 130,500 (square kilometres) km^2, the Burdekin River Basin is one of Queensland's largest. The Burdekin River flows into coastal waters near the Great Barrier Reef (GBR).

Land use varies, ranging from beef cattle production and mining in the inland areas, to irrigated sugarcane and crop cultivation on the coastal delta and floodplains including the Burdekin River Irrigation Area (BRIA). The BRIA is supplied from Lake Dalrymple, Queensland's largest reservoir, which has a capacity of 1,860 gigalitres and is formed by Burdekin Falls Dam.

The SGCP MLA crosses the upper tributaries of Sandy Creek and Native Companion Creek, which are both tributaries of the Belyando River. The Belyando River is part of the Suttor River sub-basin, which has a catchment area of approximately 52,550 km^2.

The MLA covers an area of approximately 310 km^2, which is approximately 0.6 % and 0.2 % of the Suttor River and Burdekin River catchments respectively. The MLA is located approximately 350 km upstream of the Burdekin Falls Dam and 510 km upstream of the river mouth (refer to **Figure 9-1**).

9.4.2.1.2. Local Catchments – MLA Area

The SGCP crosses the catchments of Tallarenha Creek in the north, and Sapling Creek and Dead Horse Creek in the south. **Figure 9-2** and **Figure 9-3** shows the location of these three catchments in relation to the SGCP. As shown in **Figure 9-3**, Tallarenha Creek flows north to Lagoon Creek which flows into then Sandy Creek before joining the Belyando River 120 km to the north. Tallarenha Creek has a catchment area of approximately 209.5 km^2, and elevations from approximately 530 metres (m) Australian Height Datum (AHD) at the catchment ridge to approximately 365 m AHD at the Capricorn Highway crossing just downstream of the MLA boundary. Almost all of the Tallarenha Creek catchment to this location is within the MLA.

An unnamed, poorly defined tributary of Tallarenha Creek flows west of the proposed Coal Handling and Preparation Plant (CHPP) area and through the northern section of the open-cut. This tributary joins Tallarenha Creek 900 m beyond the northern MLA boundary. This tributary is fed by other poorly defined tributaries which cross the proposed mining area in a generally north-easterly direction. The Tallarenha Creek channel itself is located west and north of the proposed open-cut operation, but would be undermined by the proposed underground longwall operation.

Sapling Creek and Dead Horse Creek are east-flowing tributaries to Alpha Creek, which flows to the north through the township of Alpha before joining Native Companion Creek. Native Companion Creek flows north before joining the Belyando River near the Sandy Creek confluence. Sapling Creek and Dead Horse Creek have catchment areas of approximately 63.5 km^2 and 65.5 km^2 respectively. The upper catchments of these creeks are located west of the MLA, where ground surface elevations are up to 550 m AHD. The lower catchment elevations on the Alpha Creek floodplain are approximately 360 m AHD.

Alpha Creek has a catchment of 2,429 km^2 to the Dead Horse Creek confluence. A 1.6 km reach of Alpha Creek flows through the MLA between Dead Horse Creek and Sapling Creek, however, no disturbance planned in association with the SGCP would directly impact the bed or banks of Alpha Creek.

Sapling Creek requires diversion away from the proposed open-cut operation and parts of the upper catchment will be undermined by the underground operation. Dead Horse Creek will receive additional flows from the Sapling Creek diversion, but otherwise will not be affected directly by the SGCP.

Land use within the catchments is predominantly cleared farmland used for low intensity cattle grazing. There is little to no development within the assessment area.

9.4.2.1.3. Infrastructure Corridor

The proposed infrastructure corridor runs in a generally north-south direction (refer to **Figure 9-2**). With the exception of the northernmost 3 km, which drains west to Saltbush Creek (a tributary of Lagoon Creek), the corridor drains north-east to Native Companion Creek.

Native Companion Creek is located between 4 km and 11 km to the east of the infrastructure corridor. **Figure 9-2** shows the approximate extent of the Native Companion Creek floodplain mapped by the Queensland Reconstruction Authority. **Figure 9-2** also shows that the proposed corridor is outside the extent of the mapped floodplain.

Catchments crossing the proposed infrastructure corridor are shown in **Figure 9-2**. The catchment boundaries were defined using a combination of data from airborne laser scanning (ALS) data prepared for the Proponent, and data from the Shuttle Radar Topographic Mission (SRTM) where ALS data was unavailable.

The local topography is relatively flat, and drainage paths from these catchments are poorly defined. Channels with bed and banks are only apparent in the available terrain data for catchments 3, 4 and 6 (refer to **Figure 9-2**). Runoff from catchment 6, the largest crossing the corridor, would generally flow north.

Ground surface slopes in the vicinity of the catchment 12 crossing are less than 1:500, and likely flow directions are therefore difficult to determine. The results of the 2-dimensional hydrodynamic flood modelling show that runoff from these areas, flows in generally northerly direction along the corridor alignment.

9.4.2.1.4. Local Drainage Network

The alignments of the streams crossing the MLA are shown in **Figure 9-3**. The area is overlain by consolidated siltstone and sandstone. These deposits are thickest in the northern and central region of the SGCP. In the eastern part of the SGCP, there are alluvial deposits of gravel, sand and poorly consolidated clayey sandstone.

9.4.2.2. Existing Water Users

Surface water resources around the SGCP and infrastructure area have limited beneficial uses as they are ephemeral. A search of the State of Queensland Water Entitlements System was undertaken to identify regional surface water licence holders. The Burdekin Haughton Water Supply Scheme and the Bowen Broken Water Supply Scheme operate within the wider Burdekin Basin catchment.

There is no major water infrastructure in the Belyando/Suttor subcatchment, however, it contains a number of private weirs, pumps and off-stream storages licensed for water harvesting, irrigation and stock water. Licensed irrigators tend to be concentrated in areas with suitable alluvial plains adjacent to the Suttor and Belyando Rivers and their tributaries. Water licence holders were identified downstream of the SGCP site.

Figure 9-4 shows the locations of water licence holders in the vicinity of the SGCP, including the infrastructure area located to the north of the ML area. There may be other users who take water for stock or domestic purposes.

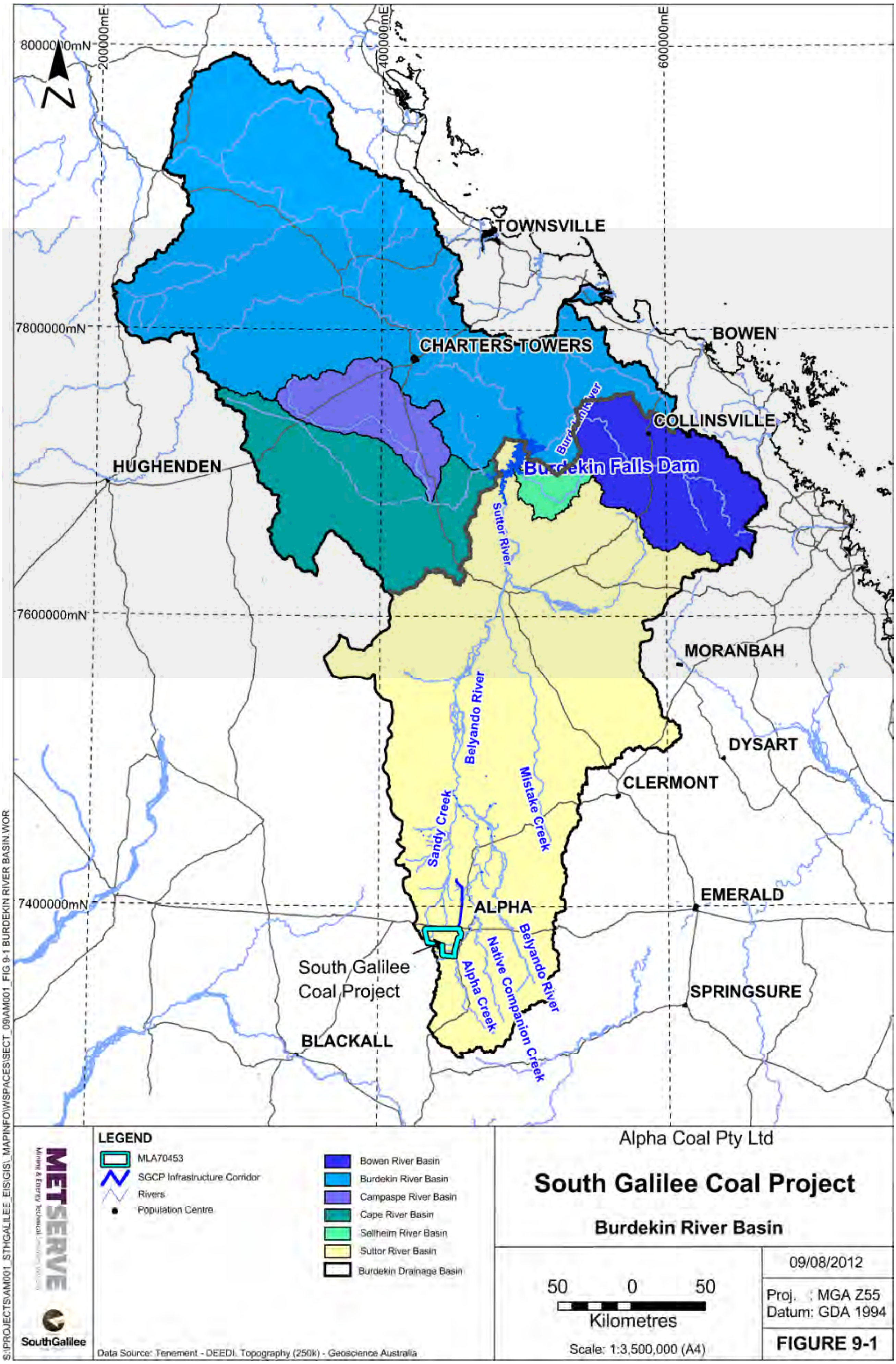
One Quarry Material Allocation Notice (QMAN) has been identified downstream of the SGCP. It is valid for Lagoon Creek, downstream of Tallarenha Creek, and allows the extraction of up to 45,000 cubic metres (m^3) per year up to a total of 225,000 m^3 between 1 September 2011 and 31 August 2016. Refer to **Annexure A** for the QMAN search results.

9.4.2.3. Climate

Long-term rainfall data have not been recorded at the SGCP site, however records have been kept at nearby Bureau of Meteorology (BOM) rainfall stations. The nearest long-term station is the Alpha Post Office rainfall station, located about 7 km north east of the MLA, where records have been kept since 1886. In order to infill gaps in the record, the Patched Point Dataset for the Alpha Post Office station was obtained from DEHP. The Patched Point Dataset uses original BOM measurements for a particular meteorological station, but missing data are filled (or "patched") with interpolated values.

DEHP's interpolations are calculated by splining and kriging techniques. Mean annual rainfall from this dataset over the 123 year period from 1889 to 2011 for which patched data is available, is 562 millimetres (mm). Annual rainfall at Alpha has been highly variable, ranging from 205 mm in 2002 to 1577 mm in 1956.

Mean monthly rainfall is highest between December and February. Mean monthly pan evaporation is highest between October and March. Mean annual pan evaporation is estimated to be 2,246 millimetres per annum (mm/a), with annual totals ranging between 1,677 mm/a and 2,614 mm/a.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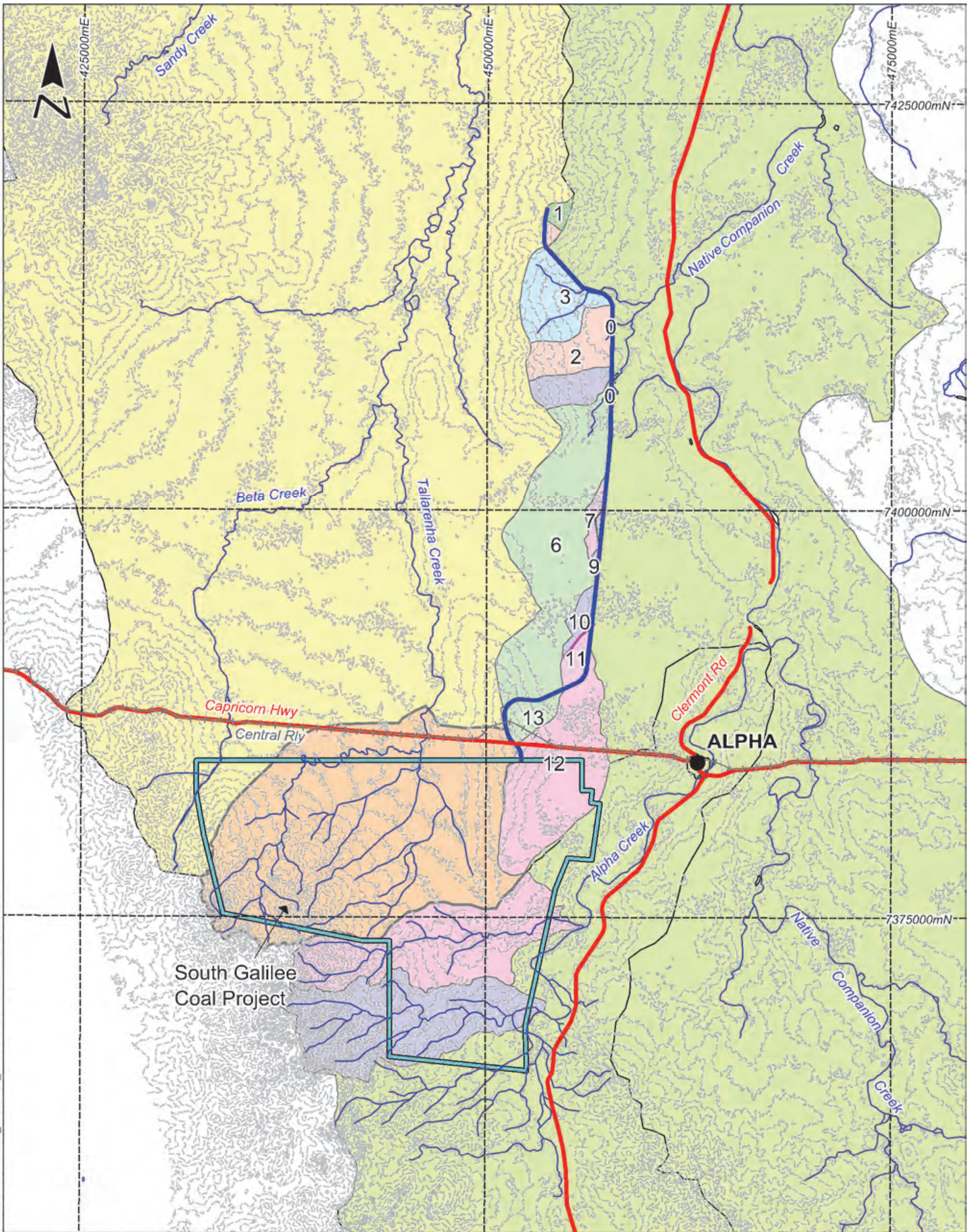
Scale: 1:3,500,000 (A4)
09/08/2012
Proj. : MGA Z55
Datum: GDA 1994
FIGURE 9-1



S:\PROJECTS\AM001_STHGALILEE_EIS\GIS_MAPINFOWSPACES\SECT_09\AM001_FIG 9-2 LOCAL CATCHMENTS.WOR

LEGEND

- MLA70453
- CATCHMENT BOUNDARY
- LOCAL CATCHMENT BOUNDARY
- SGCP INFRASTRUCTURE CORRIDOR
- ROADS
- RAILWAYS
- WATERCOURSE
- QRA FLOOD EXTENT

Data Source: Tenement - DEEDI. Topography (250k) - Geoscience Australia

METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

Alpha Coal Pty Ltd

South Galilee Coal Project

Local Catchments

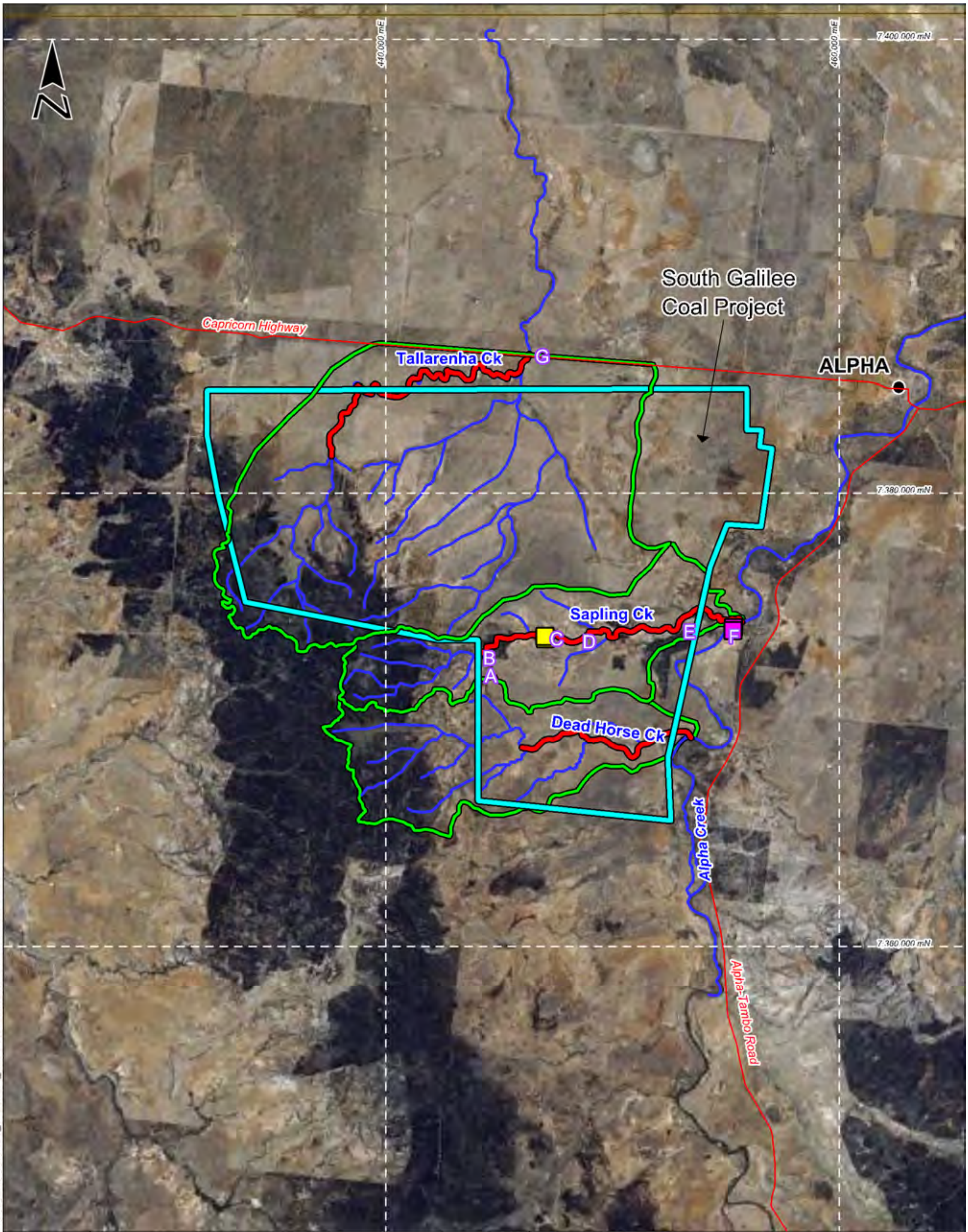
5 0 5
Kilometres

Scale: 1:350,000 (A4)

04/10/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 9-2



S:\PROJECTS\AM001_STHGALILEE_EIS\GIS_MAPINFO\WSPACES\SECT_09\AM001_FIG 9-3 LOCALDRAIN & WATERCOURSES.WOR

METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

LEGEND

- MLA70453
- DERM Watercourse
- Drainage Line
- River Basin
- Alpha Creek Monitoring Point
- Sapling Creek Monitoring Point
- Photographic Locations
- Population centre

Data Source: Tenement - DEEDI. Topography (250k) - Geoscience Australia

Alpha Coal Pty Ltd

South Galilee Coal Project

Local Drainage and Watercourses Mining Lease Application Area

5 0 5

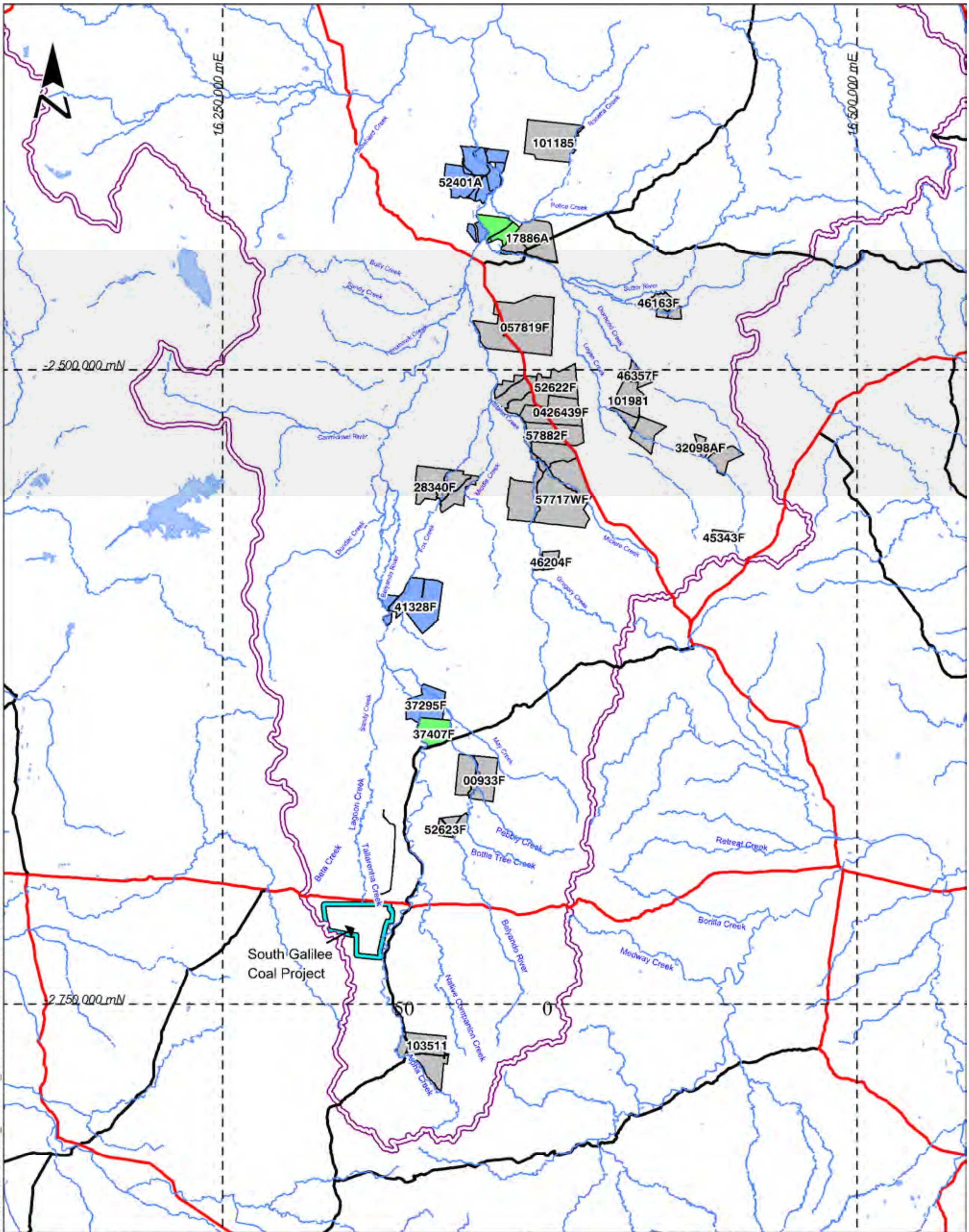
Kilometres

Scale: 1:250,000 (A4)

10/08/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 9-3



LEGEND

- MLA70453
- SGCP Infrastructure Corridor
- Watercourse
- Main Highway
- Secondary Roads
- Burdekin Basin
- License to take water
- Licence to interfere with impounding-embankment or wall
- Unaffected licence

Data Source: Tenement - DEEDI. Topography (250k) - Geoscience Australia

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South Galilee Coal Project

Downstream Water Users

50 0 50

Kilometres

Scale: 1:2,000,000 (A4)

10/08/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 9-4

S:\PROJECTS\AM001_STHGALILEE_EIS\GIS_MAPINFOWSPACES\SECT_09\AM001_FIG 9-4 DOWNSTREAM WATER USERS.WOR

9.4.3. Hydrology

9.4.3.1. Regional Hydrology

Catchment streamflow has been recorded at several gauging stations downstream of the MLA. The nearest DNRM gauge providing long-term streamflow data is in Native Companion Creek at Violet Grove, approximately 13 km north-east of the SGCP and approximately 30 km downstream of the MLA boundary.

This gauge has measured streamflow from a catchment of 4,065 km^2 since 1967. Mean streamflow is greatest between December and February, though average streamflow is also high in April. The flow duration curve indicates that the local streams are ephemeral, with long periods of low flow. Flows greater than 1 litre per second (L/s) have been observed 70 % of the time. The catchment runoff response is characterised by long periods of no flow interspersed with short periods of streamflow.

9.4.3.2. Flood Hydrology – Mine Area

A flood study was undertaken to estimate existing design flood levels and the flood extent along the streams crossing the MLA (refer to **Figure 9-6)**. The study shows the estimated depth of inundation across the MLA for the Probable Maximum Flood (PMF) Average Recurrence Intervals (ARI) flood event.

Full details of the methodology and results of the flood study are provided in **Appendix D and E** of **Appendix F— Surface Water**.

Design peak flow rates for creeks in the vicinity of the site are summarised for a range of Average Recurrence Intervals in **Table 9-2**.

Table 9-2 SGCP Creek Design Peak Flow Rates at Catchment Outlet (m^3/s)

Average Recurrence Interval (years)	Design Discharge (m^3/s)		
	Tallarenha Creek	Sapling Creek	Dead Horse Creek
2	125	53	76
50	535	228	327
100	686	295	420
1,000	957	454	586
3,000	1,152	546	704
PMF	3,005	1,421	1,833

The tenement boundary encroaches onto the floodplain of Alpha Creek at two localised areas in the south-east. Alpha Creek flooding will otherwise have little effect on the SGCP.

Flood flows in the north and north-east flowing tributaries of Tallarenha Creek cross the proposed mining area. The inundation is shallow (generally less than 500 mm in the 100 year ARI flood) and covers a broad area. Flood velocities are generally less than 1 m/s, except in the channels and localised areas, where velocities can exceed 2 m/s.

In the upper reaches of Tallarenha Creek, flood flows are well confined to a floodplain less than 500 m wide. However, as it turns east, a portion of flow breaks out and flows north to the Capricorn Highway. In small floods, this flow heads east along the highway. In larger floods, it crosses the highway and railway and flows north-east to the downstream reaches of Tallarenha Creek.

Flooding at Dead Horse Creek will not directly affect the SGCP, while Sapling Creek crosses the southern end of the proposed mining area. Sapling Creek and Dead Horse Creek have less significant floodplains, and the extent of flood inundation is typically less than 100 m wide, except in broader, flatter areas near the confluence with Alpha Creek.

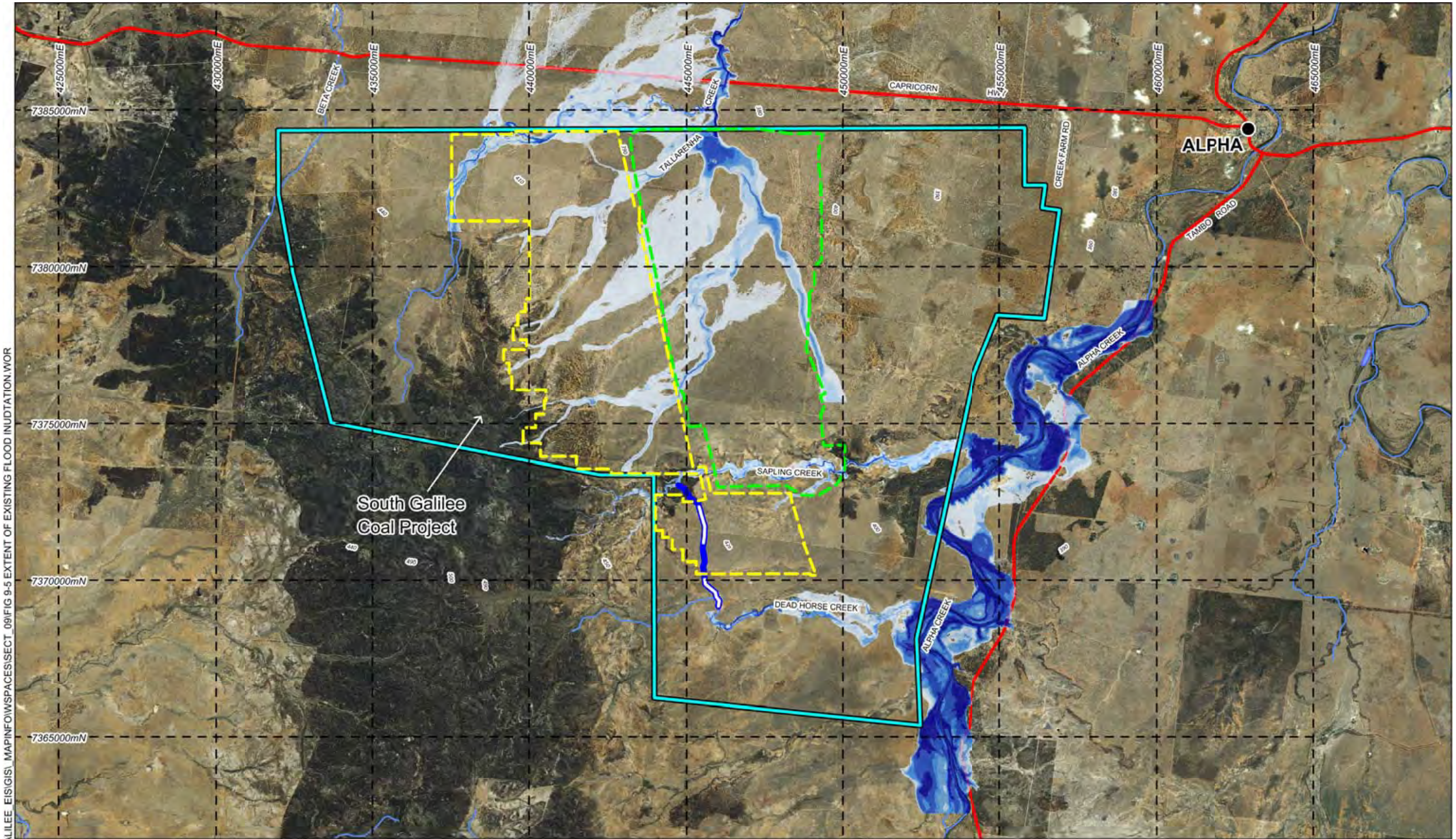
Design flow conditions in Sapling Creek and Dead Horse Creek in the vicinity of the SGCP are summarised for a range of ARIs in **Table 9-3** and **Table 9-4**. The 1 in 100 year ARI for Tallarenha and Sapling/Dead Horse Creeks are shown in **Figure 9-5**. The 1 in 100 year ARI flood velocity for Tallarenha Creek is shown in **Figure 9-6**. Other flood intervals are shown in **Appendix E** of **Appendix F— Surface Water.**

Table 9-3 Sapling Creek Design Flow Conditions

Average Recurrence Interval	Flow Rate m/s			Velocity m/s			Total Section Stream Power N/m²			Total Section Shear Stress N/ms		
(years)	Min	Md	Max	Min	Md	Max	Min	Md	Max	Min	Md	Max
2	30	54	63	0.5	1.4	2.7	1.1	22	271	3	18	99
50	137	246	275	0.8	2.1	5.3	2.3	37	614	4.8	29	186
100	176	315	355	0.9	2.2	4.8	2.9	4.3	628	5.5	26	160

Table 9-4 Dead Horse Creek Design Flow Conditions

Average Recurrence Interval	Flow Rate m/s			Velocity m/s			Total Section Stream Power N/m²			Total Section Shear Stress N/ms		
(years)	Min	Md	Max	Min	Md	Max	Min	Md	Max	Min	Md	Max
2	35	55	59	0.1	1.6	3.1	0	34	355	0.2	24	116
50	125	209	248	0.5	2.3	3.7	3.3	68	296	6	34	123
100	183	292	322	0.6	2.5	4.0	5	39	448	7	30	163



S:\PROJECTS\AM001_STHGALILEE_EIS\GIS_MAPINFO\WSPACES\SECT_09\FIG 9-5 EXTENT OF EXISTING FLOOD INUDTATION.WOR

METSERVE

SouthGalilee

2.5 0 2.5

Kilometres

Scale: 1:250,000 (A4)

LEGEND

- MLA70453
- SGCP infrastructure corridor
- Road/Access
- Rivers/Creeks
- Surface Disturbance Boundary
- Underground Disturbance Boundary
- 10-meter Contour
- Proposed Sapling Creek Diversion

Data Source: WRM. Topography - Geoscience Australia.

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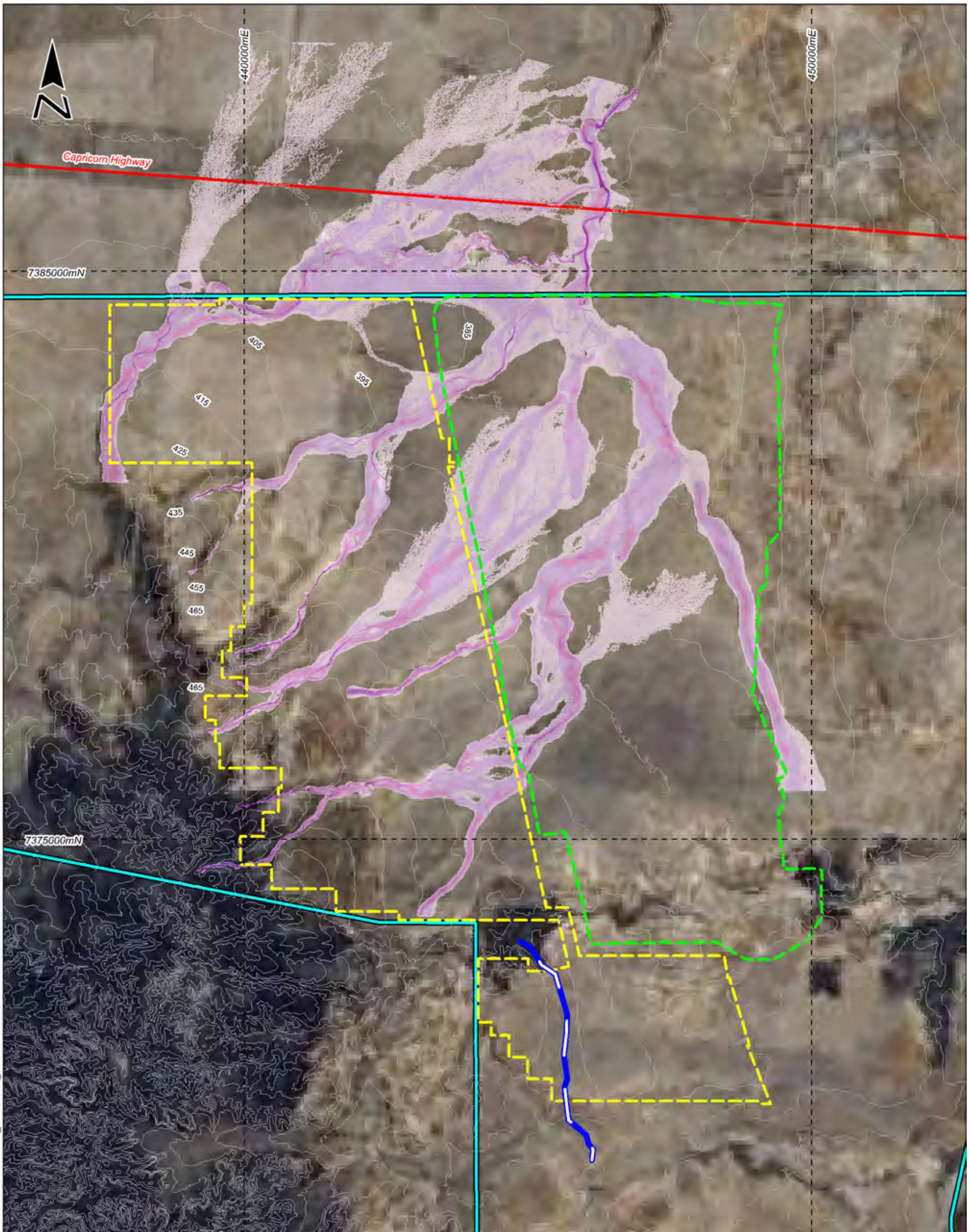
South Galilee Coal Project

Extent of Existing Flood Inundation-
100 Year ARI

07/10/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 9-5



S:\PROJECTS\AM001_STHGALILEE_EIS\GIS_MAPINFOWSPACES\SECT_09\AM001_FIG 9-6 TALLARENHA CREEK-FLOOD VELOCITY 100 YR ARI.WOR

METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

LEGEND

- MLA70453
- Surface Disturbance Boundary
- Underground Disturbance Boundary
- Principal Road
- Road
- 10-m Contour
- Proposed Sapling Creek Diversion

Q100 VELOCITY (m/s

- 0.0m/s < 0.5m/s
- 0.5m/s < 1.0m/s
- 1.0m/s < 1.5m/s
- 1.5m/s < 2.0m/s
- 2.0m/s < 2.5m/s
- 2.5m/s < 3.0 m/s
- 3.0m/s < 3.5m/s
- 3.0m/s < 4.0m/s

Data Source: Tenement - DEEDI. Topography (250k) - Geoscience Australia

Alpha Coal Pty Ltd

South Galilee Coal Project

Tallarenha Creek - Extent of Existing Flood Inundation-100 Year ARI

0 2.5 5

Kilometres

Scale: 1:100,000 (A4)

05/09/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 9-6

9.4.3.3. *Flood Hydrology – Infrastructure Area*

A flood study was undertaken to estimate design flood levels and the extent of inundation under existing conditions along the infrastructure corridor. Full details of the methodology and results of the flood study are provided in **Appendix D and E** of **Appendix F— Surface Water.**

Design flood flows in the unnamed tributaries of Native Companion Creek at the outlet of the model area are summarised in **Table 9-5**.

Table 9-5 Infrastructure Catchment Design Discharges

Average Recurrence Interval (years)	Flow Rate m^3/s
2	421
50	710
PMF	4,239

Figure 9-7 shows the estimated extent and depths of inundation along the infrastructure corridor for the Probable Maximum Flood event. Other flood intervals are shown in **Appendix E** of **Appendix F— Surface Water.** The figure shows that flow is in a generally northerly direction via two broad connected flow paths, in which depths are generally less than 0.5 m.

9.4.4. Geomorphic Stream Conditions

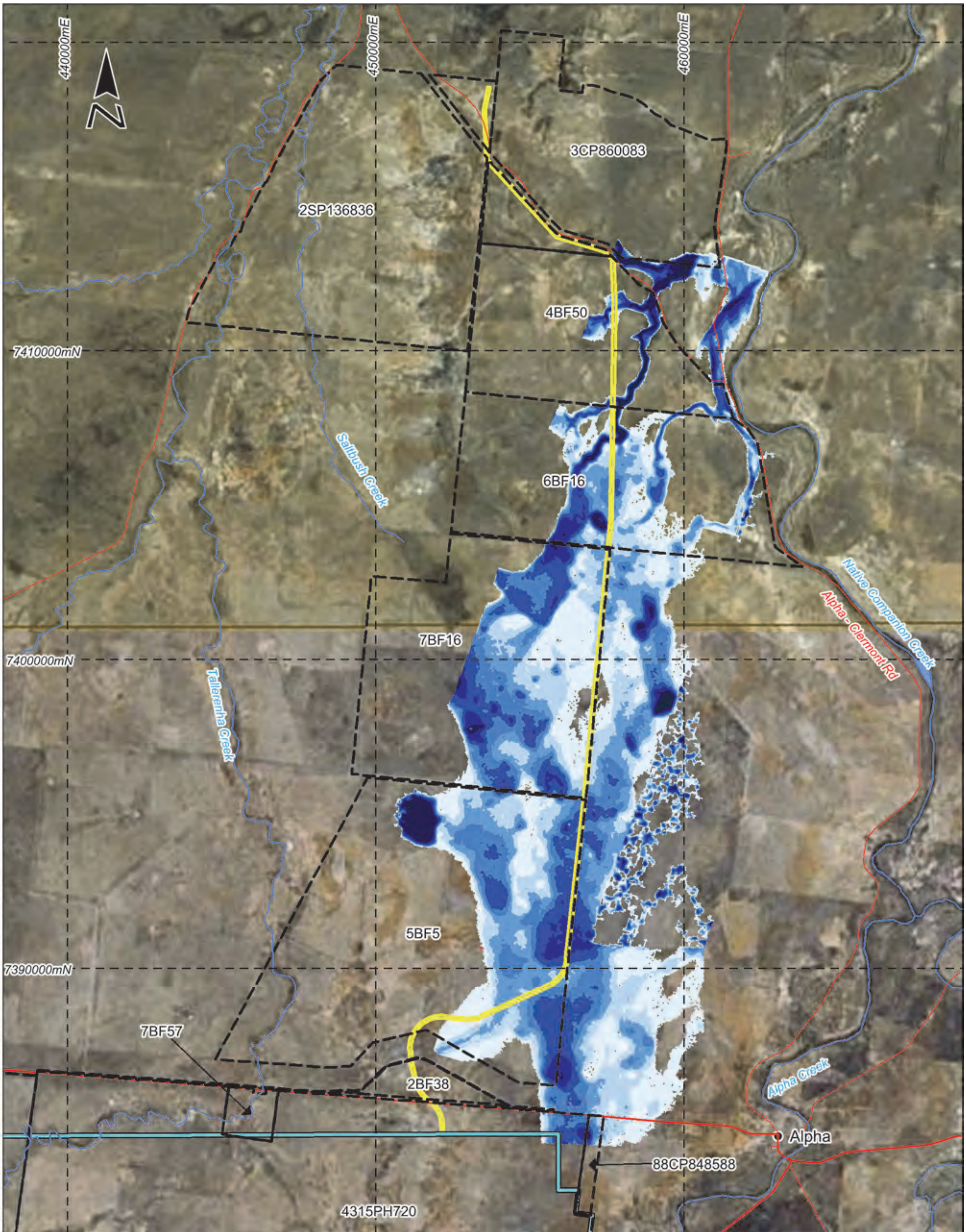
9.4.4.1. *Landscape Scale*

Sapling Creek and Dead Horse Creek have similar geomorphological characteristics. They have similar catchment areas, flow in a similar direction and cross similar geological features. Areas of the upper (western) parts of these catchments are drained by a closely spaced network of well-defined, relatively steep gullies. The creek channels themselves are also relatively steep, straight and well incised compared to other streams in the area.

In the lower eastern reaches, the channels widen, and a floodplain becomes better defined. Sapling Creek crosses a relatively steep escarpment at the edge of the Alpha Creek floodplain.

9.4.4.2. *Watercourse Features*

Photographs of the Sapling Creek channel are shown in **Appendix F—Surface Water**. In the upper reaches, the channel is relatively deep, the banks are well vegetated and apparently stable, with a coarse sandy bed. Further downstream, the channel becomes wider.



S:\PROJECTS\AM001_STHGALILEE_EIS\GIS_MAPINFOWSPACES\SECT_09\20120310_RENUMBEREDFIGS\FIG 9-7_8 & 9-19_9-20 WATER FIGURES-INFRA CORRIDOR

METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

LEGEND

- MLA70453
- Directly affected property
- SGCP infrastructure corridor
- Roads
- Population centre

Q100 FLOOD DEPTH (m)

- 0.0 - 0.5m
- 0.5 - 1.0m
- 1.0 - 1.5m
- 1.5 - 2.0m
- 2.0 - 3.0m
- 3.0 - 4.0m
- >4m

Data Source:
Cadastral (Barcaldine May2010)-DERM. Topo (250k raster)-Geoscience Australia.

Alpha Coal Pty Ltd

South Galilee Coal Project

Infrastructure Corridor-Existing Conditions-PMF Flood Depths and Extents

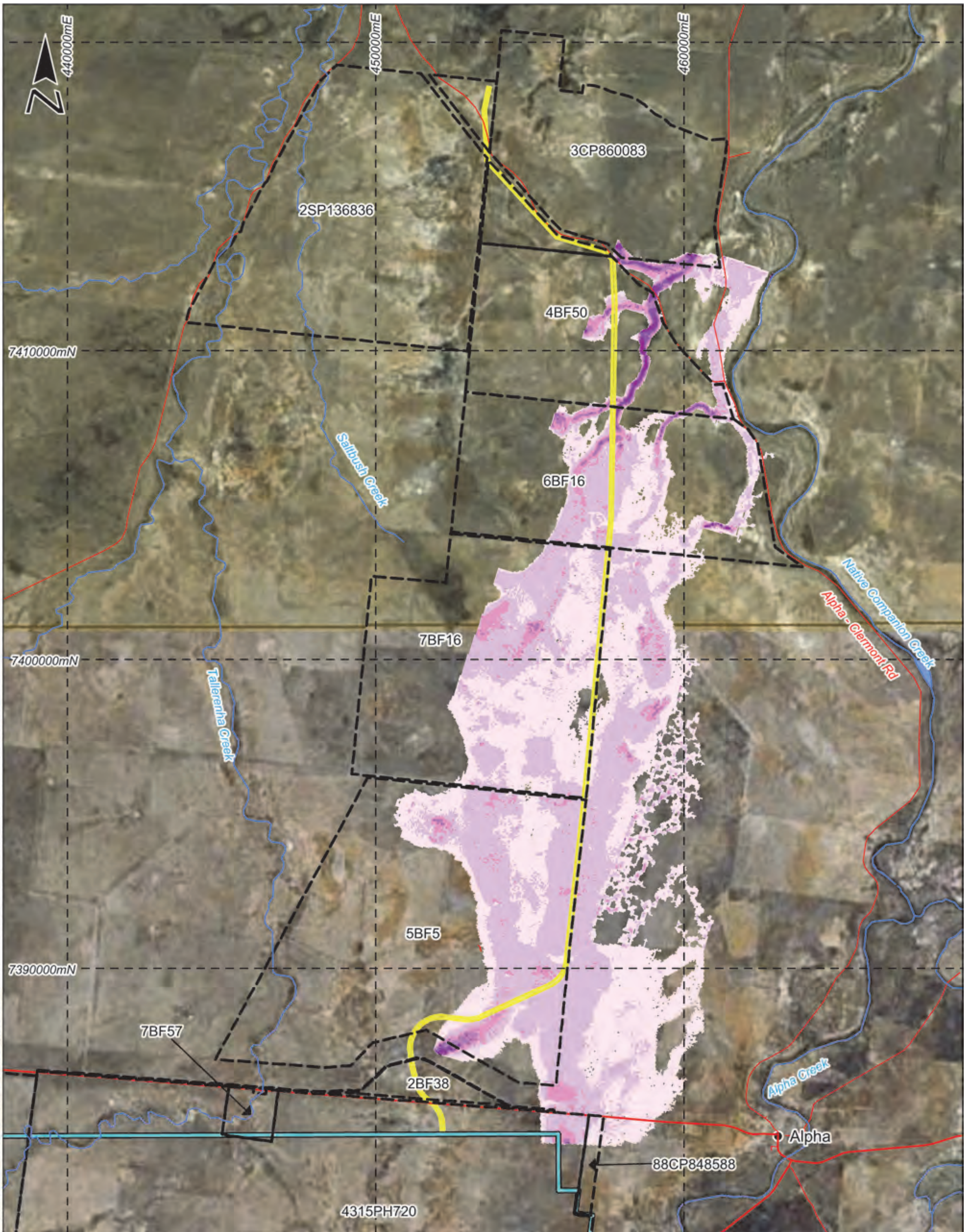
0 5
Kilometres

Scale: 1:175,000 (A4)

03/10/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 9-7



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METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

LEGEND

- MLA70453
- Directly affected property
- SGCP infrastructure corridor
- Roads
- Population centre

Q2 Velocity (m/s)

- 0.0m/s < 0.5m/s
- 0.5m/s < 1.0m/s
- 1.0m/s < 1.5m/s
- 1.5m/s < 2.0m/s
- 2.0m/s < 2.5m/s
- 2.5m/s < 3.0 m/s
- 3.0m/s < 3.5m/s
- 3.0m/s < 4.0m/s

Data Source:
Cadastral (Barcaldine May2010)-DERM. Topo (250k raster)-Geoscience Australia.

Alpha Coal Pty Ltd

South Galilee Coal Project

Infrastructure Corridor-Existing Conditions-PMF Flood Velocities

0 5
Kilometres

Scale: 1:175,000 (A4)

03/10/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 9-8

9.4.5. Baseline Water Quality

9.4.5.1. Water Quality Values

The *ANZECC Guidelines* define the environmental values of receiving waters as those values or uses of water that the community believes are important for a healthy ecosystem.

Under Section 7 of the *EPP (Water)*, there are no particular environmental values attributed to the specific waterways located within the SGCP and infrastructure area as they are not listed in Schedule 1.

Section 7 (2) however, assigns the environmental values in the receiving water to be protected under the category 'other waters' as:

- ecosystem protection (Level 2 – disturbed ecosystems, QWQG)
- agricultural uses (Irrigation and Stock Watering).

The ANZECC guidelines specify levels of protection corresponding to each of the following measures of the receiving water ecosystem condition:

- of high conservation value
- SMD
- highly disturbed.

The receiving waterways adjacent to the SGCP are SMD.

9.4.5.2. Baseline Surface Water Quality

The watercourses within the SGCP site and infrastructure area are ephemeral in nature and provide seasonal habitat for aquatic fauna and flora. The watercourses were noted to be SMD from current grazing activities.

The surrounding land use in the Belyando/Suttor subcatchment is predominantly grazing with some broad acre cereal cropping. Agricultural activities including crop irrigation, stock watering and farm use are the primary uses within the subcatchment. There are areas of conservation value and many of the tributaries are seasonally used as local recreational areas.

Background water quality data has been collected by the Proponent at various locations across the SGCP area. The following Sections present water quality assessment results for parameters of relevance to the SGCP. The variability of flow in ephemeral streams can lead to changes in the physical and chemical properties of flow when compared to perennial streams. The current *ANZECC Guidelines* therefore may not be well suited to the characteristics of water quality for ephemeral streams.

Data on water levels and salinity (electrical conductivity (EC)) has been recorded on Alpha Creek and Sapling Creek. The relationship between water level and EC and pH in Alpha Creek (when water level exceeds 0.5 m gauge height) for recordings made between January 2010 and December 2011 is characterised by the following:

- EC reduces with flow rate, and is less than 100 microsiemens per centimetre (µS/cm) when flow depths exceed 8.5 m
- pH varies between 6.5 and 10.7, with the high values occurring during low or zero flow. During low flow, pH is typically close to neutral. The cease to flow level is probably around 1.0 m
- when flow depth exceeds 1 m, EC is typically below 300 µS/cm
- when flow depth exceeds 0.5 m, EC is less than 450 µS/cm.

Elevated turbidity may be attributable to existing land uses in the catchment including open pasture and grazing which has historically involved widespread clearing and subsequently caused sediment mobilisation in waterways.

Higher EC values are also likely to be associated with land degradation, soil erosion and tree clearing from surrounding agricultural activities in the catchment. Graphs demonstrating water quality relationships are shown in **Figure 9-9** and **Figure 9-10**.

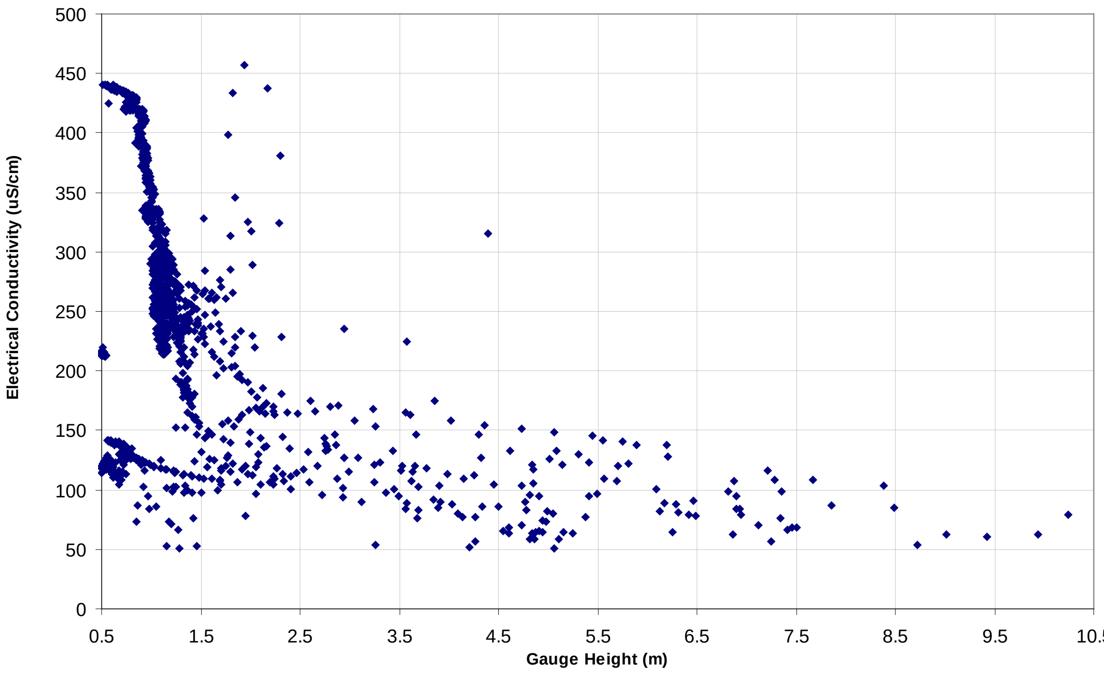


Figure 9-9 Salinity vs Flow Depth Relationship for Alpha Creek

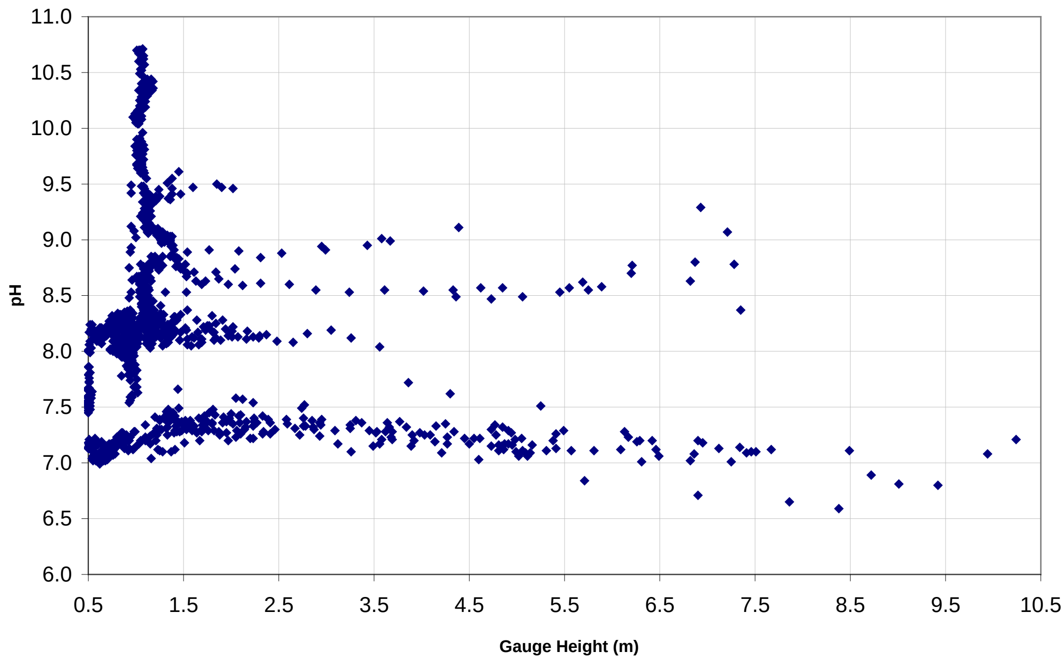


Figure 9-10 pH vs Flow Depth Relationship for Alpha Creek

Water quality has also been recorded in Native Companion Creek and is presented in **Table 9-6** with observed exceedances of trigger values shown in red. . Data to date has shown water quality samples have generally been within trigger water quality guidelines. Exceedance of metals guidelines during first flush flow events may occur.

Table 9-6 Native Companion Creek at Violet Grove Water Quality Data Summary

Parameter	Native Companion Creek (Violet Grove)			
	Receiving Water Trigger	Count	Median	90th percentile
Conductivity (µS/cm)	1,000	60	142	300
pH	6.5 – 8.0	61	7	8
Turbidity	-	35	200	597
TSS (mg/L)	-	59	90	170
Sulfate (mg/L)	1,000	43	2	7
Aluminium (µg/L)	27	30	50	415
Copper (µg/L)	1	32	25	50
Iron (µg/L)	300	42	75	1227
Zinc (µg/L)	8	31	10	60
Boron (µg/L)	370	38	50	100
Manganese (µg/L)	1,900	34	5	27
Ammonia (as N) (µg/L)	320	28	37	86
Nitrate (µg/L)	1,100	47	1350	3132
Fluoride (total) (µg/L)	2,000	60	185	300

9.4.5.3. Regional Sediment Transport Characteristics

Annual total suspended solid loads to the Great Barrier Reef Lagoon are estimated to be 17 million tonnes. The Burdekin River catchment is estimated to supply approximately 30% of this total (4.7 million tonnes per year), of which 4.1 million tonnes are from human activity derived from extensive areas under grazing (Reef Water Quality Protection Plan, 2011).

Sediment transport rates from the Native Companion Creek catchment (which has an area of 5,460 km^2 including the project area of 310 km^2) have been estimated in SedNet modelling studies by the CSIRO (Kinsey-Henderson, Sherman and Bartley, 2007). These studies concluded the creek conveys relatively high mean event concentrations of suspended sediments and nutrients (629 mg/L) attributable mainly to hillslope erosion (62%). However, due to its relatively low contribution to catchment runoff, Native Companion Creek contributes only a small proportion (less than 0.2 million tonnes per annum) of total sediment load (Dight, 2009).

The Burdekin Falls Dam significantly reduces sediment transport rates to the Great Barrier Reef Lagoon. The sediment trapping efficiency has been estimated as approximately 60-70% of suspended sediment in moderate to large flow events, and up to 80-90% in smaller events (Lewis et al,2009).

9.5. EXISTING GROUNDWATER ENVIRONMENT

The hydrogeological description of the SGCP in this section includes:

- geology/stratigraphy
- aquifer type and confinement
- depth to, and thickness of the aquifers
- depth to water level and seasonal changes
- groundwater flow directions
- current groundwater extraction regime (local and regional)
- interaction with surface water
- groundwater quality
- sources of recharge and points of discharge
- current access to groundwater resources in the form of bores, springs, including quantitative yield of water and access locations.

9.5.1. Environmental Values

The following environmental values are recognised by the National Water Quality Management Strategy (NWQMS):

- aquatic ecosystems
- primary industries
- recreation and aesthetics
- drinking water
- domestic use other than drinking
- industrial water
- cultural and spiritual values.

The environmental values considered in this Section include the water quality, quantity and standing water levels relating to the local and regional groundwater resources.

9.5.1.1. Aquatic and Groundwater Dependent Ecosystems

Within the SGCP region, including the GAB recharge beds formed by the Clematis Sandstone outcrop west of the SGCP, there are no springs or permanent creeks/streams in which the baseflow is maintained by groundwater discharge. Aquatic ecology surveys in the region have not identified any stygofauna (ALS, 2011). Therefore, there are no identified groundwater dependent ecosystems (GDE) within the SGCP area.

9.5.1.2. Primary Industries/Agricultural Use

Groundwater sourced from the bores within and adjacent to the SGCP (mainly the Tertiary, Triassic and Permian aquifers) is primarily utilised for stock watering.

9.5.1.3. Recreational and Aesthetic Use

Recreational and aesthetic groundwater use may be considered as valid environmental values where groundwater is used by local households.

9.5.1.4. Drinking Water

Groundwater from the SGCP is generally not compliant with drinking water guidelines without processing due to its high salinity. There are some isolated exceptions where the salinity is within guidelines, and it is noted that some users may choose to ignore guidelines or may not test the water source. Some Tertiary and Quaternary alluvial sediments contain groundwater which is used for the Alpha township water supply.

9.5.1.5. Industrial Use

New proposed mines in the surrounding area (e.g. Alpha Coal Project (ACP), Kevin's Corner Coal Project (KCCP), and Galilee Coal Project (GCP)) will intersect groundwater within some aquifers and will actively extract water from the resource to facilitate mining. This water may then be reused for industrial purposes such as haul road watering and coal washing where practicable.

9.5.1.6. Cultural and Spiritual Values

No cultural or spiritual values of groundwater at and in the vicinity of the SGCP site have been identified (refer to Section 15.4 of the EIS). This is very likely due to the lack of springs and the substantial depth to the water table (typically 10 m).

9.5.2. Geological Setting

The SGCP lies within the Galilee Basin which contains sediments of Triassic, Permian and Carboniferous age. The Galilee Basin is a large scale intracratonic basin with predominantly fluvial sediment infill. Strata within the Basin strata are essentially flat lying and dip to the west and south west at less than one degree.

Major parts of the Galilee Basin are overlain by younger Jurassic-Cretaceous material of the Eromanga Basin with the exception of the eastern margin where the Galilee Basin material is covered by Tertiary (in places) and Quaternary sediments.

Within the SGCP area the rocks of the Galilee Basin are represented by the following geological formations (from older to younger):

- the Upper Carboniferous-Lower Permian Joe-Joe Formation - which consists of mudstone with interbedded labile and commonly argillaceous siltstone grading to fine sandstone
- the Lower Permian Colinlea Sandstone - unconformably overlies the rocks of the Joe-Joe Formation and is comprised of sandstone as the dominant rock type with minor siltstone and coal
- the Upper Permian Blackwater Group which is represented by Bandanna Formation (or its equivalents) conformably overlies the Colinlea Sandstone Formation and comprises sandstone, fossiliferous siltstone, shale and coal
- the Lower Triassic Rewan Formation unconformably overlies sediment of the Bandanna Formation and is represented by argillaceous mudstone, siltstone and labile sandstone
- the Rewan Formation is conformably overlain by Dunda Formation material represented by labile sandstone, mudstone and siltstone
- the Lower to Middle Triassic Clematis Sandstone sediments unconformably overlies the Dunda Formation and in places rests on the Rewan Formation. The Clematis Sandstone strata are primarily represented by quartz sandstone with minor siltstone and mudstone

- the Clematis Sandstone is overlain with apparent conformity by the Middle to Upper Triassic Moolayember Formation. The Moolayember Formation is represented by mudstones, siltstones sandstones and shales.

Figure 9-11 shows that thin Tertiary and Quaternary sediments overlay the Galilee Basin strata. The thickness of the Tertiary/Quaternary cover ranges between several metres to several tens of metres.

Quaternary deposits generally comprise of colluvial material (weathered and transported by gravity) and alluvial material (transported and deposited by surface water streams) and consist of sand, gravel and clay sequences. Thicker Quaternary sediments are associated with current creek valleys. Tertiary sediments comprise interbeds of clays and sands with sandstone and mudstone layers.

Triassic strata generally crop out along the Great Dividing Range and have limited distribution within the SGCP area, which is mostly underlain by the older Permian Bandanna and Colinlea Formations.

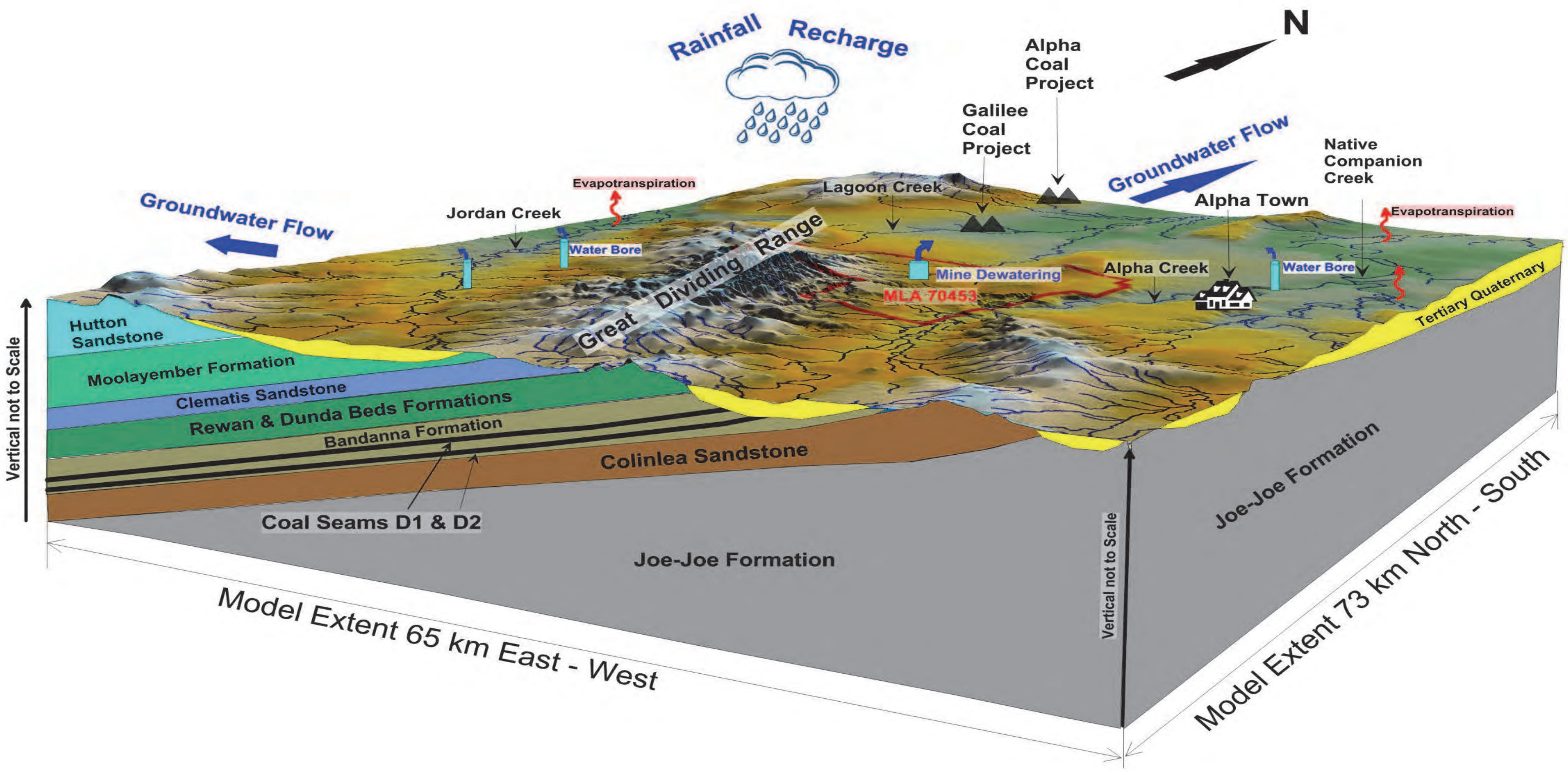
The Permian deposits of the Galilee Basin within the SGCP region comprise shale, siltstone, sandstone and coal of the Bandanna Formation and the underlying Colinlea Sandstone. These units are not regarded as comprising a significant groundwater resource as only limited and minor flows have been encountered.

Widespread development of peat swamps resulted in the deposition of coal seams within the Permian Bandanna Formation. During coal exploration, the intersected coal seams were named alphabetically from A to F. The major target of the Project is coal seam D which comprises two sub-seams D1 and D2.

Geology is discussed further in **Section 7—Land**.

Based on the review of available publications and groundwater bore data sourced from the Department of Natural Resources and Mines (DNRM) (and the previous Department for Environment and Resource Management (DERM)), groundwater in the area has been encountered in all geological formations **(Figure 9-11)**, although it is the Quaternary/Tertiary and the GAB sediments that provide almost all groundwater sources in this region. The most significant groundwater resources in the area are attributed to the GAB. The eastern margin of the nearest part of the GAB to the SGCP is thus represented in the groundwater model, along with the Rewan Formation aquitard that separates the GAB aquifers from the Galilee Basin units hosting the SGCP.

The Quaternary/Tertiary and Permian sediments on the regional scale are generally regarded as an insignificant groundwater resource. On a local scale, Tertiary and Quaternary alluvial sediments appear to contain groundwater resource sufficient to provide water supply to local farms and small townships (e.g. Alpha).



Data Source : RPS Aquaterra

Alpha Coal Pty Ltd

South Galilee Coal Project

Regional Geology Relative to the SGCP

03/10/2012

FIGURE 9-11

9.5.2.1. Quaternary Alluvial and Tertiary

Based on the bore logs provided in DNRM database, Quaternary/Tertiary sediments comprise a thin cover of several metres and up to several tens of metres, consisting of interbedded clay/sand sequences where the groundwater supply is obtained from sand layers. The majority of groundwater bores which source groundwater from these sediments are located within creek valleys where there is a greater thickness of alluvial material.

9.5.2.2. Great Artesian Basin (GAB)

The GAB is a large hydrogeological basin consisting of the Eromanga, Surat and Carpentaria Basins as well as parts of the Bowen, Surat and Galilee Basins. The GAB consists of confined artesian and sub-artesian groundwater.

The DNRM report "Hydrogeological Framework Report for the Great Artesian Basin Water Resource Plan Area" (2005) presents the following overview of the GAB:

- The GAB is one of the largest artesian groundwater basins in the world. With an area of over 1.7 million square kilometres the GAB underlies approximately one-fifth of the Australian continent. The GAB stores a huge volume of water estimated to be 64,900 million ML
- The aquifers of GAB are recharged by infiltration of rainfall, and leakage from streams, into outcropping sandstone mainly on the eastern margins of the Basin along the Great Dividing Range (in the SGCP region, the Clematis Sandstone forms the recharge/intake bed)
- Groundwater flows naturally from these recharge areas toward springs in the west and southwest. Much further to the north, flow is to the north and northwest.

The base of the GAB is formed by the low permeability Rewan Formation, which is itself underlain by the low permeability Dunda Formation. The Rewan and Dunda Formations form the regional aquitard at the base of the GAB and separate groundwater in GAB from groundwater in the Galilee Basin. The combined thickness of the aquitard is around 250 m. The Rewan aquitard has a very low vertical hydraulic conductivity in the order of 1×10^{-4} to 1×10^{-3} m/day, based on previous investigations during an early phase of GAB groundwater modelling (Audibert, 1976). The economic coal seams at the SGCP (D1 and D2 seams) occur below and to the east of the Rewan/Dunda units.

These units outcrop several kilometres west of the western limit of the SGCP underground coal mining, and form an effective barrier to the potential for drawdown due to mine dewatering to extend towards the GAB aquifers. Nevertheless, the eastern extent of the GAB has been included in the numerical modelling undertaken for the SGCP impact assessment.

The Clematis Sandstone is a recharge/intake bed of the GAB that outcrops along the Great Dividing Range and occurs above and to the west of the Rewan/Dunda units. The Queensland extent of Triassic-aged GAB in relation to the underlying older basins is shown on **Appendix G—Groundwater** and **Figure 9-11**, along with the SGCP MLA area.

Groundwater flow may be summarised as occurring away from the main recharge area formed by the Clematis Sandstone outcrop along the Great Dividing Range:

- to the west and into the GAB system on the western side of the Range
- to the east and north-east and into the Galilee Basin on the eastern side of the Range.

9.5.2.3. GAB Springs

Some natural discharge of GAB groundwater can occur via springs in some areas. However, DNRM (2005) does not identify any natural springs attributed to the Triassic GAB aquifers in the SGCP region. The mapped locations of known springs are shown in **Appendix G—Groundwater**.

These springs are not associated with Triassic formation outcrops and are considered to emerge from the younger formations such as the Hutton Sandstone (which does not occur in the SGCP area). The nearest spring to the SGCP site is located over 100 km to the south-east.

9.5.3. Previous Groundwater Investigations

Previous groundwater investigations in the Galilee Basin have been undertaken for proposed coal projects to the north of the SGCP, including the ACP, KCCP and the GCP. These studies built on early groundwater investigations related to coal resource studies undertaken in the 1980s.

Information from previous studies for this investigation was compiled from a variety of sources, including:

- published regional geological maps
- the government groundwater database (DNRM)
- reports on geological, geotechnical and environmental investigations of the SGCP area
- the digital terrain model and geological framework model for the SGCP area and surrounds.

Groundwater investigations for the SGCP were also conducted in recent years by consultants including Geoaxiom and Heritage Computing (unpublished), including the installation of groundwater monitoring bores and vibrating wire piezometers, slug tests, and groundwater modelling.

A geological framework model was developed by SGCP consultants (Collective Experience, 2012). This was used by RPS Aquaterra, along with the digital terrain model to establish the geological structure and layer elevations (including topography) within the numerical groundwater flow model.

9.5.4. Groundwater Occurrence

The regional geological and hydrogeological setting is described in **Section 9.5.2**, and is summarised by the following points in relation to the SGCP area:

- the primary geological units within the SGCP area can be divided into Quaternary, Tertiary, Triassic and Permian age sediments (from younger to older)
- the Quaternary-Tertiary sediments have an average thickness of 21 m (range of 3 to 52 m)
- Triassic units outcrop/subcrop in the western part of the SGCP area, where the elevation rises into the Great Dividing Range, coincident with the outcrop of the Clematis Sandstone (a GAB recharge bed)
- the Lower to Middle Triassic Clematis Sandstone is underlain by the low permeability Rewan Formation and Dunda Beds (Lower Triassic), which itself outcrops/subcrops on the eastern flank of the Great Dividing Range, separating the Clematis Sandstone (GAB) from the SGCP area (Galilee Basin proper)
- east of the Great Dividing Range, the Triassic to Permian units are generally overlain by a thin cover of younger Quaternary-Tertiary units across the broad catchment floor; the average depth to the base of weathering in this area is 51 m (range of 18 to 95 m)
- the coal seams within the SGCP MLA 70453 occur in the Upper Permian Bandanna Formation; the D1 and D2 are the primary target coal seams for the SGCP
- underlying the coal seams is the Lower Permian Colinlea Sandstone
- the Lower Permian Joe-Joe formation is a low permeability base to this package; it outcrops/subcrops east of the SGCP (including near Alpha township), again with a thin cover of Quaternary-Tertiary sediments
- groundwater flows away from the main recharge area formed by the Clematis Sandstone outcrop along the Great Dividing Range, and

- to the west and into the GAB system on the western side of the Range
- to the east and north-east and into the Galilee Basin on the eastern side of the Range.

Water level data measured in exploration holes drilled to the base of the deepest coal seam D2 have indicated that the groundwater flow system within the formations hosting the coal measures is consistent with the more regional DNRM data but also indicates the potential for easterly sub-gradients in some local areas close to the SGCP.

The geological units used to represent the existing groundwater environment and for groundwater impact assessment modelling are shown in **Table 9-7**.

Table 9-7 South Galilee Coal Project Groundwater Model Layers

Layer	General lithology	Inclusive lithology	Comments
1	Quaternary Alluvium and Regolith	Alluvium, Weathered Tertiary	Minor aquifers
2	Permian overburden	Bandanna Formation including Clematis Sandstone, Dunda Beds, Rewan Formation	Clematis aquifer recharge to GAB at outcrop; other units poor aquifers, and Rewan Formation is aquitard
3	Coal seam D1	D1 – upper, middle and lower plies	Typical 2m thickness
4	Bandanna Formation/Colinlea Sandstone interbeds	Colinlea Sandstone interbeds	Typical 10m thickness
5	Coal seam D2	D2 – upper, middle and lower plies	Typical 2m thickness
6	Colinlea Sandstone interbeds	Colinlea Sandstone	Minor aquifer
7	Joe-Joe Formation	Joe Joe Formation	Poor aquifer, subcrops near Alpha township

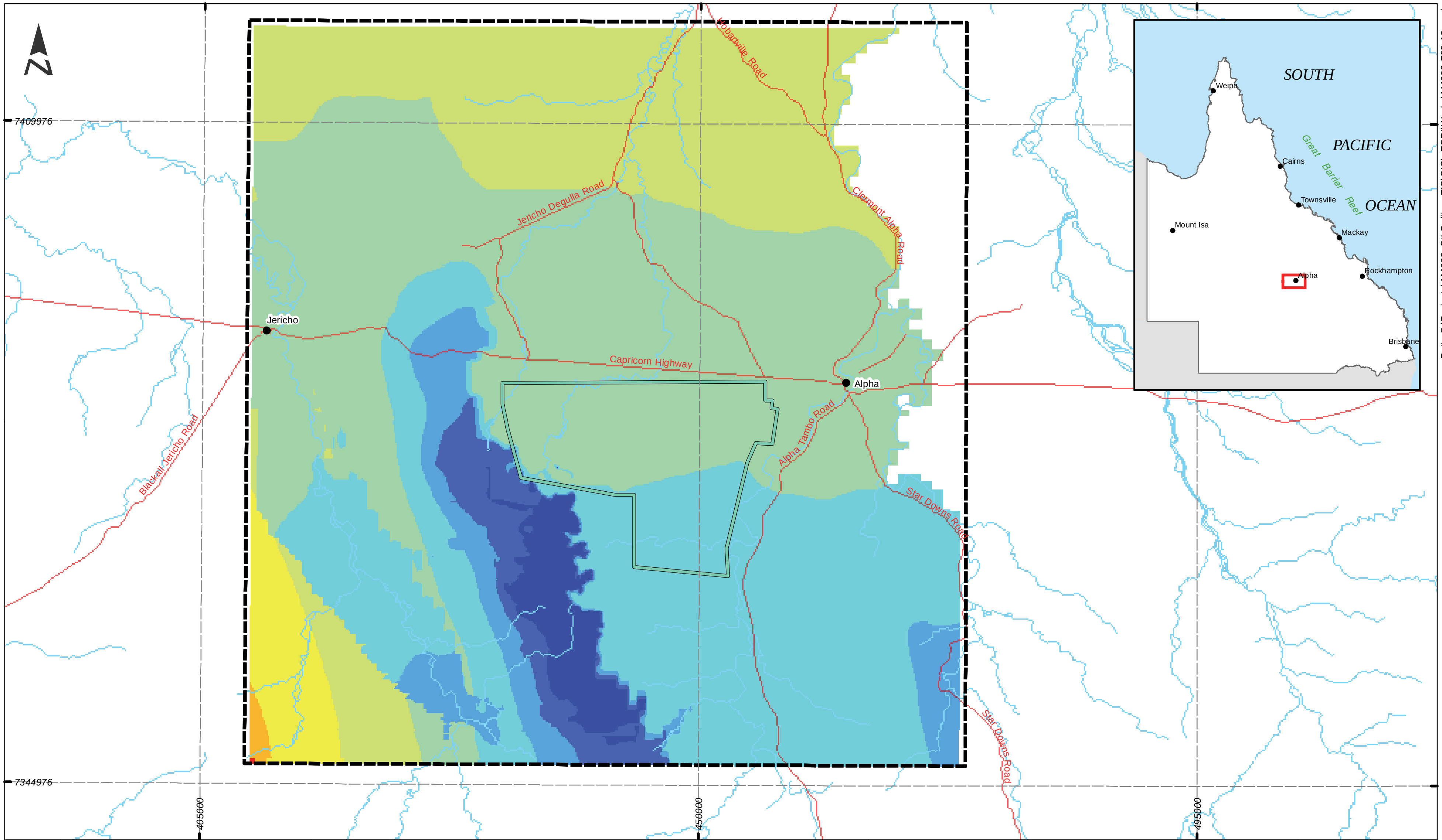
The occurrence of groundwater at the SGCP is shown in **Appendix G—Groundwater**. **Figure 9-12** illustrates the existing groundwater levels at the SGCP.

The key elements of the conceptual hydrogeological model are summarised below, with reference to the graphical presentation of **Figure 9-11**:

- The aquifer system is recharged mainly through rainfall infiltration, at relatively low fractions (<5%) of annual rainfall and with the highest recharge rates in areas of higher topography, notably the Clematis Sandstone outcrop aligned with the Great Dividing Range
- The groundwater flow patterns reflect surface topography generally, extending from the co-aligned Great Dividing Range and GAB intake beds of the Clematis Sandstone west and south of the SGCP, and extending into the two main basins, with the main flow components:
- groundwater flow to the east and north and into the northern Galilee Basin and Burdekin surface drainage basin
- groundwater flow down-dip to the west and out into the GAB system.

- Surface and groundwater interaction processes are limited, as streams are ephemeral, flowing only when rainfall generates adequate runoff. The streams provide low volumes of recharge to the water table, which is typically more than 10 m below ground level. Evapotranspiration from terrestrial vegetation is therefore not a key aquifer discharge process.

This conceptual hydrogeological model forms the basis for the design and implementation of the numerical groundwater flow model described in **Appendix G—Groundwater**, which is used for impact assessment and to develop mitigation and management plans.



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METSERVE

SouthGalilee

10 0 10

Kilometres

Scale: 1: 550,000

LEGEND

- MLA 70453
- Model Extent
- Major Roads
- Rivers/Creeks
- Population Area

Watertable Elevation (mAHD)

- < 225
- 225 - 250
- 250 - 275
- 275 - 300
- 300 - 325
- 325 - 350
- 350 - 375
- 375 - 400
- 400 - 425
- > 425

Alpha Coal Pty Ltd

South Galilee Coal Project

Groundwater Existing Environment-
Calibrated Water Table mAHD

5/10/2012

Proj :
Datum: GDA 1994

FIGURE 9-12

9.5.5. Groundwater Users

9.5.5.1. DNRM Database Search

Registered bore data was obtained through an information request to DNRM for a rectangular area within the following coordinates (consistent with the groundwater model domain boundaries):

- Easting (MGA, zone 55) – 409 000 to 475 000 (approx. 66 km)
- Northing (MGA, Zone 55) – 7 347 000 to 7 420 000 (approx. 73 km).

The DNRM Groundwater Database lists 381 registered bores within 40 km of the SGCP. Of these, 331 bores are either existing or still viable and are equipped for groundwater extraction. Not all registered bores included in the database have logs or formation interpretations.

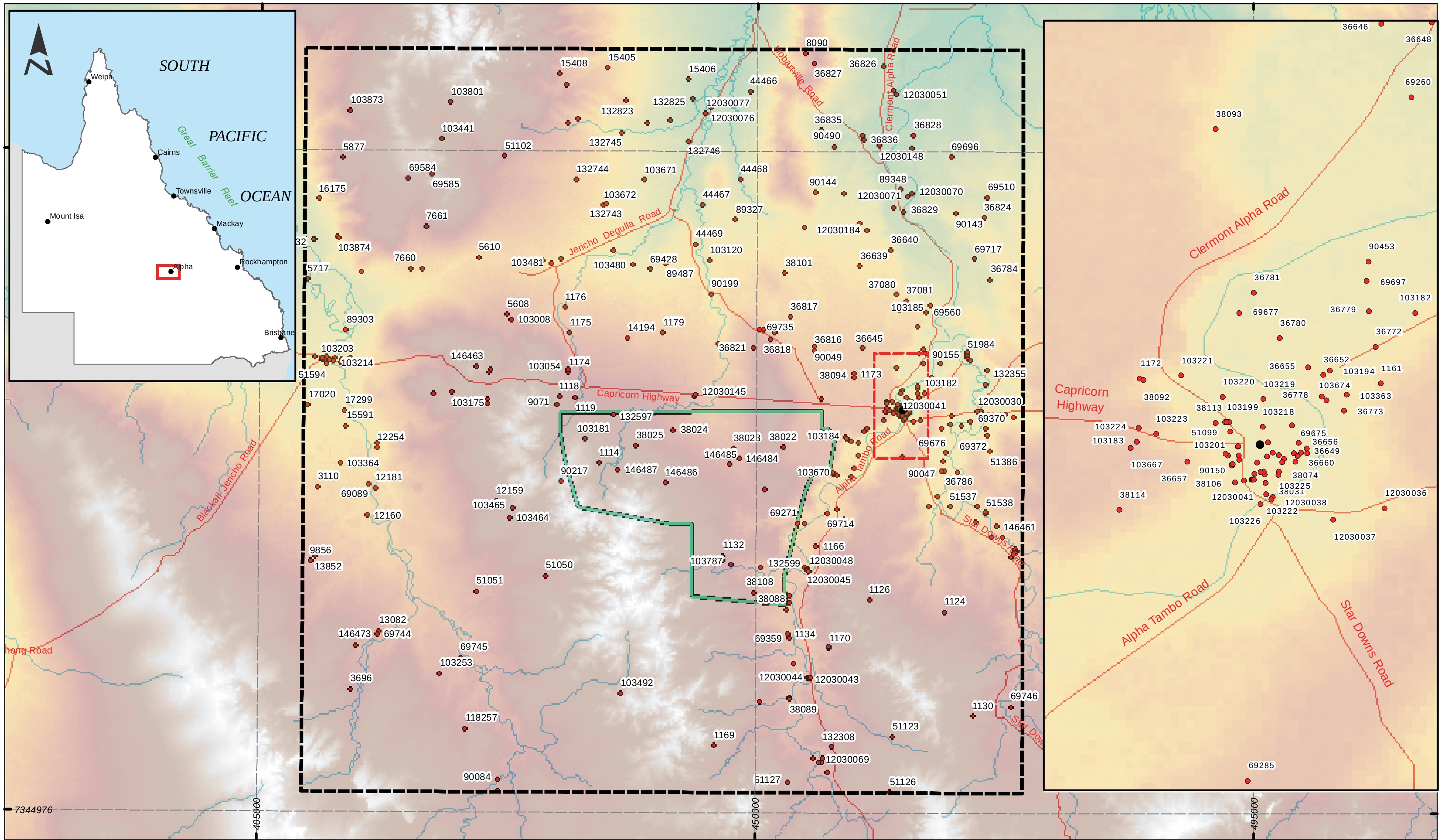
There are 186 bores for which geological/stratigraphic interpretation was included in the DRNM database. The location of each of these bores is shown on **Figure 9-13** and further information is presented in Appendix D of **Appendix G—Groundwater**.

The information indicated that 149 out of 381 bores registered have depth to groundwater level records, which were used to plot the elevation of groundwater levels (**Figure 9-13**) in all formations within the study area. In some cases, where there is no ground surface elevation information for the bores that have groundwater levels in the database, the surface elevation was estimated using the Shuttle Radar Topography Mission (SRTM) digital terrain model (DTM) constructed for Australia.

Table 9-8 summarises the available information from the DNRM groundwater level database and shows that groundwater levels in alluvial material is generally shallower than in Tertiary and Permian units, although the average depth to water table is in excess of 10 m.

Table 9-8 Bores with groundwater levels from DNRM Groundwater Database

Geological Unit	Number of bores	Number of bores installed near Alpha town	Depth to groundwater range (average shown in brackets) from-to (m)	Groundwater elevation range from-to (mAHD)	Range of bore yield (average shown in brackets) from-to (L/sec)
Alluvial Material	52	16	3 – 39 (14.9)	304 – 382	0.01 – 5 (1.5)
Tertiary Sediments	42	19	8 – 52 (27)	300 – 380	0.01 – 16 (2.3)
Triassic Sediments	22	-	10 – 93 (46.9)	317 – 355	0.1 – 9 (1.5)
Permian Sediments	33	-	10 – 86 (34.3)	300 – 389	0.06 – 6 (1.7)
TOTAL	**149**	**35**			



METSERVE	South Galilee	**LEGEND** MLA 70453 Model Extent Major Roads Rivers/Creeks Population Area Registered Bores (DNRM Data) Elevation (mAHD) High : 914 Low : 224	Alpha Coal Pty Ltd **South Galilee Coal Project** **Location of DNRM Registered Bores**
	10 0 10 Kilometres Scale: 1: 550,000		5/10/2012 Proj : Datum: GDA 1994 **FIGURE 9-13**

The majority of the bores were constructed to source groundwater from shallow units such as Alluvial and Tertiary material, clustering in concentrations along the alluvial channels of major creeks (e.g. Alpha Creek).

This confirms the interpretation that the streams (which are hosted within alluvial deposits) are ephemeral ('losing streams'), that may provide low volumes of recharge during intermittent periods when there is flow in the stream.

9.5.5.2. DNRM Water Management System Search

The DNRM Water Management System (WMS) database includes all licensed groundwater bores for different catchment areas. The study area is located within two major river catchments: Suttor River (code 1203) and Barcoo River (code 0033). Altogether 28 licensed bores were identified within a 40 km radius of the SGCP, with locations shown on **Figure 9-14**.

The majority of the licences are for stock and domestic water use. A few bores have a licence for irrigation water use. There is no groundwater usage (i.e. volumetric groundwater allocation) information available for licensed bores, as no flow meters are required by DNRM to be installed.

9.5.5.3. Alpha Town Water Supply

The closest cluster of licensed bores to the SGCP are located near the Alpha township, roughly 10 km to the east of the SGCP, and the township is interpreted as the major existing groundwater user.

The following information on the Alpha township water supply bores was received from the Barcaldine Regional Council:

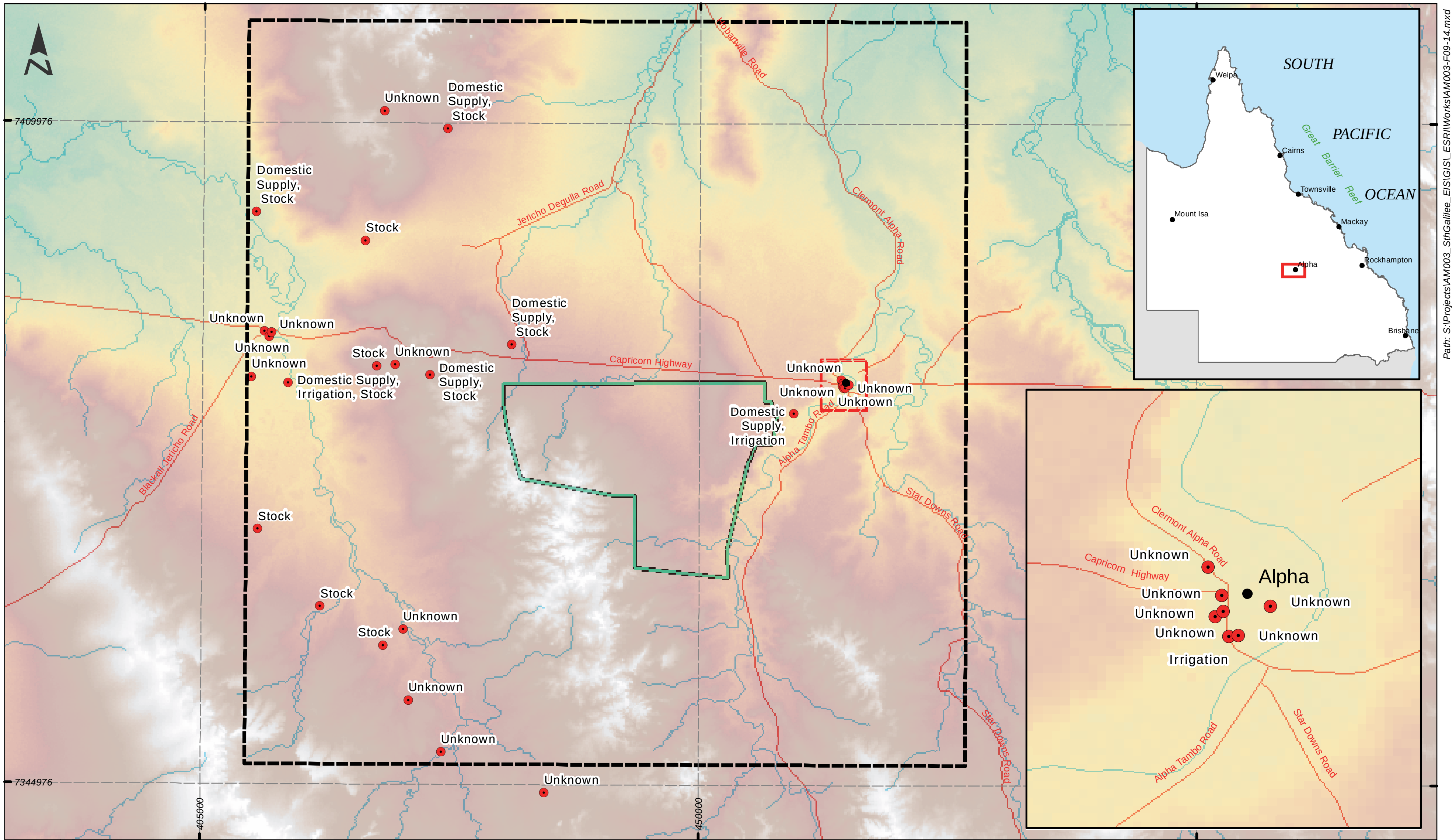
- there are 10 groundwater bores installed at Alpha for the town water supply
- the bores source groundwater from unconsolidated Tertiary and alluvial sediments
- 87 ML was extracted in 2010/11 and 164 ML in 2011/12 (i.e. equivalent to pumping rates of less than 1 L/sec per bore).

Extraction for Alpha town water supply is included in the groundwater model.

9.5.5.4. Bore Census

A bore census was undertaken by Matrixplus (2009) on properties close to the SGCP lease. This involved visiting each property and locating, where possible, all operating and abandoned bores. Observations and measurements were made where possible at each bore including the location, condition of the bore, pumping equipment and groundwater flow and quality data.

The central and eastern portion of the SGCP is comprised of the Creek Farm property. The remaining neighbouring properties are Sapling Farm to the south west, Betanga in the west and Chesalon in the northwest. Based on discussions with landholders in and adjacent to the SGCP lease, groundwater is used primarily for stock watering.



METSERVE

SouthGalilee

10 0 10

Kilometres

Scale: 1: 550,000

LEGEND

- MLA 70453
- Model Extent
- Major Roads
- Rivers/Creeks
- Licensed Bore
- Population Area

Elevation (mAHD)

High : 914

Low : 224

Alpha Coal Pty Ltd

South Galilee Coal Project

Location of DNRM Licensed Bores

5/10/2012

Proj :

Datum: GDA 1994

FIGURE 9-14

The number of landholder bores identified during the bore census are shown in **Table 9-9**. The full census results are included in **Appendix E** of **Appendix G—Groundwater**. The bore census did not locate some of the registered bores listed in DNRM database.

Table 9-9 SGCP Landholder Bore Census

Property	Number of Bores in Use	Total Number of Bores
Creek Farm	5	16
Betanga	3	12
Sapling Farm	2	4
Chesalon	2	5

The census reports indicate a range of bore yield between 0.1 and 2 L/sec. The operation hours for farm bores do not usually exceed 10 hours a day. Therefore the maximum annual pumping rate from a single bore may be up to 26 ML/year.

9.5.5.5. Impacts of Current Pumping

The groundwater in the area has been used primarily for town water supply for Alpha, stock and domestic water supply, and some small scale irrigation, where the quality of groundwater is adequate.

The majority of the registered bores are clustered along the major creek valleys (e.g. Alpha Creek or Native Companion Creek). Despite the presence of the 28 licenced bores in the area, data on volumetric usage of groundwater from these bores was not available as they do not have flow meters installed.

Information available indicates that average bore yields are typically 1 to 2 L/sec, which equates to 13 ML/year if it is assumed that bore operation is 10 hours/day for 6 months per year.

However, the bore yields vary within a wide range from 0.01 L/sec to 16 L/sec, indicating significant hydraulic heterogeneity of the aquifer materials. The available groundwater level data does not indicate extensive drawdown in the area, indicating that the extraction that is occurring is not a significant component of the water balance.

The average yield is considered to be insignificant compared to the overall groundwater recharge estimate. As there is a lack of specific data (e.g. bore locations, depths, volumes, etc), extraction from the licensed bores is not included in the modelling, other than for the Alpha township, as it is the major user.

9.5.6. Baseline Groundwater Quality

9.5.6.1. Monitoring Program

To date, 10 monitoring bores have been installed at the SGCP site: four open (standpipe) monitoring bore sites and six grouted-in vibrating wire piezometer (VWP) sites (**Figure 9-15**).

S:\PROJECTS\AM001_STHGALILEE_EIS\GIS_MAPINFOWSPACES\SECT_09\20120310_RENUMBEREDFIGS\FIG 9-12 LOCATION OF GROUNDWATER MONITORING SITES.WOR

METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

LEGEND

- MLA70453
- Railway
- Principal road
- Groundwater Monitoring Areas (Drill Sites)

Data Source: Tenement - DEEDI. Topography (250k) - Geoscience Australia.

Alpha Coal Pty Ltd

South Galilee Coal Project

Location of Groundwater Monitoring Sites Established for the SGCP

5 0 5

Kilometres

Scale: 1:200,000 (A4)

03/10/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 9-15

The standpipe monitoring bores have been established in a line along the dip of the Permian strata in an east-west direction. These bores are constructed with 100 mm diameter PVC casing which has been slotted over a discrete target horizon in each bore, and they are fitted with pressure transducers which provide a continuous record of groundwater level fluctuations. The standpipe bores also enable the collection of groundwater water quality samples.

The VWP sites provide piezometric pressure data via pressure sensors grouted at specific depths below ground level at each monitoring site. The sensors measure the pressure of the overlying groundwater column at discrete points, which is captured by data loggers at the surface and subsequently converted to groundwater level data. The boreholes into which the VWP sensors have been placed have been fully grouted with a cement-bentonite grouting mix, and thus cannot be used for water quality measurements.

Two rounds of groundwater quality sampling were conducted for MB01-MB04 and water level information from the electronic water transducers was downloaded. The downloaded groundwater level records have not been subject to detailed analysis at this stage because the reference levels of the monitoring bores and VWPs have not yet been professionally surveyed.

Initial analysis identified some discrepancies in the groundwater levels (assuming topography from the digital elevation model). A program of further investigation (including surveys) is planned as part of the implementation of the Groundwater Monitoring Program.

9.5.6.2. Water Quality Data

Groundwater quality information was obtained from both regional data (from DNRM – see **Appendix B** of **Appendix G—Groundwater**) and local data (exploration drilling and monitoring).

Groundwater samples collected from the SGCP monitoring bores (MB01-MB04) were tested for a full suite of analytes. The table of results and the adopted water quality criteria (i.e. ANZECC Guideline values for freshwater aquatic ecosystems, recreational use, irrigation and livestock drinking water) are presented in **Appendix C** of **Appendix G—Groundwater**.

9.5.6.2.1. Groundwater Salinity

Groundwater salinity values expressed in total dissolved solids (TDS, mg/L) and/or electrical conductivity (EC, µS/cm) were combined to assess a regional distribution of groundwater salinity at the SGCP area. The groundwater salinity pattern generally follows the groundwater flow pattern, in that the salinity of groundwater is fresher at the hills and ridges of the Great Dividing Range and increases to the north and east. Groundwater salinity at the SGCP site is greater than 1,000 mg/L and in some places greater than 2,000 mg/L (i.e. not within drinking water guidelines, but nominally suitable for irrigation and stock). The presence of fresh groundwater (< 1,000 mg/L) occurs in places along the major creeks (notably along Alpha Creek and Native Companion Creek).

9.5.6.2.2. Major Cations and Anions

Water samples tested for major cations (calcium, magnesium, sodium and potassium) and major anions (bicarbonate, carbonate, sulphate and chloride) were applied to a Piper diagram analysis to assess whether groundwater within the SGCP area is associated with similar or potentially different groundwater recharge sources. The Piper diagrams are shown in **Appendix G—Groundwater**.

The Piper diagram analysis shows that the majority of groundwater samples form one cluster of sodium-chloride type, indicating groundwater in alluvial, Tertiary, Triassic and Permian sediments are of similar origin (assessed to be rainwater infiltration).

Some samples collected from groundwater in alluvial and Tertiary sediments plot distinctly from the major cluster. The dominant anion in those samples is bicarbonate (HCO_3) and dominant cations are calcium and sodium. The dominance of these ions indicates a minor influence on groundwater quality from localised recharge sources associated with ephemeral streams and irrigation activities.

9.5.6.2.3. Baseline Groundwater Quality Assessment

The results of groundwater sampling from regional bores shows that groundwater in the area generally has elevated concentrations of nitrate and some metals (e.g. iron, zinc and manganese) which exceed ANZECC Guideline criteria for fresh aquatic ecosystems and/or and irrigation (refer Appendix C of **Appendix G—Groundwater**).

The results of groundwater sampling from the onsite monitoring bores (MB01 to MB04) shows that pH was generally within recommended guidelines (slightly acidic to neutral), and all tested analytes were reported to be either below the laboratory reporting limits or below the adopted ANZECC Guidelines criteria, with the exception of zinc, boron and ammonia.

The exceedences for the on-site monitoring bores (MB01 to MB04) were as follows:

- zinc concentrations exceeded the freshwater aquatic ecosystem 95% species protection limit of 0.008 mg/L in all four bores
- boron concentrations exceeded the freshwater aquatic ecosystem 95% species protection limit of 0.37 mg/L in one monitoring bore MB03
- ammonia concentrations exceeded the freshwater aquatic ecosystem 95% species protection limit of 0.9 mg/L in monitoring bores MB01 and MB04.

The overall groundwater quality analysis results indicate that the baseline groundwater is generally but not universally compliant, with the ANZECC Guidelines for irrigation and livestock drinking water criteria (where the salinity of groundwater allows), but is not generally suitable for drinking purposes due its high salinity, and is generally not compliant with 95% freshwater aquatic ecosystems criteria for zinc, boron and ammonia.

9.5.7. Groundwater Recharge and Discharge

9.5.7.1. Recharge

The aquifer systems in the SGCP area are generally recharged from rainfall infiltration, with small volumes of leakage from the losing/ephemeral stream system.

The cumulative rainfall deviation (CRD) method, based on the water-balance principle, is often used to identify whether observed water level fluctuations are due to rainfall recharge or other processes. Cumulative rainfall deviation is the accumulated difference between the actual rainfall recorded (e.g. in a month or a year) and the long term mean. If there is poor correlation between groundwater level hydrographs and the CRD, then it may be concluded that rainfall recharge is not significant, or that some other recharge processes are dominant (e.g. regional inflow, upward leakage from the deeper aquifer systems etc.).

The closest BOM rainfall station is located in Alpha. The data from this station was used in the CRD analysis, along with long term DNRM groundwater level data from bores installed in Alluvial, Tertiary and Permian strata. No long term groundwater levels were available from the bores installed in Triassic sediments.

The groundwater level hydrographs versus CRD are presented in **Appendix G—Groundwater** and show a good correlation between measured fluctuation of groundwater levels and the CRD graph. This generally indicates that recharge to groundwater in all strata is likely to be associated with the rain water infiltration.

The greatest rainwater infiltration typically occurs at high elevation areas where rocks outcrop. **Figure 9-12** shows the general decrease in groundwater level elevations from the upland areas in the west and south-east (the high elevation areas associated with the Great Dividing Range) to the east and north-east (into the Galilee Basin), and also further to the west (into the GAB). The high hills of the Great Dividing Range are thus identified as the main groundwater recharge area.

As it is difficult to estimate the recharge rate due to the absence of direct measurements (e.g. lysimeters), a broad estimate was made using the Chloride Mass Balance (CMB) best practice method. CMB inputs are annual rainfall precipitation, concentration of chloride in either soil pore water or actual rain water and chloride concentration in groundwater in the potential recharge region.

The CMB formula is written as $R=QC_r/C_{gw}$, where Q - annual rainfall, Cr – chloride concentration in rainwater and C_{gw} – chloride concentration in groundwater. Annual average rainfall of 560 mm/year is based on the Alpha Town Post Office weather station records.

The registered DNRM bores from which multiple groundwater samples were available were selected for the CMB recharge estimate (i.e. more than three samples to exclude no-representative values). These bores with chloride values and sampling dates are included in **Appendix G—Groundwater**.

The average chloride concentration calculated for all bores was 350 mg/L, with the exception of bore 12030076, where it was 7,400 mg/L, as this bore is located further from the Great Dividing Range than other bores (i.e. it is more remote from the main recharge areas). The concentration of chloride in rainfall was obtained from Ransley et al (2010), which includes data measured in various areas in Australia.

Using this information, the recharge to the groundwater at the SGCP area can be estimated to be in the range 1 to 20 mm/year (roughly 1% to 4% of the annual rainfall). The groundwater recharge rates used in the groundwater model were benchmarked against these estimates.

Aquifer tests were conducted in monitoring bores MB03 and MB04 to provide an indication of aquifer permeability. A 90 minute constant discharge pumping test was conducted in MB03 at a rate of 1 L/sec. The water levels were measured by an electronic water level transducer during pumping and post pumping water level recovery. The data from the pumping test in MB03 were analysed using the Cooper-Jacob method (drawdown curve) and the Theis method (residual drawdown/recovery).

A slug test was conducted in MB04, which involved the near instantaneous removal of a slug of water which created a water level drop (displacement) in the bore of 14.18 m. Water level recovery after the displacement was monitored for 27 minutes. The data from the slug test were analysed using the Bouwer-Rice method.

The results were analysed using the Aqtesolv Pro software (Appendix A of **Appendix G—Groundwater**) to estimate aquifer transmissivity (T) and horizontal hydraulic conductivity (Kh), as summarised in **Table 9-10**.

Table 9-10 Aquifer Tests at SGCP

Bore	Method	Kh (m/day)	T (m^2/day)	Formation
MB03	Jacob	0.2	15	Colinlea, D1/D2/interburden combined
MB03	Recovery	0.23	16.1	Colinlea, D1/D2/interburden combined
MB04	Bouwer-Rice	0.29	7.4	Colinlea, to the east of the D1/D2 extent

Previous groundwater work conducted by others (JBT Consulting, 2010) identified hydraulic conductivities of geologic materials at the ACP some 62 km to the north from the SGCP site, as summarised in **Table 9-11**.

Table 9-11 Hydraulic conductivity from investigations at Alpha Coal Project (JBT, 2010)

Geologic Material	Horizontal Hydraulic Conductivity Kh (m/d)	Vertical Hydraulic Conductivity Kz (m/d)
Alluvium/Tertiary	3.7×10^{-4} to 50.	1.5×10^{-6} to 40.
Dunda Beds and Rewan Formation	1×10^{-4} to 1.4	1×10^{-5} to 1.4×10^{-1}
GAB (Clematis Sandstone)	8×10^{-4} to 5.	8×10^{-5} to 5×10^{-1}
Bandanna Formation	1×10^{-5} to 1.	1×10^{-5} to 1×10^{-1}
Colinlea Sandstone (incl coal seams)	1×10^{-4} to 10.	1×10^{-4} to 1.

Another assessment of aquifer hydraulic parameters was included in the groundwater modelling report (URS, 2012) for the ACP, summarised in **Table 9-12**.

Table 9-12 Hydraulic conductivity from Alpha Coal Project groundwater model (URS, 2012)

Geologic Material	Horizontal Hydraulic Conductivity Kh (m/d)	Vertical Hydraulic Conductivity Kz (m/d)
Alluvium/Tertiary	5	0.5
Dunda Beds and Rewan Formation	4×10^{-3} to 4×10^{-4}	2×10^{-4} to 4×10^{-5}
GAB (Clematis Sandstone)	1×10^{-1} to 5	5×10^{-1}
Bandanna Formation	4×10^{-3}	2×10^{-4}
Colinlea Sandstone (incl coal seams)	1×10^{-3} to 1.5	1×10^{-2} to 1×10^{-5}
Joe-Joe Formation	4×10^{-4}	4×10^{-5}

Another assessment of aquifer hydraulic parameters was undertaken during investigations for the Galilee Coal Project, summarised in **Table 9-13** (URS, 2012).

Measured values for vertical hydraulic conductivities are not provided in the GCP report. In the modelling it was assumed that vertical hydraulic conductivity values are an order of magnitude lower than horizontal values.

Table 9-13 Hydraulic conductivity from GCP (URS, 2012)

Geologic Material	Range of Horizontal Hydraulic Conductivity values Kh (m/d)
Alluvium/Tertiary	1×10^{-3} to 3×10^{-3}
Dunda Beds and Rewan Formation	1×10^{-3} to 1.4×10^{-1}
GAB (likely Clematis Sandstone)	2.9 to 12
Bandanna Formation and/or Colinlea Sandstone (interbeds)	1×10^{-3} to 1×10^{-1}
Coal Seams B, C, D, E	0.25 to 6.8
Joe-Joe Formation	Not tested

This information was used to benchmark the parameters adopted for the SGCP groundwater model.

9.5.7.2. Discharge

The main groundwater discharge process is regional throughflow along hydraulic gradients, and this is best described through the numerical model (**Section 6** of **Appendix G—Groundwater**), which also accounts for other minor discharge processes (e.g. groundwater pumping, evapotranspiration). The Steady State model run represents the long term average catchment conditions without any active mining operations. The available measured groundwater levels were analysed over a wide range of years to estimate representative level data for use in evaluating model performance.

The Steady State model water balance given in **Table 9-14**, indicates that:

- the major inflow components are rainfall recharge (60%) and boundary inflow (30%), with stream leakage making up a small portion (10%)
- the major outflow components are boundary discharge (52%), and evapotranspiration (47%).

Table 9-14 SGCP Model Steady State Water Balance

Component	Groundwater Inflow (Recharge)		Groundwater Outflow (Discharge)	
	(m^3/day)	% of total	(m^3/day)	% of total
Wells	0	0	200	1
Recharge	11,808	60.4	0	0
Evapotranspiration	0	0	9141	46.8
River Leakage	2010	10.3	0	0
Head Dependent Boundaries	5734	29.3	10,211	52.2
TOTAL	**19,552**	**100%**	**19,552**	**100%**

9.6. POTENTIAL SURFACE WATER IMPACTS

The SGCP will feature three open-cut pits and an underground mine. During establishment of the open-cut pits, waste rock initially will be stockpiled immediately to the west of the pits.

The potential impacts on surface water during the life of the SGCP are summarised below:

- potential change in runoff quality from disturbed catchments
- open-cut pit water (including surface runoff and groundwater inflow
- runoff from areas disturbed by mining (including waste rock emplacement areas and rehabilitated areas) to be managed within the minesite water management system, or otherwise via controlled releases during high rainfall events
- potential reduction in streamflows due to the need to contain mine-affected water and reduced discharge opportunities
- subsidence and impacts on natural catchments
- potential changes to Tallarenha Creek flooding due to construction of clean water diversion around the disturbed areas
- diversion of Sapling Creek south into Dead Horse Creek to separate clean runoff from undisturbed areas from the mine workings (an increase of peak flows into Dead Horse Creek of approximately 47 %).

9.6.1. Hydrology

The surface water assessment (refer to **Appendix F—Surface Water**) identified potential hydrological impacts on the catchment that may occur as a result of the SGCP.

The catchment hydrology may be affected by the presence of the mine and the creek diversion. Potential impacts include:

- changes in the catchment extents
- changes in the catchment runoff characteristics where the proposed mining operations would occur
- impacts of the timing of discharges from the mine to the natural system
- changes to flood discharge estimates through the SGCP area and downstream.

Subsidence induced by the proposed underground operations will impact on the channel and floodplain of Tallarenha Creek and its tributaries, as this will impact on the pattern of flooding in this area. The Sapling Creek diversion will also be undermined by the proposed underground workings. The subsequent subsidence will potentially affect flood flows in the diversion.

The proposed diversion, flood protection levees and mine water management system will have an impact on the larger sub-catchment boundaries. Water captured in the open-pit and the associated water management system will be reused on-site. The proposed water management system will contain the bulk of these inflows on-site for preferential reuse. As a result, streamflow in the receiving waters (Tallarenha Creek, Sapling Creek and Alpha Creek) will be reduced.

As the MWMS is designed in accordance with best practice to capture and contain all runoff originating from potentially contaminating catchments there will inevitably be some small reduction in the total catchment area that sustains flows to the downstream watercourse.

The greatest potential reduction of downstream flows will occur in the later stages of the mine when the catchment extents of the MWMS are greatest. The mine water catchment area data provided shows that in year 30 the potential extent of catchment area reporting to the MWMS is 43.7 km^2. This is a worst case assumption where rehabilitated areas are not yet sufficiently established to allow runoff from these areas to be diverted out of the MWMS.

Under the worst case scenario the reduction in flows as a result of the MWMS would be less than 9 % for the Tallarenha Creek Catchment, and 0.4 % for the Alpha Creek Catchment. This small reduction will not materially impact on the downstream environmental values identified. Progressive rehabilitation of all disturbed areas and waste rock emplacements will reduce the minor impact on downstream flows, as the runoff from these areas will be sufficiently clean to allow for diversion back into the receiving environment.

The SGCP has the potential to have a number of influences on flood hydrology. These influences tend to compensate each other and as a consequence minimise the net impact of flood flows.

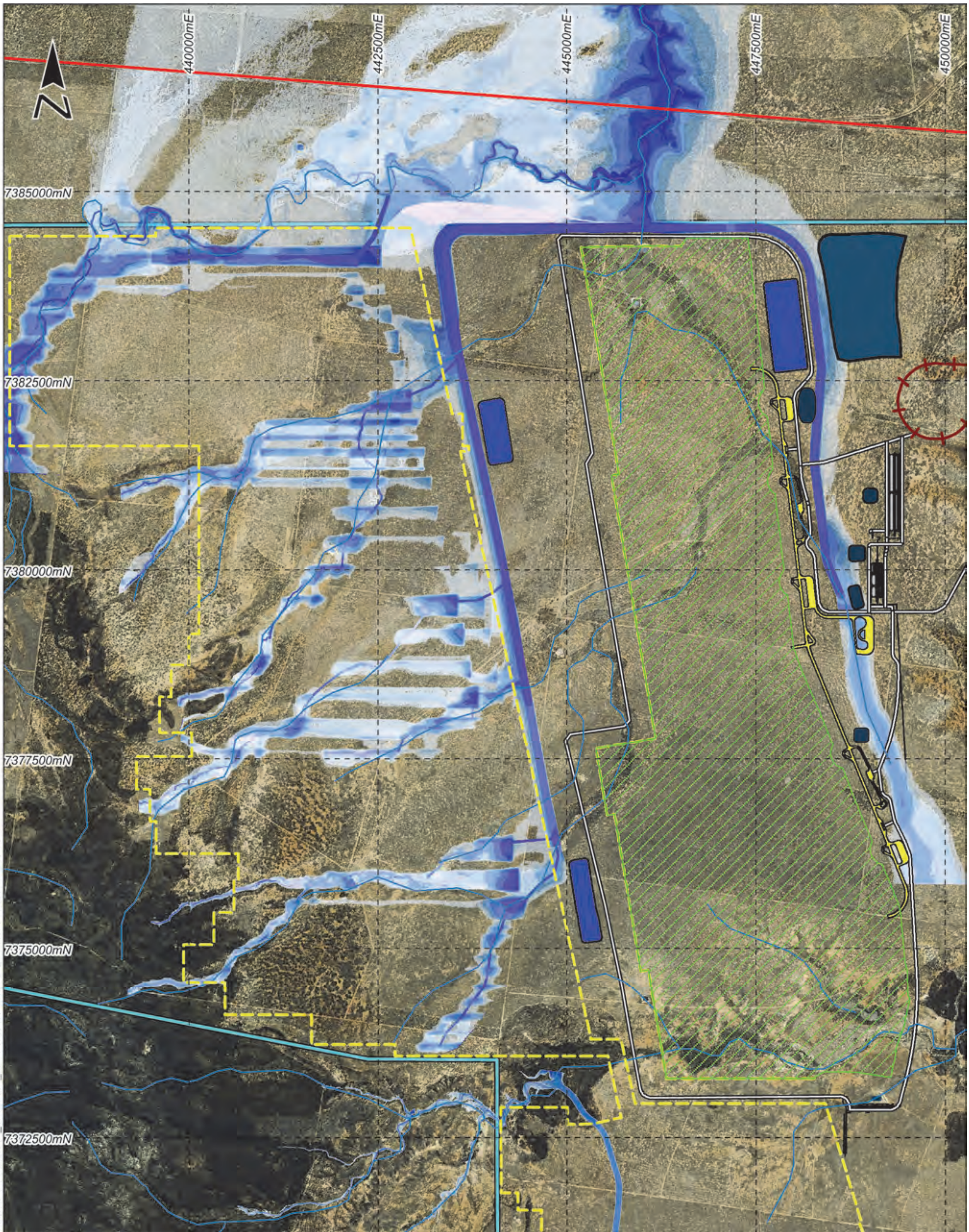
The potential impacts on flood flows include:

- the disturbed mine areas will tend to produce higher runoff rates during intense storm events. In actual operations this will not impact on the watercourse floods because these impacts will be contained within the MWMS
- the MWMS will contain runoff from the mine areas, and this will result in a reduction in catchment areas contributing to flood hydrograph volumes and peak flows. This will tend to reduce the peak flows in the downstream watercourse
- the proposed watercourse diversion of Sapling Creek into Dead Horse Creek will increase surface water flows in Dead Horse Creek

- the proposed flood protection levees will constrict the floodplain area and result in some loss of floodplain storage. This will consequently effect flood routing along the watercourses and slightly increase the peak flows in the downstream watercourses. This effect would be greater for larger flood events.

Hydrologic modelling was conducted to assess the differences in hydrology due to the proposed mining operation. A detailed discussion of the modelling and assumptions are presented in **Appendix F—Surface Water**. Results of flood depths and velocities are summarised in **Figure 9-16** to **Figure 9-20**.

The characteristics and estimated change to annual run-off from local overland flow catchments are shown in Table 4-8 of **Appendix F – Surface Water**. This includes the mean annual flows and the percentage change in flows. The impact on median flow will be the same as the predicted impact on mean flows.



S:\PROJECTS\AM001_STHGALILEE_EIS\GIS_MAPINFOWSPACES\SECT_09\AM001_FIG 9-23 PMF FLOOD DEPTH AND EXTENTS.WOR

METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

LEGEND

- MLA70453
- Principal road
- Sedimentation Dam
- Dirty Water Dam
- Active Pit Y33
- Spoil Y33
- Underground Mine Foot

PMF Flood Depth (m)

- 0.0m < 0.5m
- 0.5m < 1.0m
- 1.0m < 1.5m
- 1.5m < 2.0m
- 2.0m < 3.0m
- 3.0m < 4.0m
- >4.0m

Data Source: WRM Appendix E, Figure 1.11

Alpha Coal Pty Ltd

South Galilee Coal Project
PMF Depth and Extents
Tallerenha Creek

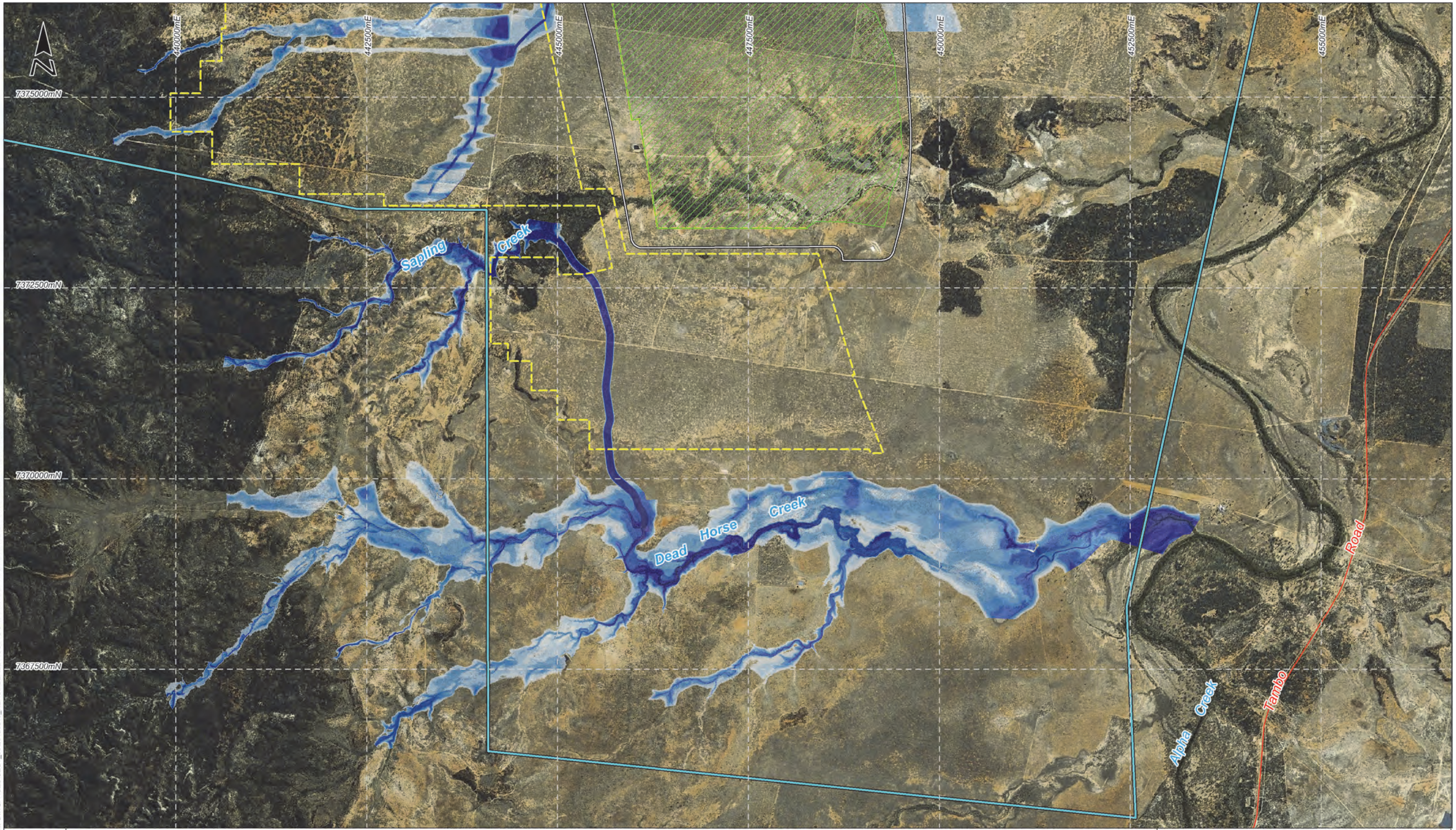
0 1 2
Kilometres

Scale: 1:75,000 (A4)

03/10/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 9-16



S:\PROJECTS\AM001_STHGALILEE_EIS\GIS_MAPINFO\WSPACES\SECT_09\20120310_RENUMBERED\FIGS\FIG 9-17 PMF DEPTH & EXTENTS SAPLING & DEAD HORSE CREEKS.WOR

METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

LEGEND

- MLA70453
- Principal road
- Spoil Y33
- Underground Mine Foot

PMF Flood Depth (m)

- 0.0m < 0.5m
- 0.5m < 1.0m
- 1.0m < 1.5m
- 1.5m < 2.0m
- 2.0m < 3.0m
- 3.0m < 4.0m
- >4.0m

Data Source: WRM Appendix E, Figure 2.8

Alpha Coal Pty Ltd

South Galilee Coal Project

PMF Depths and Extents
Sapling and Dead Horse Creeks

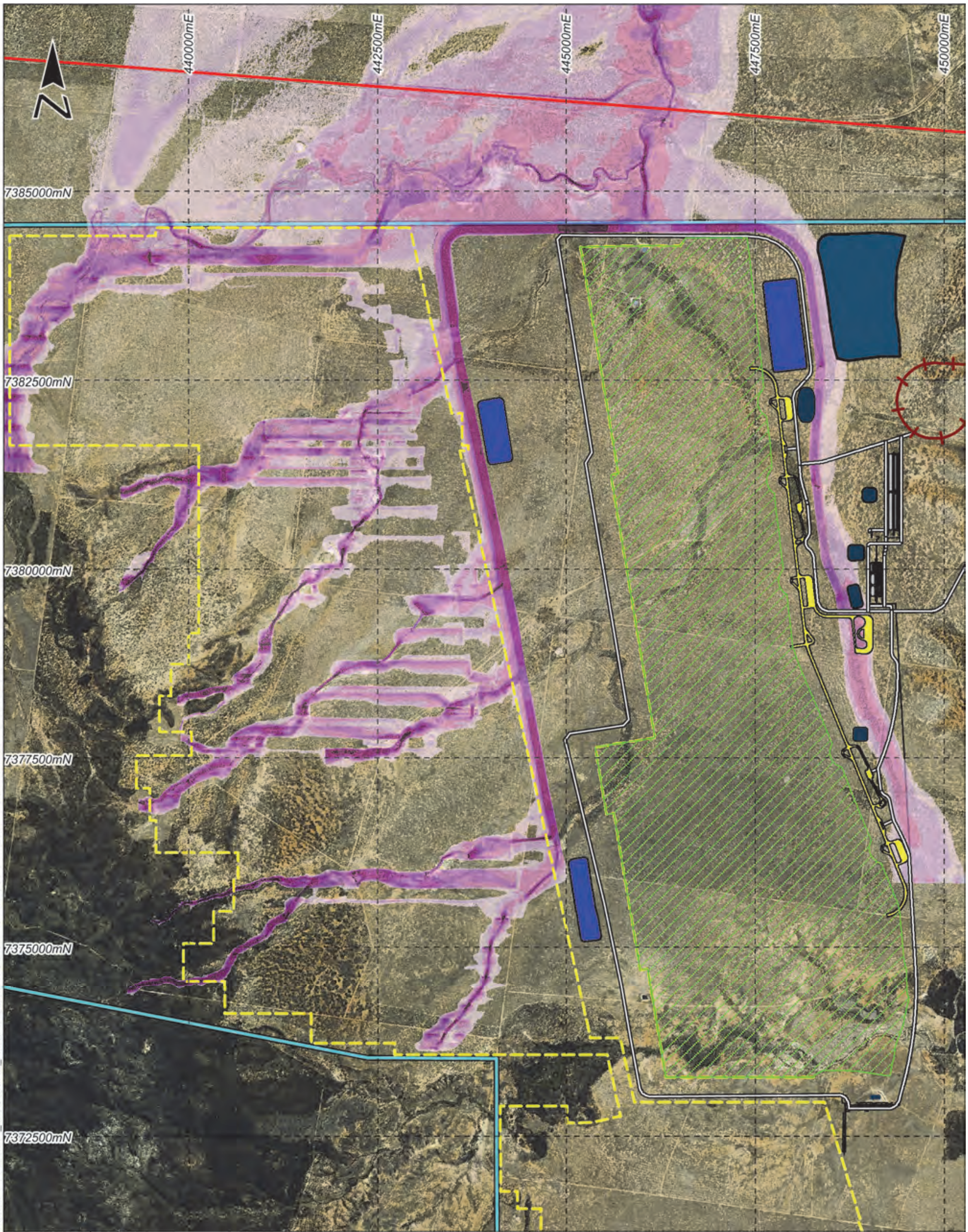
1 0 1
Kilometres

Scale: 1:50,000 (A3)

03/10/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 9-17



S:\PROJECTS\AM001_STHGALILEE_EIS\GIS_MAPINFOWSPACES\SECT_09\20120310_RENUMBEREDFIGS\FIG 9-18 PMF FLOOD VELOCITIES-TALLERENHA CRK.WOR

METSERVE
Mining & Energy Technical Services Pty Ltd

SouthGalilee

LEGEND

- MLA70453
- Principal road
- Sedimentation Dam
- Dirty Water Dam
- Active Pit Y33
- Spoil Y33
- Underground Mine Foot

PMF Velocity (m/s)

- 0.0 - 0.5m/s
- 0.5 - 1.0m/s
- 1.0 - 1.5m/s
- 1.5 - 2.0m/s
- 2.0 - 2.5m/s
- 2.5 - 3.0m
- 3.0 - 3.5m/s
- 3.0 - 4.0m/s

Data Source: WRM Appendix E, Figure 1.11

Alpha Coal Pty Ltd

South Galilee Coal Project

PMF Flood Velocities-Tallerenha Creek

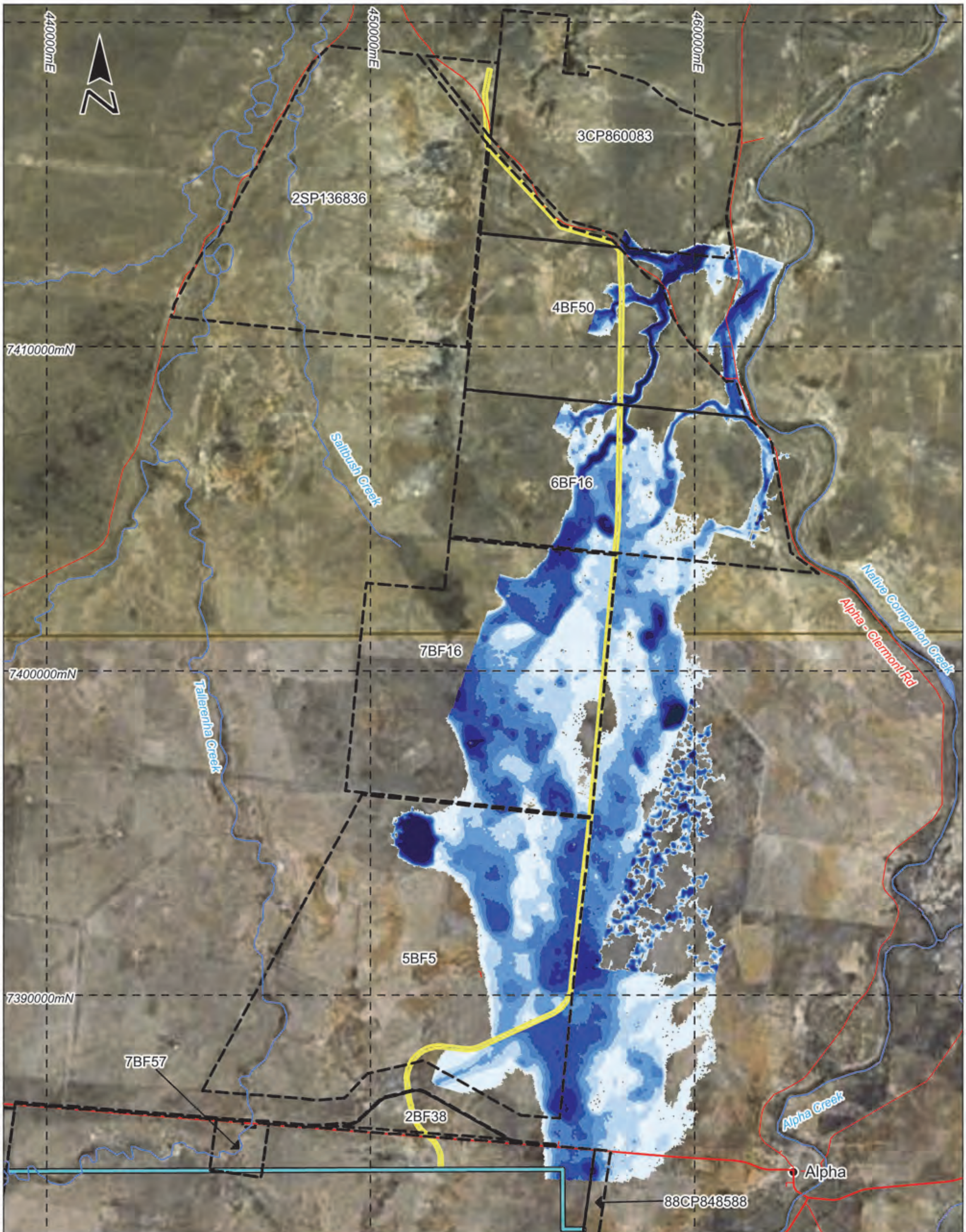
0 1 2
Kilometres

Scale: 1:75,000 (A4)

03/10/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 9-18



S:\PROJECTS\AM001_STHGALILEE_EIS\GIS_MAPINFOWSPACES\SECT_09\20120310_RENUMBEREDFIGS\FIG 9-7_8 & 9-19_9-20 WATER FIGURES-INFRA CORRIDOR

METSERVE Mining & Energy Technical Services

SouthGalilee

LEGEND

- MLA70453
- Directly affected property
- SGCP infrastructure corridor
- Roads
- Population centre

Q100 FLOOD DEPTH (m)

- 0.0 - 0.5m
- 0.5 - 1.0m
- 1.0 - 1.5m
- 1.5 - 2.0m
- 2.0 - 3.0m
- 3.0 - 4.0m
- >4m

Data Source:
Cadastral (Barcaldine May2010)-DERM. Topo (250k raster)-Geoscience Australia.

Alpha Coal Pty Ltd

South Galilee Coal Project

PMF Depths and Extents-Infrastructure Area

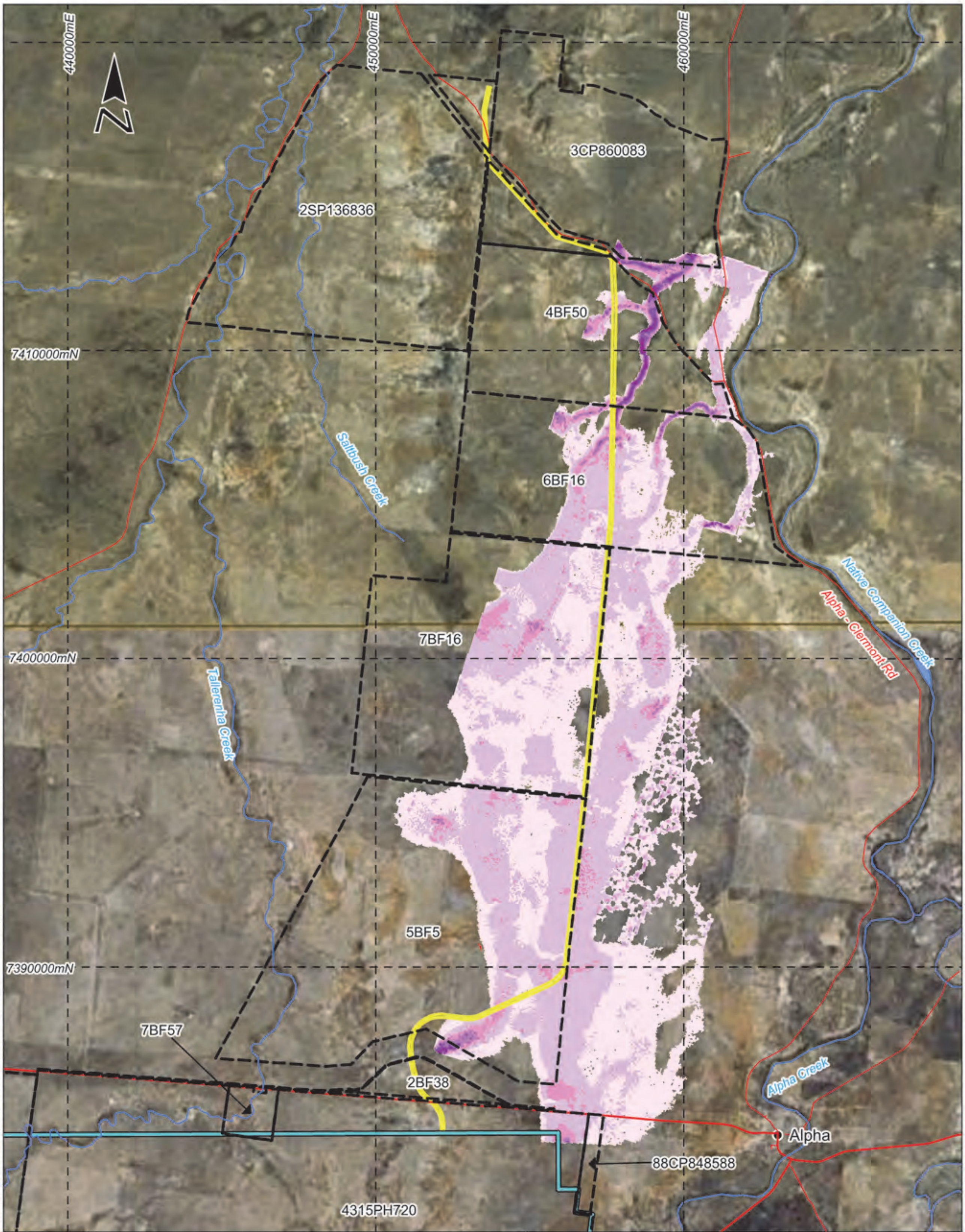
0 5 Kilometres

Scale: 1:175,000 (A4)

03/10/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 9-19



LEGEND

- MLA70453
- Directly affected property
- SGCP infrastructure corridor
- Roads
- Population centre

Q2 VELOCITY (m/s)

- 0.0m/s < 0.5m/s
- 0.5m/s < 1.0m/s
- 1.0m/s < 1.5m/s
- 1.5m/s < 2.0m/s
- 2.0m/s < 2.5m/s
- 2.5m/s < 3.0 m/s
- 3.0m/s < 3.5m/s
- 3.0m/s < 4.0m/s

Data Source;
Cadastral (Barcaldine May2010)-DERM. Topo (250k raster)-Geoscience Australia.

METSERVE Mining & Energy Technical Services

SouthGalilee

Alpha Coal Pty Ltd

South Galilee Coal Project

PMF Flood Velocities-Infrastructure Area

0 5
Kilometres

Scale: 1:175,000 (A4)

03/10/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 9-20

S:\PROJECTS\AM001_STHGALILEE_EIS\GIS_MAPINFOWSPACES\SECT_09\20120310_RENUMBEREDFIGS\FIG 9-7_8 & 9-19_9-20 WATER FIGURES-INFRA CORRIDOR

Mine-induced subsidence will potentially result in the formation of pools within the channels of Tallarenha Creek and its tributaries. The evaporation and seepage from these pools could potentially reduce streamflow in the downstream reaches of Tallarenha Creek.

Subsidence induced cracking of the Tallarenha Creek and Sapling Creek catchment could also potentially result in enhanced infiltration and subsequent loss of streamflow in the receiving waters.

9.6.2. Water Quality

9.6.2.1. Construction

The SGCP and associated infrastructure corridor has the potential to adversely impact on surface water resources during construction without appropriate mitigation. Activities associated with the construction of mine infrastructure, construction of water management infrastructure, and earth moving activities are the main activities of potential impact. These activities may lead to erosion and sediment mobilisation, altered flow characteristics and contaminant mobilisation.

Potential impacts on water quality throughout the construction phase include:

- sediment mobilised during construction activities may enter surface water runoff during rainfall events and discharge to watercourses leading to adverse effects on water quality
- potentially contaminated aqueous waste streams from temporary refuelling facilities, chemical storage facilities and vehicle washdown areas could enter into drainage lines
- erosion and damage to sediment control infrastructure from significant rainfall events during construction.

9.6.2.2. Operations

During the operational phase of the SGCP, in addition to those identified during construction activities, potential adverse impacts may arise from water management system infrastructure failures (storages, pipes, embankments) and creek diversions.

Potential impacts on water quality during the operation of the SGCP include:

- failure of water storages, storage embankments, pipelines, levees or bunds has the potential to result in non-compliant discharge and environmental impacts for downstream receiving waters, ecosystems and landholders
- erosion and sediment mobilisation from mining and processing operations can cause deleterious effects on downstream water quality and aquatic habitats.

Land disturbance associated with mining has the potential to adversely affect the quality of surface runoff by increasing sediment loads and transporting contaminants from waste rock and coal seams. The results of the geochemical overburden assessment (Environmental Geochemistry International (EGi), 2011) indicate that the bulk of the overburden and interburden material is likely to be non-acid forming (NAF). The roof within 5 m of the upper coal seam appears to be the main potentially acid-forming (PAF) horizon of concern, with a number of other lower capacity PAF horizons associated with coal seams and interburden.

Final pit floor material is likely to be low capacity PAF. ROM coal and washery wastes are also likely to be mainly PAF. Water extract testing indicates that once acid conditions develop, elevated concentrations of dissolved Al, Co, Cu, Fe, Mn, Ni, SO_4 and Zn are likely to occur.

EC1:5 values ranged from 40 to 3,130 µS/cm with approximately half the samples falling within the non-saline to slightly saline range with an EC of 300 µS/cm or less. Eleven of the remaining samples were saline (> 600 µS/cm). Results indicate a general lack of immediately available acidity and salinity in the samples except where partial oxidation of pyrite has occurred. Hence control of Acid Rock Drainage (ARD) will largely control salinity.

Contaminant concentrations in pit water have significant potential to adversely impact downstream environmental values if it is released into the environment under certain conditions.

Changes to the profile of Tallarenha Creek caused by mine-induced subsidence, and to Sapling Creek, due to the diversion to Dead Horse Creek could affect the movement of sediment through the system.

Land disturbance caused by construction and operational activities within with the MLA areas, and during construction of the infrastructure corridor, has the potential to increase sediment loads in the receiving waters. However, the impact on the Great Barrier Reef Lagoon will be minimal because:

- Erosion and sediment control measures will be implemented to reduce sediment loads in runoff from construction sites. An Erosion and Sediment Control Plan will be developed prior to all construction work in accordance with recommendations of the International Erosion Control Association's Best Practice guidelines
- Runoff from disturbed areas of the operational site will be captured in the site water management system, so that coarse sediment will settle, and the risk of discharge of sediment-laden runoff will be low
- The project area makes up less than 0.3 % of the catchment area to Burdekin Falls Dam and the contribution of other downstream catchments to total sediment loads is far greater than that of Native Companion Creek (the sediment load is less than 5 % of the total Burdekin River sediment load and less than 2 % of the total sediment load to the Great Barrier Reef Lagoon)

- The Burdekin Falls Dam further reduces sediment loads from its tributary catchments (including Native Companion Creek) by between 60 % and 90 %.

The chemical and physical properties of water including stormwater entering at the point of discharge into natural surface waters from the mine will not be deleterious to flora and fauna as the mine water management system will intercept and segregate water as described in **Section 9.8.2**.

If extremely high rainfall events creates an excess of water that is required to be discharged off-site, it will be managed to meet appropriate release critera as discussed in **Section 9.8.3.5**.

Water quality runoff from the infrastructure corridor areas will be similar to that of the surrounding agricultural landuse. Details of potential temporary and/or permanent impacts to aquatic flora and fauna are shown in **Section 8 – Nature Conservation**.

9.6.3. Impact on Existing Water Users

Where possible, clean runoff from undisturbed catchments will be diverted around the SGCP workings. However, the capture and reuse of water in the mine water management system will result in reductions in flow in the receiving water catchments.

The proportion of the Alpha Creek catchment that is disturbed and intercepted in the MWMS will increase to 0.2 % in Year 1, and to 0.4 % in Year 33. Up to 9 % of the Tallarenha Creek catchment will be disturbed by the SGCP and intercepted in the MWMS.

Changes in the profile of Tallarenha Creek have the potential to alter the movement of sediment into downstream QMAN areas. Significant impacts on downstream QMAN holders are considered unlikely (refer to **Section 4.3.4** of **Appendix F—Surface Water**). Potential impacts from the infrastructure corridor on existing water users are predicted to be minimal based on the minor changes on flood levels, extent and velocities. Refer to **Section 9.6.5.2** and **Appendix F—Surface Water.**

9.6.4. Stream Diversions

The diversion of Sapling Creek will be required for the SGCP to gain unimpeded access to coal reserves that would otherwise be inaccessible. To supplement the stream diversion channel, flood protection levee banks will be required to protect the mine from flooding.

Stream diversions for mining projects are historically known to potentially produce adverse impacts on stream channel geomorphology. Best practice stream diversion design implemented over the last eight to ten years, since the research and publication of the Australian Coal Association Research Project (ACARP) guidelines for stream diversions is now widely recognised to improve the sustainability of modern stream diversions.

The SGCP will implement these best practice principles for the Sapling Creek diversion (refer to **Section 4.4.2** of **Appendix F—Surface Water**).

The potential adverse impacts of poorly designed stream diversions can include instability of the stream channel with potential for adverse impacts including:

- excessive erosion leading to water quality impacts, unsustainable downstream sediment loads, and impacts on aquatic ecosystems
- excessive lateral migration of the stream channel with risk to valuable infrastructure, riparian vegetation loss, and impacts on terrestrial ecosystems near the stream.

The most common causes of impacts due to inadequate stream diversion design can include:

- diversion channels that are too short and/or steep relative to the original stream
- channel dimensions not matching the original channel resulting in change of the bank-full flood capacity of the channel which modifies the frequency and energy of bank-full flood events and floodplain interaction
- meander design not compatible with the expected channel flow energy and substrate conditions
- channel substrates that are markedly different to the original stream resulting in either poor ability to rehabilitate the stream, and/or greater vulnerability to erosion
- excessive constriction of the floodplain corridor resulting in concentration of floodplain flow and higher energy in the stream channel.

Several methods have been developed to quantitatively compare the existing creek hydraulics to those of the diversion channel for design purposes. The most common method uses channel velocity to estimate shear stress within the channel. The shear stress can then be related to the potential for erosion or sedimentation within the channel based on the characteristics of the channel bed and banks. Guidelines for maximum permissible velocities to minimise erosion can then be established based on the channel bed material.

It is important to recognise that velocity and shear stress provide an indication of local and immediate erosion potential only. Velocity and shear stress parameters generally indicate whether there is erosion potential to cause enlargement of the local channel cross-section (depth and width). They generally do not indicate if there are other influences present which try to realign and reshape the channel alignment (e.g. meandering). The long-term stability of a channel's alignment is related to the morphological context of the reach. Stream power is a more useful indicator of hydraulic conditions reflecting the morphology of the channel, particularly for 'bank-full' flows that are commonly known to be 'channel forming' events.

Realignment of Sapling Creek will create an altered creek and riparian environment which will require effective, long-term and sustainable revegetation, consistent with existing vegetation communities in the area. High velocity flows can dislodge young establishing plants with inadequate root systems.

Similarly, if plants are unable to establish deep root systems that can access deep soil water during the dry season, they could die.

For sections of the channel excavated into rock, there is a risk that shallow rooted plants will be ripped out during high flows or die during the dry season, due to inadequate root depth which provides anchoring and/or access to soil moisture. However, it is anticipated that only minor sections of the diversion will require excavation into rock.

9.6.5. Flood Levels

9.6.5.1. Mine Area

The combination of the proposed Sapling Creek diversion and flood protection levee banks required for the SGCP may potentially impact on flood levels. The SGCP design accommodates a flood design that is intended to minimise risk to third party infrastructure. The remoteness of the Project also minimises risk of flood damage to third parties that may result from changes to the local catchment caused by the SGCP.

The impact on flood levels was assessed with the hydraulic models that were prepared to assess baseline conditions (refer to **Appendix D and E** of **Appendix F—Surface Water**). The hydraulic models were modified to include representation of the proposed concept Sapling Creek diversion works and flood protection levees.

The proposed open-cut pit will intersect a number of tributaries of Tallarenha Creek. To minimise the potential volumes of water coming into contact with disturbed areas, a channel and levee system will be constructed to the west of the proposed highwall to protect the open-cut from flooding. Another channel will be required to divert an eastern tributary of Tallarenha Creek east around the mine workings. These changes will result in significant local changes to the flooding pattern of these tributaries.

The southern end of the proposed open-cut crosses Sapling Creek, and as a result, the upper reach is to be diverted south into Dead Horse Creek. The diversion will comprise a diversion plug or levee, which will direct streamflow into the diversion. Design flood flows in Dead Horse Creek, and consequently design velocities will be increased. This will result in higher flood levels and an increased potential for erosion in Dead Horse Creek.

These results identify that some changes in flood levels are likely as a result of the mine development, but these changes are not considered to change the flood risk to existing infrastructure in the area.

9.6.5.2. Infrastructure Area

The proposed rail embankment structure along the infrastructure corridor has the potential to change the flooding characteristics in the area. These potential impacts will be mitigated by providing cross-drainage structures along the embankment to maintain existing flow conditions. The locations of these cross-drainage structures are shown in Figure 3-6 of **Appendix F – Surface Water**.

The hydraulic model of the infrastructure corridor area was modified to incorporate the proposed embankment, and openings were included at key locations such as creek crossings and high-flow areas to maintain existing flow patterns in large floods. The flood model results presented in **Appendix D and E** of **Appendix F – Surface Water** and show that the proposed arrangement of cross-drainage structures would ensure that the impact on flood depths would be minimal for most flood events.

Table 9-15 show the maximum changes at the various landholdings which are affected, as well as the changes at the identified homesteads (**Table 9-16**).

Table 9-15 Maximum Change in Depth of Flooding (m) – Surrounding Properties

Lot ID	2 Year ARI	10 Year ARI	50 Year ARI	100 Year ARI
2SP136836 [a]		0.00	0.00	
3CP860083 [a]		0.00	0.00	
4BF50 [a]		0.05	0.11	
6BF16 [a]		0.42	0.48	
7BF16 [a]		0.29	0.32	
1BF45 [a]		0.24	0.24	
60BE20 [a]		0.24	0.25	
87BE34 [a]		0.12	0.17	
5BF5 [ab]	0.72	0.27	1.46	1.64
3BF6 [b]	0.00	-	-0.34	-0.87
31BF11 [b]	1.52	-	1.62	1.56
4315PH720 [b]	2.49	-	3.03	3.23
7BF57 [b]	2.20	-	3.76	3.96
301SP108315 [b]	-	-	0.00	-
2BF38 [b]	-	-	0.00	-
1160PH286 [cd]	0.68	-	0.98	1.07
3BF53 [c]	0.98	-	1.46	1.65
1DM3 [d]	2.04	-	3.33	3.52

a – Infrastructure Corridor Model b – Tallarenha Ck Model c – Sapling Ck Model d – Dead Horse Creek Model

Table 9-16 Maximum Increase in Depth of Flooding (Homesteads) (m)

Homestead	2 Year ARI	10 Year ARI	50 Year ARI	100 Year ARI
Hobartville		0	0	
Tressilian		0	0	
Monklands		0	0	
Mentmore		0	0	
Cadwell		0	0	
Saltbush		-0.003	0.002	
Eureka		0	0	
The Grove		0	0	
Oakleigh		0	0	
Corn Top	0	-	-	0
Betanga	0	-	-	0
Villafield	0	-	-	0
Bonanza	0	-	-	0
Creek Farm	0	-	-	0
Chesalon	0	-	-	0
Bedford	0	-	-	0

During detailed design, the cross-drainage arrangements may be further optimised while maintaining flood management outcomes if required. It is not anticpated that levees or a buffer between the infrastructure corridor and surrounding waterways will be required.

9.6.6. Subsidence

Surface subsidence is considered the principal surface impact of underground coal mining. Subsidence can vary depending on the soil type, local geology, faulting, jointing, depth of mining, thickness of coal, and width of chain pillars.

In longwall mining, a panel of coal, typically about 400 m wide (350 m for the SGCP) and 3.5 to 6 km long and 2.8 to 4.5 m thick, is removed by longwall shearing machinery which travels back and forth across the coalface. The area immediately in front of the coalface is supported by a series of hydraulic roof supports, which temporarily hold up the roof strata and provide a working space for the shearing machinery and face conveyor. After each slice of coal is removed, the hydraulic roof supports, the face conveyor and the shearing machinery are moved forward.

When coal is extracted using this method, the roof above the seam is allowed to collapse into the void that is left as the face retreats. This void is referred to as a goaf. As the roof collapses into the goaf, the fracturing settlement of the rock progresses through the overlying strata and results in sagging and bending of the near surface and subsidence of the ground above.

Generally, subsidence occurs over the centre of the longwall panel and tapers off around the perimeter of the longwall. The subsidence is usually less than the thickness of the coal extracted underground.

Where several panels are mined in a series, chain pillars are left between the panels. The chain pillars crush and distort as the coal is removed from both sides, but usually they do not totally collapse and hence the pillar provides a considerable amount of support to the strata above them. The subsidence at the surface does not occur suddenly but develops progressively as the coal is extracted within the area of influence of the extracted panel.

As further adjacent panels are extracted, additional subsidence is experienced, above the previously mined panel or panels. However, a point is also reached where a maximum value of subsidence is observed over the series of panels irrespective of whether more panels are later extracted. The subsidence effect at the surface occurs in the form of a very slow moving wave.

Shallow operations tend to cause sudden localised subsidence with sharp faulting. Deeper mining generally causes more gradual subsidence with strata overlying the goaf bending downward. This creates compressive strain in the centre of the subsided area, where subsidence is greatest, and tensile strain around edges of the subsided area can lead to surface cracking.

Due to underground mining at the SGCP, land situated directly over the longwall panels will subside by a maximum vertical subsidence of 4.2 m. For the D1 seam, the maximum vertical subsidence is 2.55 m, and 1.5 m for the D2 seam.

The potential environmental impacts from subsidence include:

- impacts to catchment boundaries, potentially resulting in self-contained catchment areas where water that would have runoff to the creek channels prior to subsidence would now pool within the subsided area and be lost to groundwater due to percolation
- loss of surface water flow through limited surface cracking
- change to stream bed profiles between longwall panels, resulting in erosion between adjacent longwall panels and sedimentation over the tops of the longwall panels
- potentially reduced flood capacity in channels, resulting in more frequent inundation of floodplain areas
- reduced stability of the proposed Sapling Creek diversion channel due to subsidence over multiple panels.

The subsidence modelling results are summarised in **Sections 9.6.6.1.** to **9.6.6.3.**

9.6.6.1. Surface Ponding

Based on the current underground mine plan and subsidence surface terrain modelling, it is possible that catchment surface flow and flood flow could form ponds in subsidence-related depressions in the flood plain areas. (refer to **Appendix C** of **Appendix F—Surface Water**).

However, the reduction in the effective catchment area and catchment yield of local catchments is expected to be small. The reduction in catchment area and downstream catchment yield should therefore not adversely impact the local catchment. Additional mitigation measures will be considered following subsidence and subsequent geomorphologic assessments (refer to **Section 9.8.9**).

The water quality in the ponded areas will reflect the water quality of natural surface runoff water and would be similar to local stock watering dams. The residual ponded areas may also impact on vegetation within the ponded area.

Subsidence occurring under natural and diverted channels and associated floodplains may increase the velocity, bed shear, and stream power in the creek channel where they cross subsidence areas. Sedimentation is predicted to occur in the troughs that will form above each longwall panel. Additionally, increased erosion may occur between the longwall panels during the same time period.

It is expected that over a medium to long period after subsidence (indicatively say 20 years), that the bed profile would adjust through sedimentation and erosion to form an even graded bed profile at similar slope to the existing creek. As this occurs, the channel hydraulic capacity may be reduced, resulting in more frequent inundation of the floodplain.

9.6.6.2. Surface Cracking

The degree of cracking in watercourses is affected by the depth and proximity of mining and the local geology. Mining subsidence has the potential to cause cracking in the floors of valleys and in creeks, affecting both surface and groundwater hydrology. The impact of cracking is also affected by depth, as examples from New South Wales (NSW) indicate that mining deeper than 150 m is less likely to cause permanent water loss than mining less than 100 m deep.

The loss of surface water flows into cracks caused by subsidence is known to be a significant concern for underground longwall mining in some areas of NSW. In Queensland, there is less evidence available of impacts; however, the geology of the Bowen Basin (primarily alluvial and sedimentary deposits) indicates that potential concern of loss of surface water flow into subsidence cracks is less significant than impacts that have been reported in NSW. The high plasticity of the overburden is further likely to mitigate the effects of cracking.

The ability of a watercourse to recover from subsidence caused cracking is determined by the gradient of the stream bed, the amount of organic material in the substrate, the thickness of the alluvium and the width of the cracks. Water that infiltrates into subsidence cracking can potentially be exposed to sources of geological contamination and can re-emerge downstream. Overland flow may be re-directed and ponded due to the topographical effects of subsidence.

9.6.6.3. Impact on Levees

The proposed alignments of the flood protection levee embankments on the western side of the open-cut operations generally follow the un-subsided areas between longwall panels in order to reduce the potential for structural stability, and to reduce the potential for reconstruction. Therefore, subsidence from the longwall operation will not affect the proposed levees.

impacts and mitigation measures for flooding. The construction of any flood protection levees should be described with regards to construction material, design and methods. post-mine info not adequate. Where is rail spur information.

9.6.7. Ecology

Activities associated with the construction phase with the potential to impact on the surface water aquatic ecosystem values in the SGCP include:

- pit construction
- diversion of low order stream habitat within the pit areas
- removal of riparian vegetation from streams both within the infrastructure corridor and the MLA
- instream works associated with road, rail and conveyor crossings
- movement of vehicles and the plant to and from and around the construction site.

Activities associated with the SGCP operational phase that possess the potential to impact on surface water aquatic ecosystem values include:

- pit excavation and dewatering
- underground mine construction
- processing, handling and transport of ore material
- managing water on and off-site.

More information on ecological impacts is available in **Section 8—Nature Conservation**.

9.6.8. Final Void

A final void will remain after completion of open-cut mining. To provide maximum pit protection, appropriate surface water management infrastructure will be implemented to protect the final void from flooding following cessation of operations. The final void will be protected from flood events by the proposed diversion channel and flood protection levees, which will become part of the final landform.

No stored pit water is anticipated to be entrained outside of the pit by floodwater during large rainfall events (up to the 1:3000 year event) as a result of the proposed bunding and the small available catchment contribution.

An Operational Simulation (OPSIM), (Water Solutions Pty Ltd, 2012) model has been developed for the final void to determine long-term water levels. The OPSIM model works to dynamically simulate the behaviour of the void and on a daily time step basis using historical climate data. The model incorporates the Australian Water Balance Model (AWBM) (Boughton & Chiew 2003) to estimate runoff from daily rainfall and evapotranspiration data.

The year 33 void was assumed to representative of the final void configuration and it was assumed that at mine closure, the major diversions of the western catchments (including Sapling Creek) will remain in place. The minor clean water drains around the pit highwall were assumed to have been decommissioned. The catchments flowing to the void will include:

- the pit floor itself
- the natural catchment upslope (west) of the highwall and east of the diversion
- the in-pit overburden (which will have been shaped to its final profile, topsoiled and revegetated).

Long-term expected water levels in the SGCP final void appear to stabilise at around 325 m AHD (a depth of approximately 40 m compared to the total void depth of 90 m) and the long-term final void water level appears relatively insensitive to the initial water level. A range of initial water levels are shown in **Figure 9-21.**

In any void which does not have a mechanism for salts to flow out (e.g. by flushing through flood inflows and discharges, or by fresh groundwater inflows), salinity will tend to increase over time. OPSIM modelling of void shows that if initial water levels are low, the salinity will eventually increase beyond safe stock watering levels.

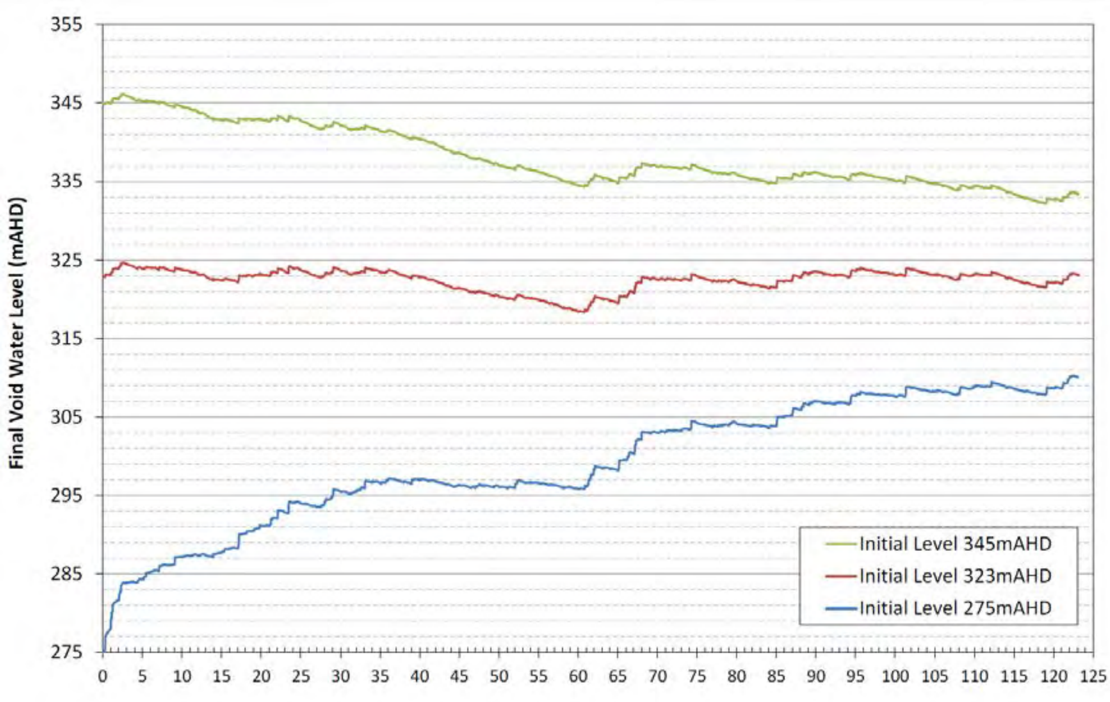


Figure 9-21 SGCP Final Void Water Level

9.6.9. Climate Change

The potential impacts of climate change (if any) on surface water the SGCP are difficult to assess as 'experts' in the field have presented evidence both for and against the theory. However, in addressing the potential risk of climate change for the purposes of this EIS, it can be noted that Engineers Australia have published a paper entitled, *Implications of Climate Change on Flood Estimation: Discussion Paper for the Australian Rainfall and Runoff Climate Change Workshop No. 2* (February 2011). The paper summarises studies that have been completed or partially completed from Australia and other parts of the globe.

The conclusions reached for Australia were generally:

- NSW recommends a sensitivity analysis with a 10 % to 30 % increase in extreme rainfall
- Queensland is considering adopting a 5 % increase per degree temperature change for the 1:100 to 1:500 Annual Exceedance Probability (AEP) events
- BOM has concluded that it was "not possible to confirm that probable maximum precipitation will definitely increase under a changing climate."

As a simplified approach to estimate the potential impacts of climate change on the SGCP, a conservative scenario where all peak discharges increase by 20 % has been assumed. The impacts of such an increase in peak discharges would include the following:

- the more frequent events would have higher discharges; however, the relative changes to existing creek system would remain the same
- water management infrastructure within the mine areas would need to be upgraded to a larger capacity
- the previous flood events would become larger, however the proposed flood levees would provide protection, but with less freeboard.

9.6.10. Potential Cumulative Impacts

The impacts of the SGCP on surface water resources have been assessed assuming that other projects in the area proceeded. A number of projects are all located downstream of the SGCP. As the proposed water management system will aim to maximise reuse of water on-site, through the provision of a large on-site water storage, the potential for cumulative impacts on downstream receiving water quality is limited.

Water will only be released from the site dams in compliance with the EA conditions, which will be developed in consultation with DEHP to manage potential cumulative impacts.

9.7. POTENTIAL GROUNDWATER IMPACTS

This Section provides an assessment of the potential impacts of the SGCP on the environmental values of the groundwater resources. Matters addressed include:

- potential impacts on groundwater flow and quality from all SGCP phases in each aquifer, with reference to their suitability for current and potential downstream uses
- potential impacts on groundwater recharge regimes or depletion, including potential impacts on the Alpha township water supply
- groundwater volumes likely to be dewatered during operations, and its likely quality characteristics, including salinity
- a description of how extracted groundwater will be managed in the surface water management system to minimise the likelihood of releasing highly saline water
- measures to prevent, mitigate and remediate any impacts on existing users or potential groundwater dependent ecosystems and vegetation

- the response of the groundwater resource to the progression and cessation of the SGCP
- cumulative affects on groundwater of surrounding mining operations.

The multi-layered finite difference groundwater flow model has been built using the industry standard MODFLOW code (McDonald and Harbaugh, 1988; Harbaugh et al, 2000). The basic flow model was coupled with the MODFLOW-SURFACT (version 4; HydroGeoLogic Inc.) code to allow for both saturated and unsaturated flow conditions, and also the simulation of variable aquifer parameters to represent mining and backfilling with overburden. The modelling was undertaken using the Groundwater Vistas (Version 6.26) pre/post-processor software package (ESI, 2012).

The AGMG (Barnett et al, 2012) build on the MDBC guidelines (Middlemis et al, 2001), with substantial consistency in model conceptualisation, design, construction and calibration principles, and performance and review criteria, although there are differences in some details.

One notable difference with the AGMG is the new method of model complexity classification. Under this system, the SGCP model may be categorised with a Class 2 to Class 3 model confidence level (Barnett et al, 2012). Similarly, under the MDBC guidelines (Middlemis et al, 2001), the model is best categorised as an Impact Assessment Model of medium to high complexity.

The SGCP groundwater model extent covers an area of just over 65 km east-west and 70 km north-south (or more than 4500 km^2).

This extent allows for an assessment of the potential for impacts on existing groundwater use near the Alpha township to the east, and on GAB formations to the west, as well as allowing for a cumulative impact assessment of the SGCP and other mining operations to the north (ACP, KCCP, and GCP).

The SGCP model extends to these boundaries:

- east to the Alpha township (the model takes into account groundwater extraction at Alpha township)
- west to the range of hills that form the catchment divide (the Great Dividing Range), to represent the Great Artesian Basin aquifers in this area
- north to the ACP; the representation in the SGCP model of impacts at the ACP includes the effects of the KCCP immediately north of ACP, as well as the GCP which is located within the model domain, and
- south to a topographic boundary about 13 km from the SGCP.

The hydrogeological units of relevance have been represented in the groundwater model by seven model layers, as detailed in **Table 9-7** and **Appendix G— Groundwater**. Separate model layers are specified for the D1 and D2 coal seams and interburden. Key GAB formations are included in the model structure in the south-western corner of the model.

The SGCP MLA area is covered by a 50 × 50 m grid which increases up to a 1000 × 1000 m grid more regionally. Each of the seven layers consists of 605 rows and 585 columns (approximately 350,000 cells). The entire model contains approximately 2.5 million cells, which is relatively large for a groundwater model.

The predictive models are based on the mine development schedule and tracked the progressive mining of open-pits and longwalls through to mine completion and post-mining recovery at the SGCP. Dewatering occurs in two stages associated with the D1 and D2 seams.

The model simulations include both open-cut and underground mining for the SGCP, as well as for the Galilee Coal Project (GCP) and the Alpha Coal Project (ACP) and Kevins Corner Coal Project (KCCP), along with subsequent post-mining groundwater recovery. For the purpose of the model simulation of cumulative impacts, it was assumed that the mining schedule for Galilee Coal Project (GCP) and the Alpha and Kevins Corner Coal Projects ('the other projects') match the start of the SGCP schedule. This means that all projects are assumed to start at the same time at mining year 1, which can be assumed to be 2015. The GCP is assumed to finish after 30 years of mining, while the ACP/KCCP extends to 33 years, along with the SGCP

More information on the groundwater modelling is shown in **Appendix G—Groundwater**.

9.7.1. Dewatering

Dewatering must occur for the safe operation of the open-cut and underground mines. The impacts associated with the required mine dewatering and subsequent post-mining recovery are related to the changes in groundwater levels, which can affect surrounding users, include:

- dewatering of the coal seams
- drawdown of groundwater within overlying and underlying aquifers
- post-mining recovery in groundwater levels and related increases in bore yields
- potential reduction in baseflow to surface water systems including springs (although it is noted that there are no known springs in the area and the streams are all ephemeral and do not receive baseflow from groundwater), and subsequent recovery.

There will also be changes to aquifer properties in the subsidence/fracture zone above mined longwall panels, which can result in connective cracking extending to near the surface. Changes in groundwater levels and pressures will accompany changes in hydraulic gradients.

Within the fractured zone, there will be substantial changes in fracture porosity and permeability, due to opening up of existing joints, new fractures, and bed separation. Changes in hydraulic properties can cause substantial changes in groundwater heads and hydraulic gradients, sometimes (but not always) with substantial changes in flow patterns in some cases.

There is no interaction between surface water and groundwater resources in the infrastructure corridor, as the depth to water table is in generally excess of 10 m.

The drawdown effects due to mining increase gradually with the development of mining and dewatering for the open pit and adjacent longwall mining areas. After 33 years of mining, the modelled water table level across the SGCP MLA predicts that the cone of depression will reach its maximum extent, with drawdown trends extending generally to the north because it is limited by low permeability units outcropping to the west, east and south:

- the low permeability Rewan Formation and Dunda Beds limit the western (and southern) extent of water table drawdown, which results in the Clematis Sandstone being largely unaffected by drawdown (some minor effects of the order of 5 m or less)
- the low permeability Joe Joe Formation limits the eastern extent of water table drawdown, such that water table levels changes in the Alpha township area are predicted to be less than 1 m.

Although there will be effectively no change the GAB recharge, there will be reductions in the confined aquifer piezometric levels in the western extent of the D1 and D2 seams at depth under these GAB aquifer systems.

Water table drawdown predictions at different stages of mining are shown in **Appendix G—Groundwater**. Water table drawdown after 33 years of mining is shown in **Figure 9-22**.

Water table drawdown due to dewatering in individual groundwater model layers has also been modelled. These layers include:

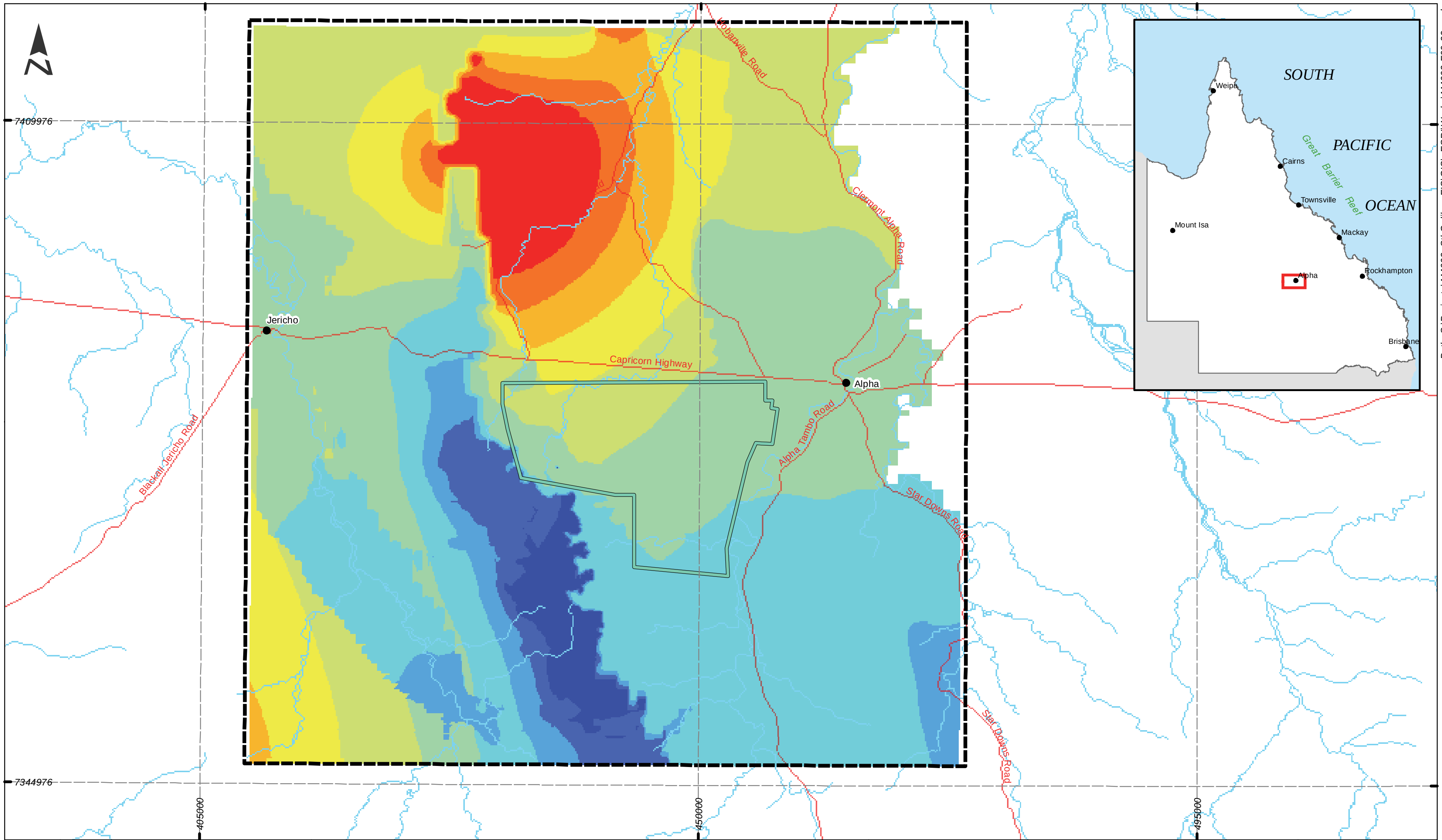
- Layer 1 - Quaternary Alluvium and Regolith (**Figure 9-23**)
- Layer 2 – Permian overburden (Clematis Sandstone) (**Figure 9-24**)
- Layer 3 – Coal seam D1 (**Figure 9-25**)
- Layer 5 - Coal seam D2 (**Figure 9-26**).

9.7.2. Existing Groundwater Users

Some groundwater bores identified in the DNRM database and during the bore survey are likely to be impacted by the SGCP. Groundwater level drawdown in existing groundwater bores has the potential to impact on the use of groundwater for agricultural purposes (stock watering) by causing material interference to bores (e.g. by limiting the available drawdown in the bore and hence reducing the yield, or by drawing the water level down below the existing pump inlet).

The material effect on these bores will depend on the reduction in the amount of available drawdown (depth between static water level and pump inlet) and whether the bores affected intersect the aquifers to be dewatered. As the dewatering impacts on groundwater levels are mainly manifest in close proximity to the mined areas, there is usually substantial residual aquifer thickness remaining at third party bores, and material effects can thus be managed by a range of actions including bore deepening and/or pump replacement. The existing extraction bores in the vicinity of the Alpha township are predicted to be largely unaffected (drawdowns less than 1 m, which is within the seasonal range), so there should be no need for mitigation actions.

Those bores within the mine lease areas are predicted to be greatly affected by drawdown of around 100 m during mining, recovering post-mining to 10-20 m below the pre-mining level (i.e. groundwater levels may fall to near or below the bottom of the bore as a result of mining). These bores are likely to require deepening or replacement. Deepening of bores is a viable option as saturated aquifer conditions remain below the water table that is drawn down by mine dewatering.**Appendix G—Groundwater** shows simulated water table drawdown resulting from mining.



METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

10 0 10

Kilometres

Scale: 1: 550,000

LEGEND

- MLA 70453
- Model Extent
- Major Roads
- Rivers/Creeks
- Population Area

Watertable Elevation (mAHD)

< 225	325 - 350
225 - 250	350 - 375
250 - 275	375 - 400
275 - 300	400 - 425
300 - 325	> 425

Alpha Coal Pty Ltd

South Galilee Coal Project

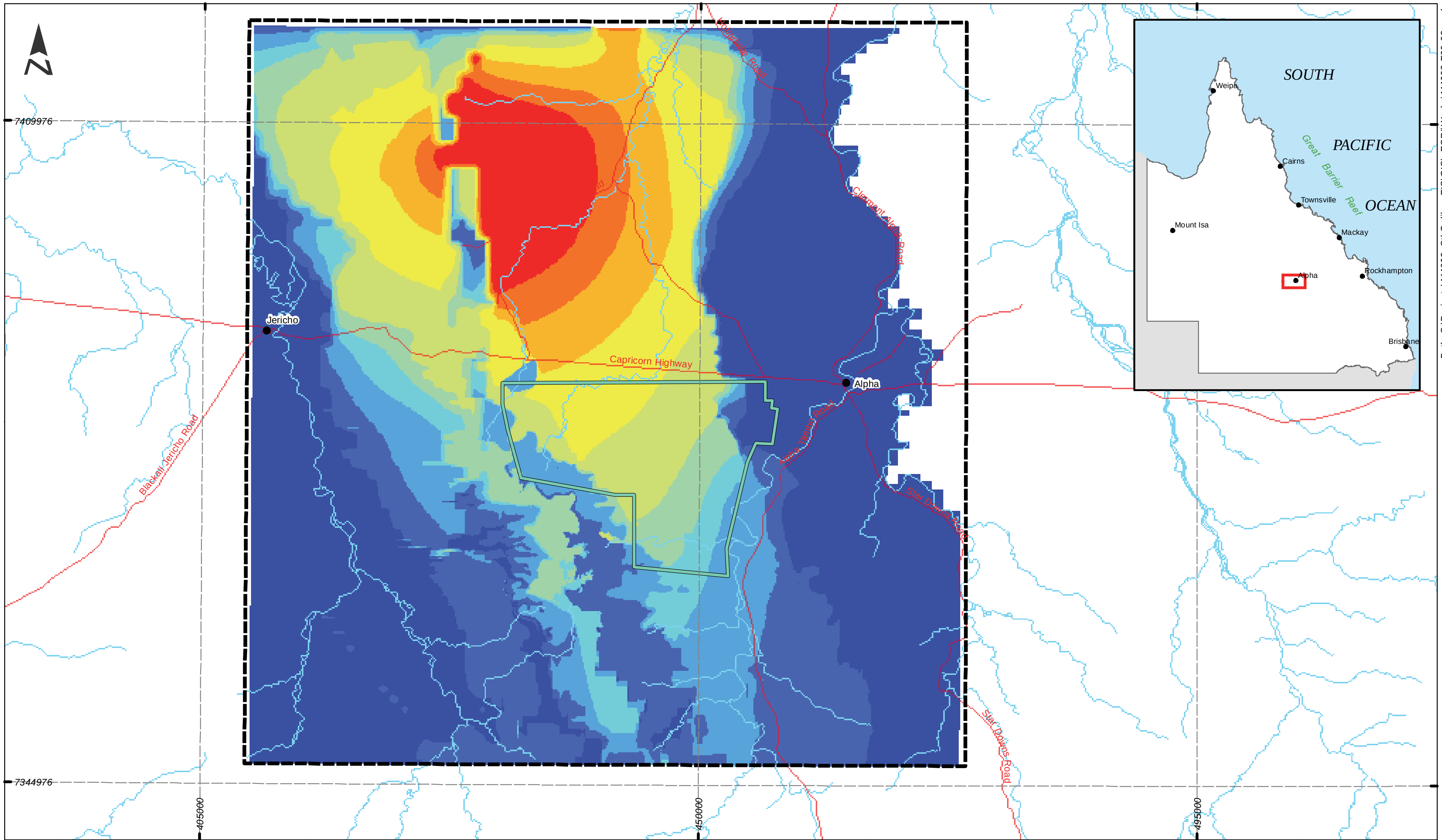
SGCP Water Table Level after 33 Years of Mining

5/10/2012

Proj :

Datum: GDA 1994

FIGURE 9-22



METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

10 0 10

Kilometres

Scale: 1: 550,000

LEGEND

- MLA 70453
- Model Extent
- Major Roads
- Rivers/Creeks
- Population Area

Drawdown (m)

- < 01
- 0.1 - 1
- 1 - 3
- 3 - 5
- 5 - 10
- 10 - 25
- 25 - 50
- 50 - 75
- 75 - 100
- 100 - 184

Alpha Coal Pty Ltd

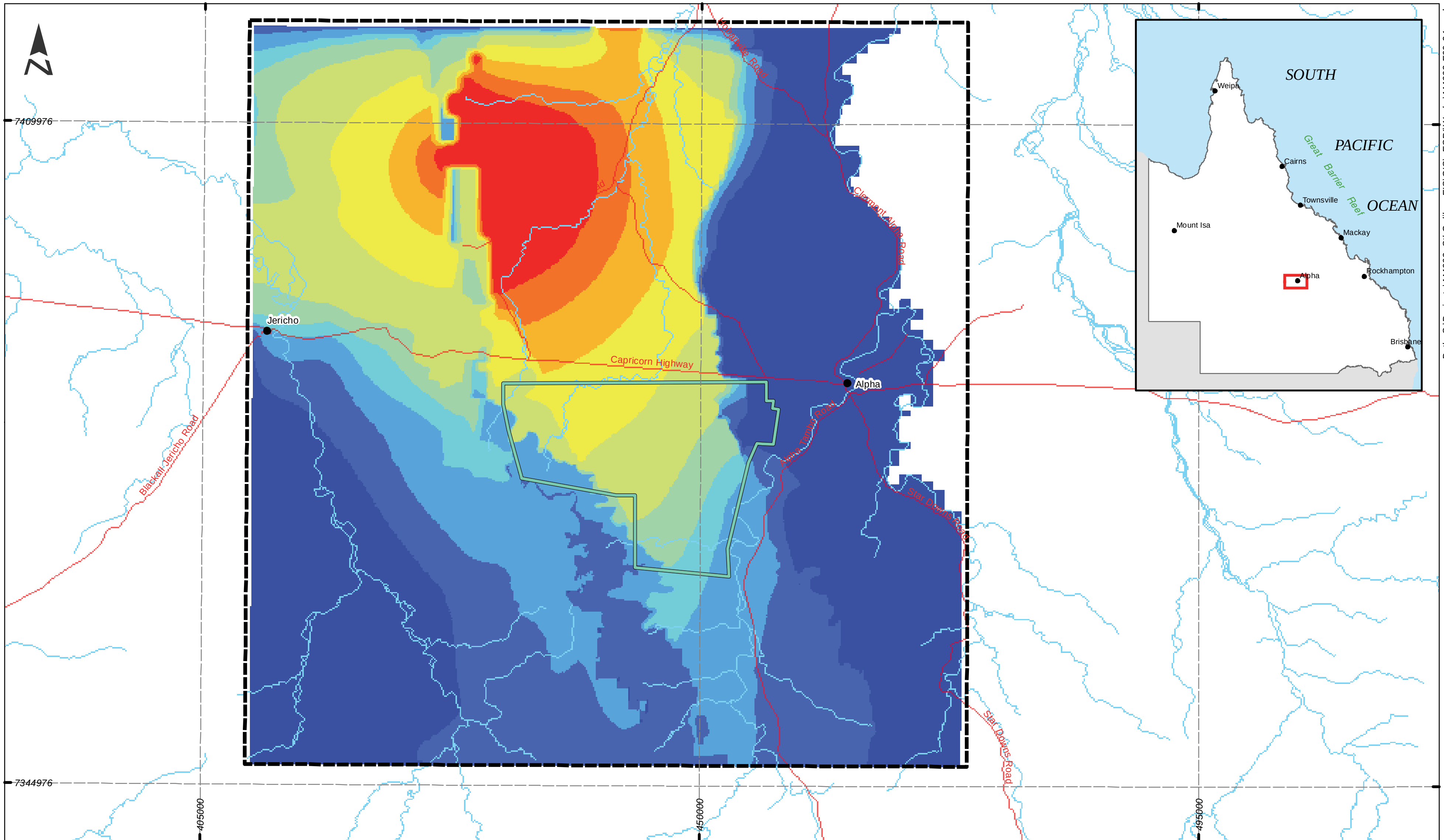
South Galilee Coal Project

SGCP Layer 1 Drawdown (Quaternary Alluvium and Regolith) after 33 Years in Mining

5/10/2012

Proj :
Datum: GDA 1994

FIGURE 9-23



METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

10 0 10

Kilometres

Scale: 1: 550,000

LEGEND

- MLA 70453
- Model Extent
- Major Roads
- Rivers/Creeks
- Population Area

Predicted Drawdown (m)

- < 01
- 0.1 - 1
- 1 - 3
- 3 - 5
- 5 - 10
- 10 - 25
- 25 - 50
- 50 - 75
- 75 - 100
- 100 - 184

Alpha Coal Pty Ltd

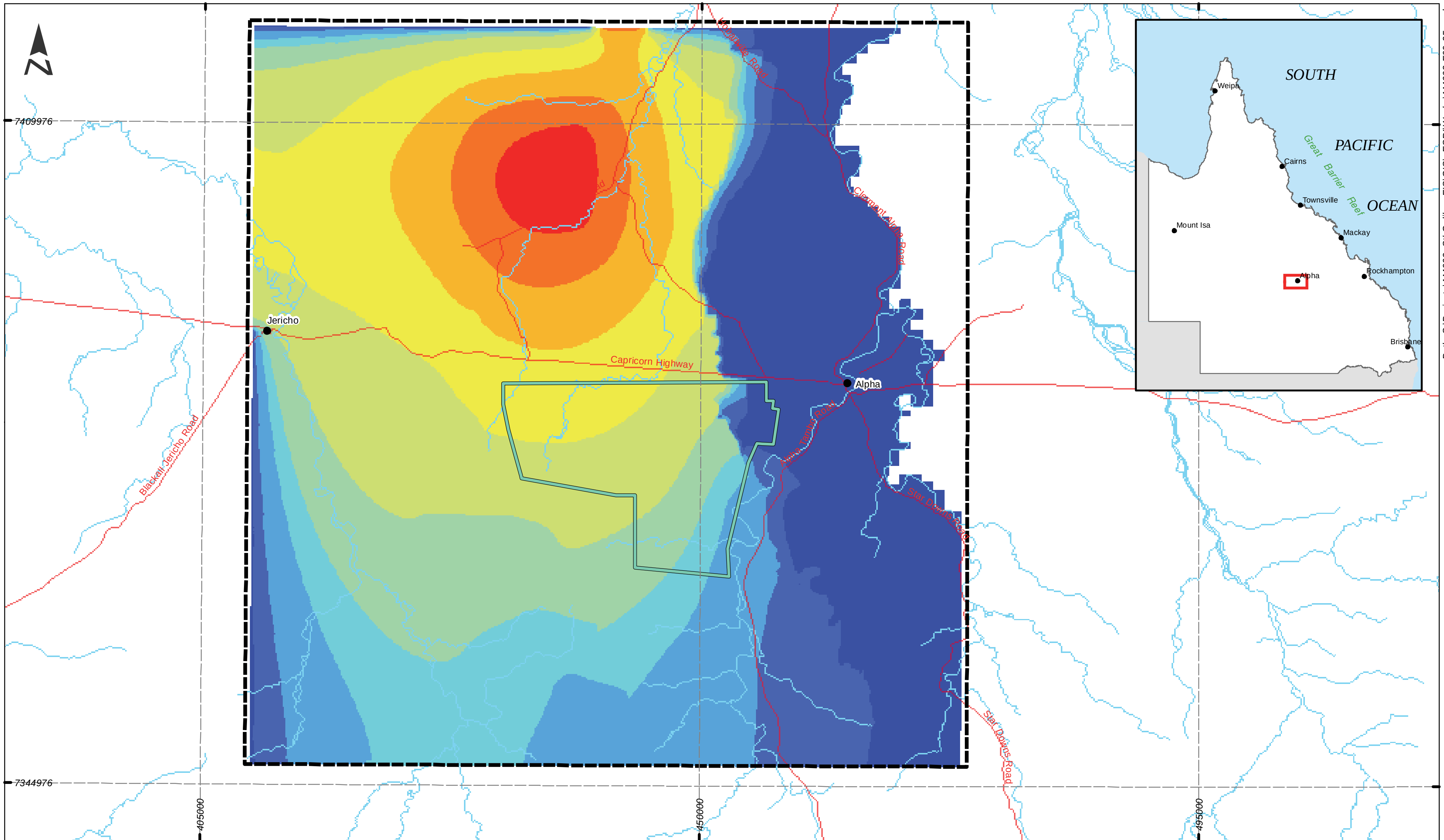
South Galilee Coal Project

SGCP Layer 2 Drawdown (Permian Overburden - Clematis Sandstone) after 33 Years of Mining

5/10/2012

Proj :
Datum: GDA 1994

FIGURE 9-24



METSERVE

SouthGalilee

10 0 10

Kilometres

Scale: 1: 550,000

LEGEND

- MLA 70453
- Model Extent
- Major Roads
- Rivers/Creeks
- Population Area

Predicted Drawdown (m)

- < 01
- 0.1 - 1
- 1 - 3
- 3 - 5
- 5 - 10
- 10 - 25
- 25 - 50
- 50 - 75
- 75 - 100
- 100 - 127

Alpha Coal Pty Ltd

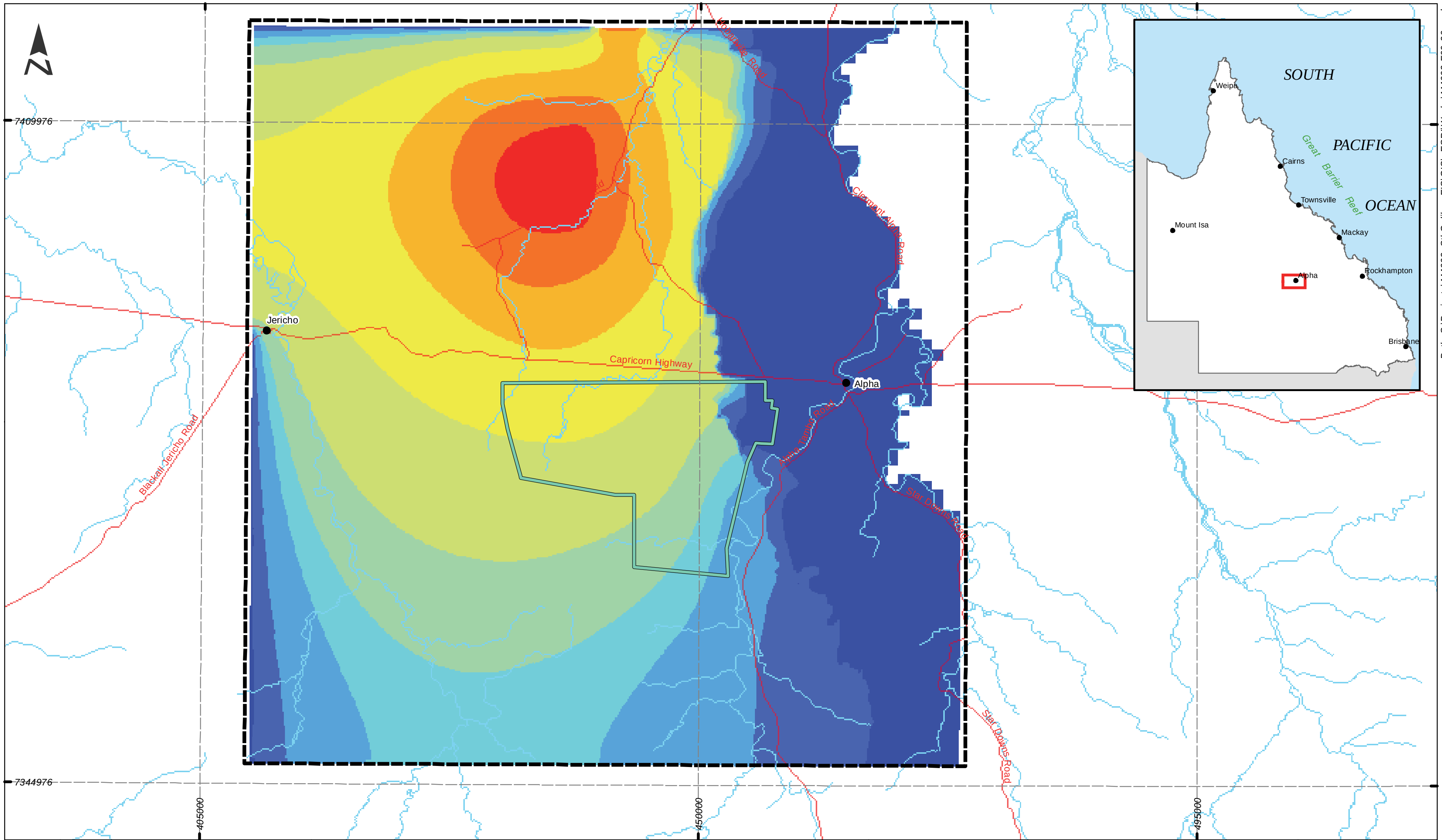
South Galilee Coal Project

SGCP Layer 3 Drawdown (Coal Seam D1) after 33 Years of Mining

5/10/2012

Proj :
Datum: GDA 1994

FIGURE 9-25



METSERVE

South Galilee

10 0 10

Kilometres

Scale: 1: 550,000

LEGEND

- MLA 70453
- Model Extent
- Major Roads
- Rivers/Creeks
- Population Area

Predicted Drawdown (m)

- < 01
- 0.1 - 1
- 1 - 3
- 3 - 5
- 5 - 10
- 10 - 25
- 25 - 50
- 50 - 75
- 75 - 100
- 100 - 127

Alpha Coal Pty Ltd

South Galilee Coal Project

SGCP Layer 5 Drawdown (Coal Seam D2) after 33 Years of Mining

5/10/2012

Proj :

Datum: GDA 1994

FIGURE 9-26

9.7.3. Subsidence

The potential impacts related to longwall mining and resultant subsidence on groundwater resources may include:

- increased aquifer interconnection
- hydraulic connection to surface
- interflow between aquifers.

Subsidence can create stress zones in overlying aquifers causing fracturing and increasing permeability and transmissivity, resulting in changes to hydraulic gradients independent of mine dewatering. The impact of mining on the groundwater regime and groundwater inflow to the underground workings is generally influenced by the height of fracturing above the longwall blocks that provide hydraulic connection between the overlying groundwater resources and the target coal seams. This is illustrated in **Figure 9-27**.

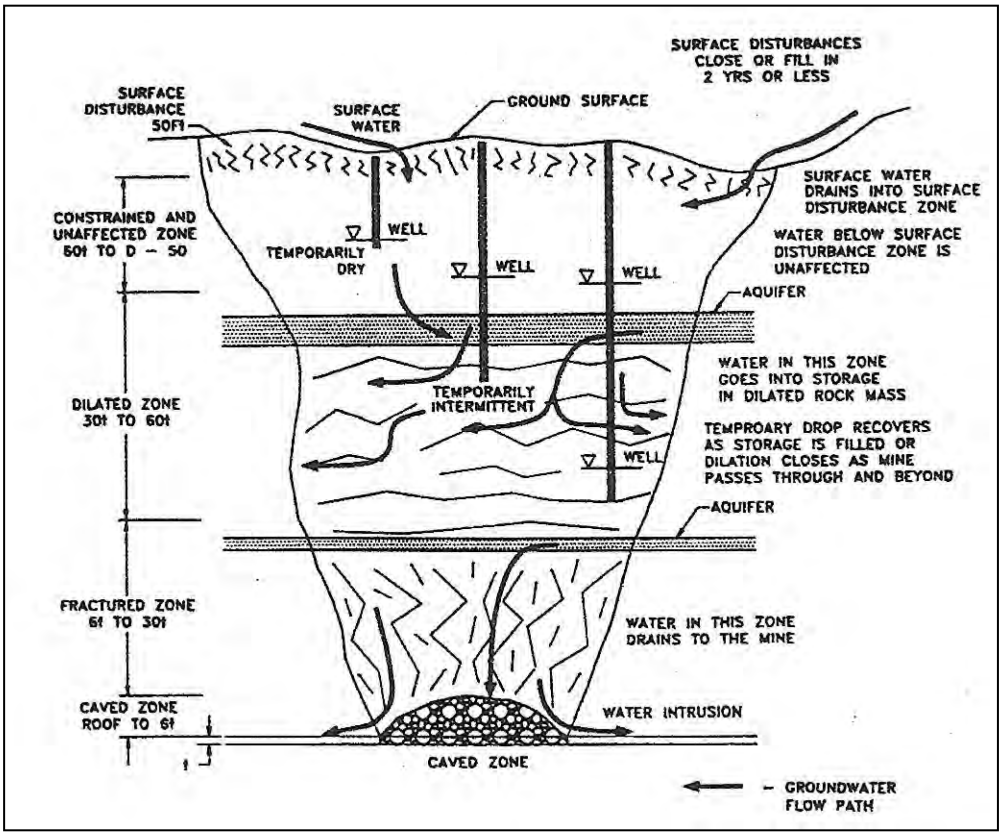


Figure 9-27 Hydrogeological Model For Fracturing Above Longwalls (Bai and Kendorski 1995)

Deep fracture mechanisms can extend upwards to a height of about 0.6 to 0.67 times the longwall width (which is 350 m at SGCP). This is a height of about 210 to 235 m, compared to the depth of cover of around 150 m at SGCP. This indicates potential for the connective cracking to extend from the longwall panel through a deep fracture zone to overlap with the shallow fracture mechanisms near the ground surface, and this has been represented in the groundwater model.

It is likely that the fractures would remain open until in-filled with sediment mobilised by intense rain events or flooding, which would tend to reduce the permeability of the fractured zone and thus reduce potential for related impacts. However, the groundwater model assumes (conservatively) that connective fracturing properties (e.g. higher hydraulic conductivity) are invoked during mining, but then do not change subsequently with time due to any sedimentation or infilling process.

The water table will be lowered in response to mining and dewatering in the immediate vicinity of the mine, and the shallow water table may drop substanially. Following cessation of mining, the water table will recover but to a different elevation than observed pre-mining due to the (assumed) permanence of the fractured zone above the longwall panels.

The adjacent open pit final void will also receive groundwater inflows and be subject to evaporation, which will tend to result in a long term depression in the water table in the local mine area. This would be partly balanced by enhanced groundwater recharge to the fractured zone, although this has not been represented in the groundwater model as a conservative approach to not underestimate the impacts. The depression in the water table in the vicinity of the SGCP in up to 70 m below pre-mining levels.

Changes in hydraulic properties through the fractured zone can affect groundwater heads and flow patterns. For example, if the effects reach the surface, baseflow to streams can potentially be reduced, and/or stream leakage can increase. However, given the ephemeral nature of the local drainage features and substantial depth to water table in the Alpha region, there is no effective baseflow to streams.

Hence, changes in aquifer hydraulic properties in the SGCP area due to subsidence are likely to affect only stream leakage, and even then only during the short periods when rainfall is sufficient to generate runoff and stream flow. hese effects would be expected to actually reduce with time due to sedimentation effects infilling the connective cracking and reducing leakage rates.

9.7.4. Groundwater Recharge and Discharge

9.7.4.1. Recharge

Evapotranspiration in the model reduces very slightly during the mining period (from a range of 9 to 10 ML/day to a minimum of 8.6 ML/day), and then recovers back towards pre-mining levels during the post-mining period.

Mining does not impact the Clematis Sandstone recharge to the GAB; it will remain unchanged with time. Recharge to the alluvium areas within the catchment also remains unchanged with time.

9.7.4.2. Discharge

Groundwater discharge to stream features is a minor element of the catchment water balance, and does not change materially with time during the mining and post-mining simulations.

Simulation results predict that the surface drainage features within the model domain provide small volumes of leakage to the groundwater flow system, and that these volumes do not change as a result of mining. The parameter values apply to represent mining and do not subsequently change, even though it is expected that the shallow fractures will seal with sediment after intense rain events or a flooding episode, limiting the ability of the fractures to quickly convey infiltration below the influence of evapotranspiration.

Modelling results also confirm that the location of the groundwater divide along the Clematis Sandstone outcrop/recharge area remains unchanged relative to the pre-mining water table. This supports the mass balance flow analysis which indicates no change in discharge volumes to the GAB from the Clematis Sandstone as a result of mine operation.

9.7.5. Mine Waste and Water Infrastructure

The following key infrastructure is considered to have the potential to impact on groundwater resources in the area:

- coal waste (rejects and tailings) disposal areas
- ROM coal stockpiles
- CHPP
- raw water dams
- mine dams
- fuel and oil storage facilities
- water and wastewater treatment systems
- sewage systems
- workshops and storage areas.

The identified impacts associated with the SGCP associated infrastructure include:

- artificial recharge
- alteration to groundwater quality
- alteration of recharge.

Recharge impacts are considered to potentially occur below the major infrastructure facilities that will be constructed for the SGCP. These include the CHPP water and waste management system, mine and coal waste areas, fuel and chemical storage areas, sewage system, and environmental dams. Downward seepage has the potential to cause mounding if the recharge volumes are high enough, which in turn can cause alteration of groundwater patterns and possible waterlogged areas in extreme cases.

All water, waste, fuel and chemical storage facilities will be designed, constructed, and operated (for example, to *AS1940*) to prevent seepage, thus the risk to groundwater resources will be limited. Monitoring will validate seepage control measures.

In general the potential for the SGCP to impact on regional groundwater quality is relatively low as groundwater flow will be toward the mine workings, and the potential for contaminants to migrate off-site via the groundwater system will be low. The greatest potential for groundwater quality impacts is considered to be poor quality infiltrating water, where downward seepage from storage facilities (i.e. tailings, rejects) has the potential to result in off-site contaminant migration via shallow groundwater flow to the surface water system. Mitigation measures to address these potential impacts are discussed in **Section 9.9.4**.

Although unlikely, seepage from water and waste facilities could result in downward leakage through surficial sediments until reaching lower permeability weathered sediments. Lateral migration on the lower permeable sediments could occur, which could migrate down gradient at shallow depth toward surface water drainages. It is envisaged that this seepage would not be controlled by regional groundwater drawdown, (which would limit the potential for impacted groundwater to leave site as flow is toward the mined voids) as this component of unsaturated flow occurs above the water table.

Thus shallow seepage monitoring may be required adjacent to the storage facilitates to enable identification and assessment of potential seepage. If monitoring detects a potential for off-site seepage then it is likely that active seepage controls (such as cut-off trenches) would be required.

The impacts of seepage into the deeper aquifers are limited due to the following:

- during mining and after closure (final pit void), groundwater flow will be towards the operating and final pit voids, and the potential for contaminants to move out via the groundwater system will be reduced
- geochemical testing indicates that most materials disturbed and exposed during mining are NAF or have low potential for PAF.

9.7.6. Ecology

As the mine progresses, simulation results predict decreased evapotranspiration volumes as a result of lowered water table levels for mining. The evapotranspiration feature in the model is depth-dependent and is designed to represent shallow groundwater discharge in low-lying areas of the landscape (e.g. the near-stream zone). It is possible that the decrease in evapotranspiration may adversely affect neighbouring plant communities.

This zone could include groundwater-dependent terrestrial vegetation if it is present, although groundwater-dependent terrestrial vegetation is not identified as a key environmental feature in the SGCP area. Predictions of reduced evapotranspiration can be interpreted as potentially reducing groundwater availability for use by plant communities.

The predicted changes to evapotranspiration are relatively small, and given the substantial depth to the regional water table under natural conditions (typically more than 10 m), it is more likely that the terrestrial vegetation that is present is more reliant on shallow soil moisture and/or infiltration from stream flows, which would be largely unaffected across the catchment (i.e. apart from areas directly affected by mining).

9.7.7. Great Artesian Basin

The Clematis Sandstone, a GAB recharge bed, crosses the south-western corner of the mining lease, and dips to the west into the GAB. At its closest point, it lies about 2 km from the western limit of proposed underground mining and about 7 km west of the western limit of proposed open-cut mining. The low permeability Dunda Beds and Rewan Formation together form a 250 m thick aquitard underlying the Clematis Sandstone and intervening between it and the SGCP coal seams.

Analysis of model results indicates that there will be no change to the GAB groundwater recharge volumes to the Clematis Sandstone, and minor drawdown effects on the Clematis Sandstone due to SGCP mining (i.e. drawdown effects in the order of 5 m). As there is predicted to be no interception of any GAB recharge, no significant drawdown and thus no variation in natural stream leakage or induced flow, licences are not required from those water sources.

9.7.8. Induced Flow

Groundwater discharge to stream features is virtually zero, but leakage from stream systems is about 2 ML/day, and both of these components of the water balance do not change with time during the mining and post-mining simulations (i.e. there is no additional induced flow from surface water streams as the depth to water table is typically 10 m or more).

9.7.9. Groundwater Quality

The inflow water to the final pit void will be a mixture of the water qualities of the waters in source lithologies and the waste rock. Given higher rainfall infiltration rates through mine waste rock, there is potential for chemicals in the waste rock to be leached out and conveyed to the voids. Geochemical investigations undertaken found that the bulk of the overburden and interburden materials are expected to be NAF. Some materials sampled close to seam levels were found to be PAF.

As the PAF materials present a potential risk, EGi (2011) has recommended selective handling, blending and disposal by deep burial or encapsulation (**Appendix I—Geochemistry Technical Report)**. The recommended mine waste segregation and handling practices will be sufficient to maintain adequate control over ARD risk on-site, so that there would be negligible impacts to groundwater quality (either directly or via final pit voids) as a result of PAF material.

Until mining is completed, water from the open-cut pits could flow down gradient along the coal seams to the underground workings, due to a strong hydraulic gradient in that direction. In the long-term, the groundwater levels above the underground workings will recover and the hydraulic gradient in the seams will flow towards the final pit void from all directions. Over time, the salinity in the final pit void will increase through evaporative concentration. However, as long as the void remains a groundwater sink, there will be no deleterious effect on environmental values of any groundwater sources.

9.7.10. Post Mining

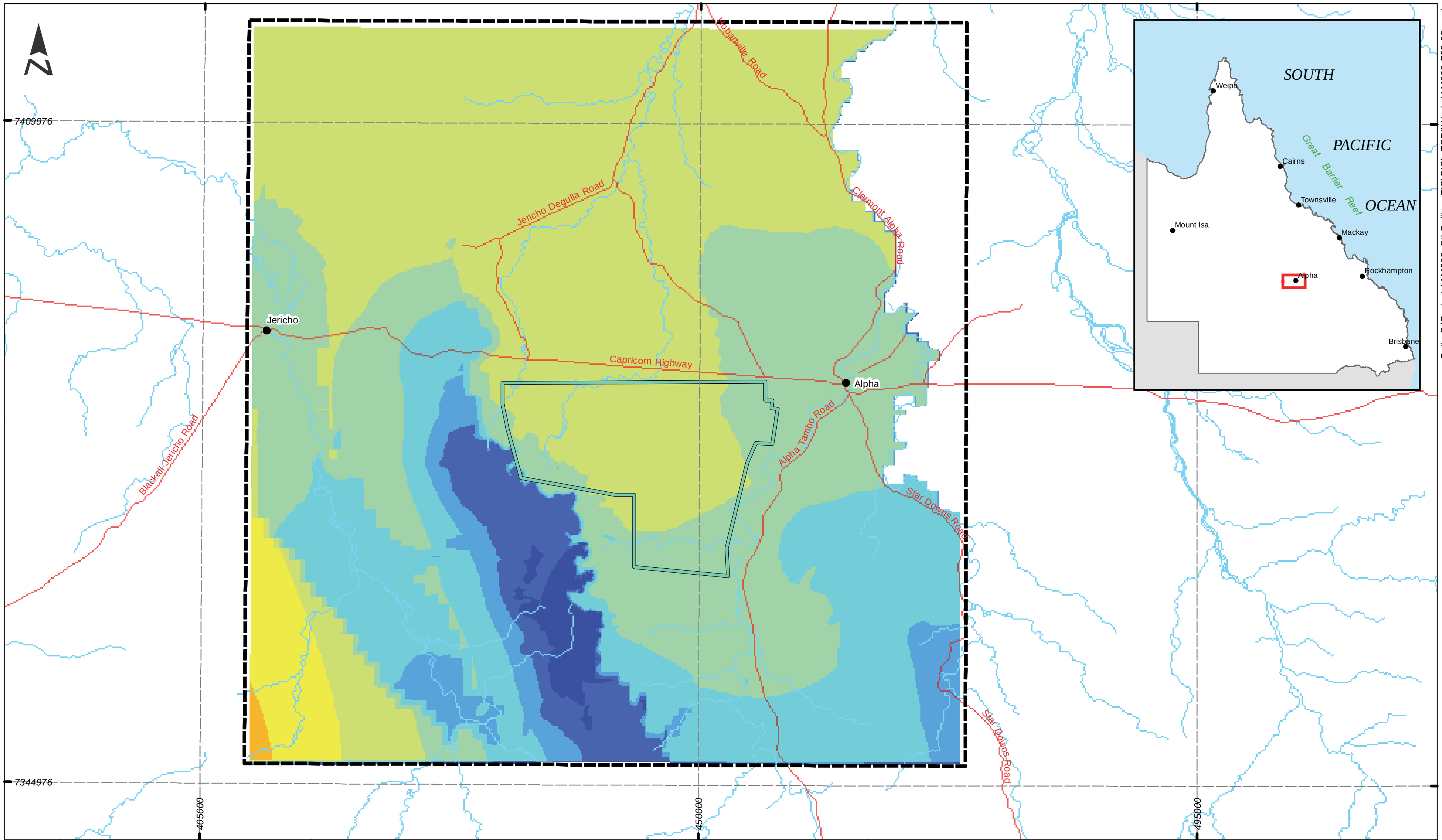
Dewatering of mine workings will cease at the conclusion of mining operations, and groundwater levels previously drawn down will begin to recover. The groundwater system will begin to re-adjust to the new aquifer conditions surrounding the mined area. Water levels/heads within the regional aquifers will eventually attain a new equilibrium level (i.e. steady state condition - refer to **Appendix G—Groundwater** and **Figure 9–28**).

In the local mine area, the new equilibrium groundwater system will have a different potentiometric surface from that which was present pre-mining owing to:

- the presence of a final pit void in the west of the open-pit area
- backfilled open pit material having different hydraulic properties than the coherent rock units that existed pre-mining
- the presence of fractures above the longwall panels.

The groundwater model predicts a permanent lowering of the water table in the area, largely due to the long term groundwater sink formed by evaporation from the open pit void exceeding the rates of groundwater inflow to it.

A post mining simulation of aquifer recovery was performed and shows that long term groundwater levels recover to around 10-20 m below the pre-mining levels, with about 80 % of that recovery occurring within about 30 years of cessation of mining, and water levels effectively re-equilibrated (to within a few metres of the long term level) within 50 years post-mining.



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METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

10 0 10

Kilometres

Scale: 1: 550,000

LEGEND

- MLA 70453
- Model Extent
- Major Roads
- Rivers/Creeks
- Population Area

Watertable Elevation (mAHD)

- < 225
- 225 - 250
- 250 - 275
- 275 - 300
- 300 - 325
- 325 - 350
- 350 - 375
- 375 - 400
- 400 - 425
- > 425

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South Galilee Coal Project

SGCP Water Table 100 Years after Cessation of Mining

5/10/2012

Proj :

Datum: GDA 1994

FIGURE 9-28

Groundwater levels in neighbouring bores immediately adjacent to the SGCP will not recover completely, but will rise up to between 10 to 20 m below pre-mining levels. However, the groundwater levels will rise substantially and this should support the ability of the bores to provide water for domestic or agricultural uses.

Appendix G—Groundwater shows the recovery of the water table and potentiometric surface.

9.7.11. Final Void

The SGCP will consist of an open pit and underground mine which will result in the disturbance of the overlying strata and the localised dewatering of aquifers as mining progresses. The depth of the open pit and thus the residual final pit void will extend to the base of the deepest seam mined below surface level.

The rising groundwater post-mining levels will provide inflows to residual open pit mine voids, resulting in a lake and subsequent evaporation from the open water surface. Depending on the balance between inflows and evaporation, residual mine void lakes can become long term hydrological sinks (or discharge features, as expected in this case), or can develop as throughflow or recharge lakes.

Mining activities and post-mining effects also have the potential to change the chemistry of groundwater via evaporation from any final pit void lake, and via subsequent groundwater mixing. Following cessation of mining at the SGCP and surrounding mines, dewatering will cease and groundwater will continue to seep into the final pit void.

As the final pit void fills with groundwater seepage, and some direct rainfall and surface runoff, water levels will begin to recover. The final pit void is located at the western end of the open-cut excavation and will be protected from major flood inundation by an engineered levee wall.

A groundwater model simulation was performed where the final pit void was assigned a hydraulic conductivity value of 1,000 m/d, a specific yield of 1.0, and an assumed maximum evaporation rate of 0.5 m/year. The simulation results suggest that the final pit void water level should stabilise at levels lower than the pre-mining water table, forming a permanent groundwater sink (receiving groundwater flow from all directions, including through the mined longwall area).

Although the salinity of water in the final pit void lake is expected to increase with time post mining due to evaporation, this reduction in water quality is not expected to impact the surrounding aquifers because the final pit void lake remains as a long term groundwater sink (no outflow).

Consequently, there will be no post-mining deleterious effect on the productive uses of existing groundwater sources, which all occur remote from the mine area and draw water from the shallow water table system (not the D1-D2 seams).

9.7.12. Cumulative Impacts

Cumulative groundwater-related impacts will occur from the SGCP in addition to the ACP, KCCP and GCP, which are other coal projects located in the Galilee Basin. The cumulative groundwater-related impacts of these projects have been assessed through groundwater model simulations in combination with the SGCP.

The effect of mine dewatering at the ACP (and the cumulative impacts of the more distant KCCP) was represented in a worst-case conservative approach in the SGCP model by head-dependent flow boundaries at the southern extent of the ACP. The level specified at the boundary is consistent with the base of mining in this area, which is the level to which dewatering would be required at ACP (whatever the influences of other mining in the region).

As outlined above, this accounts for cumulative impacts due to any potential influence of mine dewatering drawdown from the more remote KCCP, as the ACP operation would adjust the pumping required to achieve the target drawdown levels subject to the actual influence (if any) due to the KCCP. Separate simulations have been completed with and without the ACP represented in this way, to allow for unpacking of the separate influences. The model also simulated the effects of the GCP on the SGCP.

Drawdowns due to the ACP, KCCP and GCP (i.e. without the SGCP in operation) are predicted to extend southwards towards SGCP, and join with the cone of drawdown from the SGCP. These cumulative impacts on groundwater resources have been assessed with the SGCP model as documented in **Appendix G—Groundwater**.

9.8. SURFACE WATER MANAGEMENT AND MITIGATION MEASURES

The proposed surface water management and mitigation strategies are detailed as per the proposed MWMS.

The overarching operational water management strategy for the SGCP seeks to:

- minimise the amount of surface runoff impacted by mining operations by diverting clean water flows around the mining operations
- minimise the amount of raw water to be imported to site by maximising the recycling of stored water resources within the SGCP
- minimise or prevent the need for mine water to be discharged from site
- minimise impacts to water quality and quantity on existing downstream water users
- provide adequate protection of internal water management infrastructure and external surface water values during flood events.

9.8.1. Supply and Storage

9.8.1.1. Construction Water Supply

Water will be required during the construction phase of the SGCP for the following demands:

- dust suppression on cleared construction areas and access roads
- moisture conditioning for compaction of engineered fill
- construction accommodation village potable water requirements.

Water for the construction phase of the SGCP is proposed to be sourced from boreholes as part of the advanced dewatering of the mine and/or supplied from existing storages. It is currently assumed that groundwater from the advanced dewatering operations will not be of a suitable quality for potable use and will be stored in one of the proposed mine water dams to be constructed early in the construction schedule. Raw water suitable for potable demands will be stored in the proposed Raw Water Dam which will similarly be constructed early in the construction schedule.

9.8.1.2. Operation Water Supply

Operational water demands will be preferentially sourced from water collected within the MWMS. This will include runoff from all mine operational areas and all active waste rock emplacement areas as well as all open-cut and underground mine dewatering operations. Preliminary water balance modelling has indicated that the MWMS will be unable to meet all of the operational water demands particularly during sustained periods of low rainfall.

During this shortfall make-up raw water will augment the supply to ensure mine operations are maintained. Raw water make-up will also satisfy potable, sanitation and wash down demands for which the quality of mine water will be unsuitable.

At the current level of planning it is expected that the supply of raw water make-up will come from a bulk water pipeline operator. Full details of the site water balance can be found in **Appendix A** of **Appendix F—Surface Water**. The external pipeline water supply will be relied upon to meet potable demands (after treatment) and as a secondary source for make-up water when there is insufficient mine water on the site.

The allocation sought is 3,000 ML per annum will be on a ‘take or pay’ basis. Process water demand varies inversely with the ash in the product coal, which will depend on international market conditions. Hence, the water demand throughout the SGCP life will vary and the water allocation provides flexibility in terms of the site water balance.

The pipeline will terminate in the proposed 406 ML Raw Water Dam that will serve to store sufficient water reserves in the event of supply interruptions and will also function as the supply point to facilitate the transfer of raw water to the various on-site demands including fire fighting, mine infrastructure area workshops, washdown, CHPP process make-up and potable water. No arrangements for taking of surface water flows from local watercourses will be required.

The bulk water supply will be treated on-site to potable quality using a package water treatment plant utilising a suitable technology such as reverse osmosis. Treated water will be reticulated to all the mine industrial and CHPP areas, and accommodation village via the proposed dedicated service corridors. Potable water will be stored in header tanks at the water treatment plant, accommodation village and all other industrial areas. Water will also be stored at the CHPP and all other areas where sufficient water reserve is required for fire fighting.

Potable water demand has been based on an average annual demand of 84 ML/a. A water treatment plant will be constructed near the Raw Water Dam to supply potable water. Potable water will be stored in two water tanks, one to supply the accommodation village and one to supply the mine site. Short-term increases to both the operational and construction workforces above the system capacity can be accommodated through the provision of additional supplementary units as required.

All sewage water generated during the SGCP will be collected and treated on-site to Class C effluent standard. Sewage wastewater from across the SGCP area will either be piped or trucked to the wastewater treatment plant depending on its source.

Where piping is not practicable, holding tanks will store the sewage water prior to transportation. The solids by-product from the wastewater treatment plant will be periodically removed by a contractor and transported to a licensed disposal facility and the effluent will be reused for industrial usage where practicable.

The exact number and design details of referable dams (including levees) will not be finalised until the detailed design stage and during operations of the SGCP.

9.8.2. Mine Water Management System

The proposed MWMS comprises runoff containment systems for all disturbed (open-cut pits, waste rock emplacements) and all mine-affected areas (mine industrial areas, ROM, CHPP, coal processing waste, product stockpiles), mine water dams with a range of functions (runoff capture, water transfers and storage) and a network of pipes, pumps and drains to transfer water around the system.

In accordance with current best practice management strategies the MWMS will satisfy the following key objectives:

- minimise the generation and containment of mine-affected water by the passive diversion around the MWMS of all clean water entering the SGCP site as well as the on-site segregation of runoff according to its predicted quality

- provide sufficient system capacity to capture and contain all mine-affected water during significant rainfall events and to reduce the risk of a release into the receiving environment to an acceptable level
- allow for the preferential reuse of mine-affected water in mine operations (CHPP, underground mining operations, dust suppression, industrial uses) which will:
    - avoid the need for the controlled release of contaminated water (under modelled historical conditions) by continually drawing down on the site water inventory
    - maximise the systems storage capacity for future large inflows to the system
    - reduce the reliance on external water sources
    - allow for the dewatering of both the open-cut and underground mines to sustain mining operations including direct pumping of runoff and groundwater from the open-cut pits and groundwater from the underground mines.

Current best practice mine water management is to segregate water within the MWMS based on its predicted quality in order to optimise the storage and reuse of mine water and to minimise capture and storage of uncontaminated clean water.

The MWMS will be limited to disturbed and mine affected areas (disturbed catchments, contaminated water sources and contaminating processes). Clean waters (runoff and stream flow) from undisturbed areas on the site and upstream catchments will be diverted to passively flow to downstream waterways.

It is envisaged that during the course of the mine life, progressive rehabilitation of available (i.e. no longer required) disturbed areas will be undertaken and once established and demonstrated to produce acceptable quality runoff, these areas will be diverted away from the MWMS through clean water bypass drains.

The following MWMS classifications have been nominated for the site:

- clean water management system – diversion around the MWMS of uncontaminated runoff entering the SGCP from undisturbed up stream catchments as well as the interception and diversion into the existing natural watercourses of runoff generated from undisturbed areas within the SGCP site

- saline/waste rock water system – management of water originating from all potentially contaminating sources such as open-cut and underground mine dewater as well as runoff from various mine process areas such as industrial areas, product coal stockpiles, ROM pads and all active waste rock emplacement areas. Runoff from these areas is likely to contain elevated levels of salinity and/or suspended sediments, potentially low pH and possible elevated levels of metals and sulfate concentrations primarily due to contact with coal
- Raw Water System – Water supplied from an external source, which is expected to have low salinity levels, will be managed separately to all other waters and stored in the Raw Water Dam.

The key elements of the water management system include:

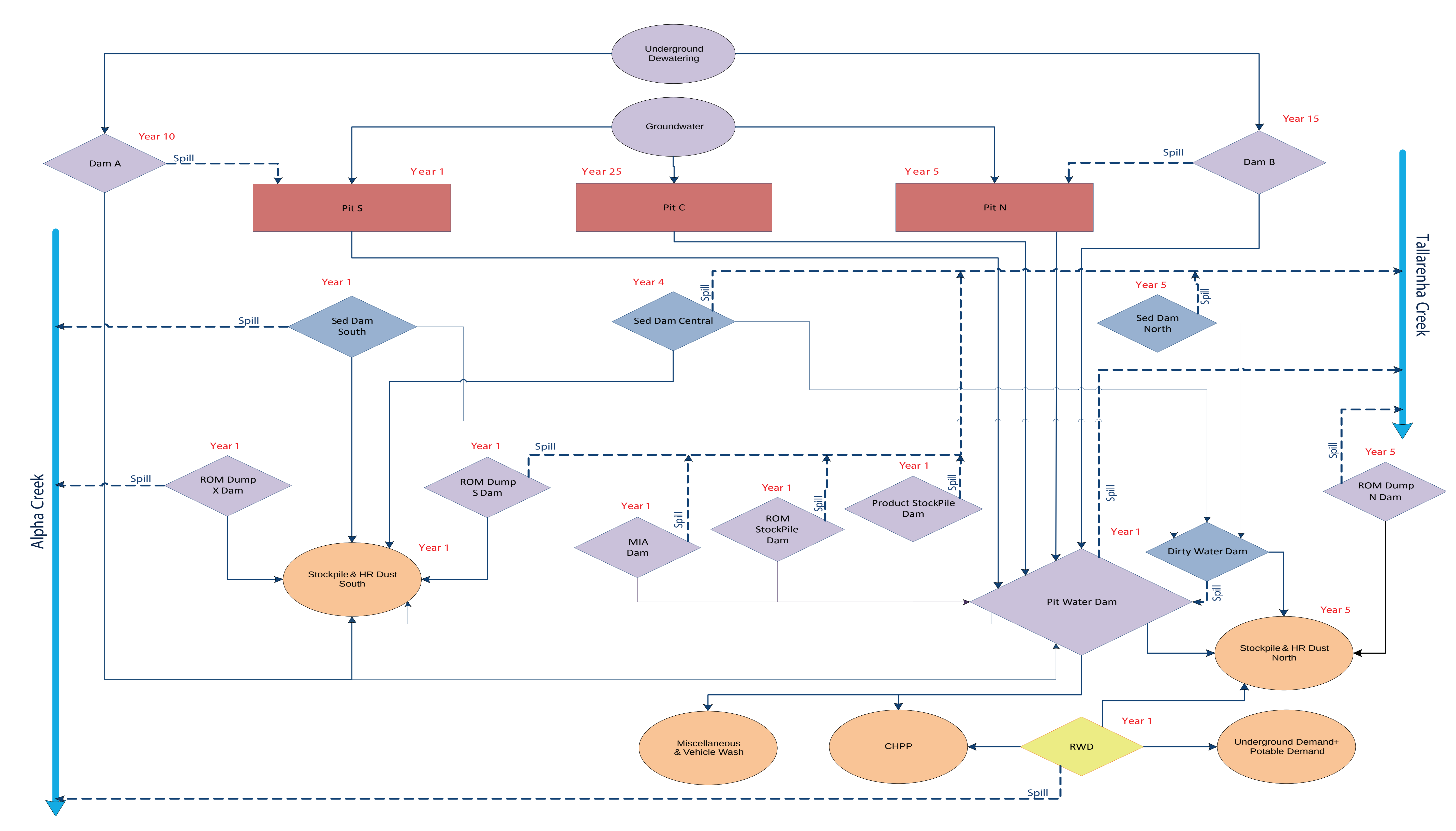
- Raw Water Dam
- waste rock dams (sediment dams)
- saline water dams (e.g. pit water, ROM).

The conceptual layouts of the proposed mine water management system are presented in **Appendix F—Surface Water** and in **Figure 9-29** to demonstrate that the required mine water management infrastructure can be accommodated in the mine layout plan.

Geotechnical and hydrogeological investigations for the mine water dam sites are to be undertaken as part of detailed design to confirm the suitability of the dam locations and to develop the dam designs and mitigation (safety) measures to the standards required for Regulated Dams (if any).

For the purposes of the impact assessment, the operational catchment areas have been classified into different types based on their hydrological and geochemical characteristics. The areas are summarised in **Figure 9-17**.

The area intercepted by the proposed SGCP MWMS increases from 1,238 ha to 4,373 ha over the SGCP life.



Data Source : WRM

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Schematic Diagram of Proposed Water Management System

03/10/2012

FIGURE 9-29

Table 9-17 Changes in Catchment Areas and Types Intercepted by SGCP MWMS

Stage	Land Use Classification							Total Area (ha)
	Natural (grassed)	Stockpile	Hard-stand	Active Pit	In Pit Waste	Out Pit Waste	Established Rehab	
Year 1	881	43	34	87	0	263	0	1,238
Year 4	685	43	34	153	273	508	0	1,696
Year 5	1,502	43	65	222	355	768	0	2,956
Year 10	1,690	43	65	312	620	561	365	3,657
Year 15	1,584	43	65	289	714	386	683	3,764
Year 20	1,409	43	65	312	808	144	1,068	3,851
Year 25	1,507	43	65	411	758	165	1,420	4,370
Year 30	1,219	43	65	351	880	113	1,700	4,373
Year 33	1,145	43	65	328	1,048	111	1,268	3,910

9.8.3. Clean Water Management

One underlying premise for the MWMS is that clean water runoff from undisturbed catchments will be diverted around the active mining area, thereby minimising the volume of water impacted by mining activities. Clean water diversion drains will be constructed around operational mining areas.

Runoff generated from undisturbed catchments within the SGCP site as well as clean water entering the SGCP area from undisturbed catchments upstream will be diverted around the MWMS. The clean water system will comprise the following elements:

- provision of a diversion channel and system of levees to divert flows from Sapling Creek into Dead Horse Creek around the open-cut and critical mine infrastructure. The diversion channel will be designed to conform with the natural creek system with flood protection levees designed to the 1:3,000 AEP flood event (plus freeboard)
- clean water catch drains will, wherever practicable, direct runoff from undisturbed catchments around the MWMS. This will include a system of upslope clean water catch drains to minimise the catchments reporting to the proposed mine water and raw water dams
- diversion around the MWMS of runoff originating from approved rehabilitated areas. As rehabilitation of the waste rock emplacements progresses and runoff from these areas reaches an acceptable quality for release they will be removed from the MWMS
- levees west of the open-cut pits to reduce peak runoff inflows and velocities from undisturbed or approved rehabilitated catchments
- raw water dam to store imported raw water

- a system of pumps and pipelines to transfer raw water to various on-site demands including:
    - the CHPP for coal washing
    - mine industrial area use (workshop, wash down)
    - haul road dust suppression
    - water treatment plant (for potable applications)
    - ROM dump/pad dust suppression.

9.8.3.1. Saline/Waste Rock Water Management

Runoff that cannot be diverted around the disturbed areas and becomes affected by mining activities is classified into two categories and managed accordingly:

- saline water - from the open-pit, ROM pads and industrial areas
- waste rock water - from the waste rock emplacements.

Saline and waste rock water both have the potential to decrease the water quality in surrounding waterways when design criteria are exceeded. The MWMS proposes management measures for mine affected water (including acidic, saline or sodic waste water). The MWMS proposes surface water infrastructure to minimise or prevent any potential impacts. Staged conceptual layouts of the proposed MWMS infrastructure is provided in **Section 4—Project Description** and in **Appendix F—Surface Water**.

Water originating from a variety of potentially contaminating sources including dewater from the open-cut and underground mines, runoff from all active waste rock emplacements and runoff from various mine process areas will be carefully managed to minimise the volumes of water requiring capture and storage. The main contaminants expected to be present include increased suspended solids and salt loads.

Water from these areas will be preferentially utilised for a variety of uses including process water in the CHPP and for dust suppression. This will optimise the sites contaminated water inventory and the demand for raw water.

The saline/waste rock water system will comprise the following elements:

- open-cut pit sumps to collect local runoff from the pit floor, ramps, high, low and end walls
- open-cut pit dewatering pumps and pipelines to transfer water from the central pit sump to mine water dams
- underground mine water collection system
- underground mine pumps and pipelines to transfer water from each collection system to mine water dams
- appropriate runoff interception and conveyance systems to capture runoff originating from the potentially contaminating mine process areas (ROM, industrial areas, CHPP, product stockpile)

- a pump and pipeline system to transfer water from each process area dam to the nearest mine water dam
- appropriate runoff interception and conveyance systems to capture runoff originating from the active areas of the waste rock emplacements
- a pump and pipeline system to transfer water from each waste rock dam to the nearest mine water dam
- a return water pump and pipeline system from each mine water dam to deliver stored water to either a fill station for dust suppression or for use as process water.

Groundwater inflows into the proposed pits are expected to be significant. Groundwater inflows of this magnitude will be collected in small in-pit sumps where it will either evaporate or be used for in-pit dust suppression. Additional pit water would be generated by the collection of surface water runoff from areas draining to the open-cut pit area, and groundwater inflow to the pits. Pit water can have elevated levels of salinity and may also contain elevated levels of suspended sediment and dissolved metals.

Contaminant concentrations in pit water at the SGCP are likely to be in excess of levels required for protection of downstream receiving water values, and will be contained in a system with a low risk of discharge. Groundwater seepage and catchment runoff water collecting in the pit will be temporarily stored in small in-pit sumps and reused for dust suppression. Water in excess of dust suppression requirements will be transferred for longer-term storage and reuse at the CHPP as required.

Waste rock runoff is expected to have elevated suspended solids but only moderate levels of salinity and other pollutants. Waste rock runoff will be captured and temporarily stored in sediment dams. Sediment dams are required over the SGCP life to intercept runoff from waste rock emplacements around the SGCP.

The sediment dams will be sized to contain runoff from the 10 year ARI 24 hour rainfall event. The storage will allow coarse sediment to settle and reduce the turbidity of runoff. This design storage will be sufficient to limit the frequency of uncontrolled off-site discharge during periods of relatively high and prolonged rainfall (when there is a reasonable prospect of natural flow in the receiving waters).

However, the risk of off-site discharge will be further limited by adopting an active waste rock runoff management system, whereby water levels in the sediment dams are constantly maintained below a set level by pumping to central waste rock runoff water storages. The sediment dams then comprise an active storage, above the pump set level, and a passive storage, below which water is simply allowed to pond unless required to meet a shortfall in demand. A description of the saline and waste rock dams are provided below.

9.8.3.1.1. Saline Water Dams

This system manages runoff from catchments which contain potentially mine affected waters. Water captured in this system is expected to have high salinity, and will potentially have elevated concentrations of dissolved metals. Water in this system will be pumped to the Pit Water Dam with a goal of containing all water on site for later reuse.

Dams forming part of this system are:

- Pit Water Dam
- ROM Dump X Dam
- ROM Dump S Dam
- MIA Dam
- ROM Stockpile Dam
- Product Stockpile Dam
- ROM Dump N Dam
- Dam A
- Dam B.

9.8.3.1.2. Waste Rock Dams (Sediment Dams)

Sediment dams serve to remove sediment from disturbed area runoff, including runoff from waste rock emplacements. This water is expected to have high turbidity, a risk of moderately elevated salinity, and a lower risk of elevated metal concentrations.

Dams forming part of this system are:

- Sediment Dam South
- Sediment Dam Central
- Sediment Dam North
- Dirty Water Dam.

The proposed design criteria of the sediment dams are to:

- retain the flow from a 10 year ARI event, 24 hour storm to allow sufficient time for 0.05 mm diameter (coarse silt) particles to settle
- maximise the length of the dam relative to the width of the dam to maximise hydraulic retention time and deposition.

Discharges from the sediment dams to natural waterways may occur in an emergency or when a rainfall event exceeds the 10 year ARI event, 24 hour design criteria. Under normal circumstances, the only losses from the sediment dams will be via seepage and evaporation. Water in the sediment dams may be transferred between the dams to be:

- directly used for dust suppression
- used as process water in the CHPP.

9.8.3.2. Raw Water Management

The Raw Water Dam will store raw water for use in the operations. The Raw Water Dam will accept and store water from the raw water pipeline and will be used to supplement the water supply of the operation as required.

9.8.3.3. Process Water System (CHPP)

The CHPP will be operated as a dry tailings system until the end of Year 3 and as a wet tailings system from Year 4 onwards. As coal waste will be processed to be buried in waste rock emplacements, the CHPP has been designed to constantly recirculate water, with additional make up water added to the system as required, which eliminates the need for a process water dam.

9.8.3.4. Dam Safety

All dams proposed as part of the SGCP will be designed, constructed and approved to minimise the potential for dam failure in coordination with the DNRM. All dams proposed for the SGCP will be subject to additional DNRM approval requirements (separate to this EIS) and detailed dam design and assessment will be undertaken. All buildings and operational areas will be protected from release waters in the event of a dam failure, minimising risk to human health and well-being, and potential loss of production.

9.8.3.5. Surface Water Release Procedure

In Queensland, discharges to the freshwater environment are regulated by the DEHP. When new mining infrastructure is proposed, a licensing agreement is formed as part of the planning process to permit offsite water discharges if they are required. Coal mining operations may result in high levels of TDS and salinity within water storages. The potential impacts of non-compliant water discharges to the receiving environment may adversely impact upon aquatic ecosystems, subsequently affecting the environmental values within the area. As described in **Section 9.8.2**, the SGCP MWMS is designed to minimise potential for water releases from the SGCP (as a 'no-release' project) in order to protect the environmental values of the downstream receiving waters.

For the purposes of this EIS assessment, water balance modelling indicates that it will be unlikely for the SGCP to undertake controlled releases from the water management system to balance the mine water inventory during very high rainfall events. However, If this is required, water releases will be undertaken in accordance with an approved procedure and in compliance with Environmental Authority conditions.

If the SGCP is required to release water during these high rainfall events, these discharges will be compliant with the Environmental Authority release limits and conditions that will be set and approved by the DEHP as part of the EIS process. This will be achieved through a controlled release strategy that allows discharge into waterways only when specific flow and water quality criteria have been satisfied. In alignment with the Environmental Authority, release limits applicable to be SGCP will be specified, which are maximum values that cannot be exceeded.

If required, water from disturbed mine catchments would be suitable for discharge after water management is undertaken in accordance with a water management plan prepared for the SGCP, which will be required by the Environmental Authority and is currently standard practice for coal mines in Queensland.

Release limits will be guided by the results of local monitoring programs that will further characterise the surface water environmental values of the area. The release conditions will be customised to suit the local catchment of the SGCP area. Monitoring programs and other water quality studies will be commissioned prior to operations to further characterise the receiving environment.

The discharge of mine-affected water to the environment is proposed to be allowable on the following criteria:

- end-of-pipe water quality, which is defined as the water quality that enters the environment. A range of water quality indicators will be used to ensure the water quality is suitable for release
- downstream water quality, which is defined as the water quality in the receiving environment at a downstream location. During a flood event, the downstream water quality provides an opportunity to utilise dilution in the receiving waterway, while ensuring that its water quality is consistent with ranges experienced in the background environment.

Trigger investigation levels will also apply, which are values that if exceeded, initiate further investigation and reporting processes. This investigation would include comparing upstream and downstream water quality data and assessing the risk of causing potential environmental harm. These release limits and trigger investigation levels will apply at the release points identified in **Table 9-22** in **Section 9.8.14**.

The release locations will be configured to enable the mine to respond to water release opportunities as soon as possible. This will most likely involve using telemetry controlled systems that will minimise potential difficulties such as accessing release dams during wet weather or missing the flow peak in the receiving waterway.

There will be little risk of water discharges occurring from the SGCP to Tallerenha Creek, except in an emergency or when a rainfall event exceeds the 1 in 3000 year ARI event. Under such circumstances, controlled discharges may be made, resulting in negligible changes in the water quality of Tallerenha Creek and Alpha Creek, as there would be significant flood flows present in the catchment.

It is anticipated that if discharges were required from the SGCP, that the offsite environmental impact would be negligible as the amount of water released would be minimal compared to the receiving water systems that would be in flood. Daily during discharge, the upstream and downstream water quality and flow monitoring points will be monitored for receiving water quality within the prescribed pH and electrical conductivity limits (and other criteria if required)via monitoring programs as described in **Section 9.8.14**.

9.8.4. Referable Dams

Relevant aspects of the *Water Supply Safety and Reliability Act 2008* include the regulations for licensing and safety management of Referable Dams in Queensland. It should be noted that the provisions of this *Act* for Referable Dams apply to dams that do not contain hazardous waste (i.e. raw water dams). All of the dams containing potentially saline water will be Regulated Dams and administered under the *EP Act*.

Only the Raw Water Dam which will contain bulk raw water from a third party supplier will potentially be classified as referrable under the *Water Act*. During more detailed design the referrable category of the proposed Raw Water Dam will be determined through the undertaking of dam failure impact assessment (DFIA) as required under the *Water Supply (Safety and Reliability) Act 2008*.

At the current concept stage of the SGCP design the Raw Water Dam is predicted to be 406 ML which would not classify it as a referrable dam.

9.8.5. Site Water Balance Model

A water balance of the SGCP's proposed water management system, based on historical climate records, has been undertaken using OPSIM software. OPSIM is extensively used in a wide range of environmental modelling applications including mine site water management.

The water balance model has been developed and refined to a level suitable for the concept design of water management infrastructure and is able to assess the performance of the SGCP's proposed water management system under a range of likely climatic extremes. The model is able to estimate potential runoff volumes, likely site water demands and identify possible water deficits or surpluses as well possible overflows from the SGCP's water storages.

The model has been configured to simulate the operations of all major components of the water management system including:

- climatic variability – rainfall and evaporation
- catchment runoff and collection
- pit dewatering
- pump and gravity transfers
- water storage filling, spilling and leaking
- industrial water extraction, usage and return.

Runoff parameters for the model have been based on calibration of natural catchment runoff characteristics to available stream gauging data.

Runoff parameters for the MWMS catchment land use types (waste rock emplacements, hardstand and rehabilitated) have been adjusted to represent the expected differences in runoff rates.

In addition to representation of the proposed MWMS, the model also includes representation of the upstream natural catchments (including the clean water bypass system) to enable an assessment of the downstream hydrological impacts resulting for the removal of a small portion (the MWMS) from the natural catchment system.

9.8.5.1. Model Catchment Data

Catchment boundaries for the MWMS have been delineated using the conceptual mine plans for the following stages:

- Stage Y1 applies for 2013–2015 3 years
- Stage Y4 applies for 2016–2016 1 years
- Stage Y5 applies for 2017–2021 5 years
- Stage Y10 applies for 2022–2026 5 years
- Stage Y15 applies for 2027–2031 5 years
- Stage Y20 applies for 2032–2036 5 years
- Stage Y25 applies for 2037–2041 5 years
- Stage Y30 applies for 2042–2024 5 years
- Stage Y33 applies for 2045–2047 2 years.

Note that catchment areas classified as rehabilitated will be allowed to bypass the MWMS and do not contribute runoff into the MWMS. The MWMS layout will evolve over the 33 year design life (refer to **Section 4—Project Description**).

9.8.5.2. Model Storage Capacities

The capacities of the various MWMS components used in the water balance are shown in **Table 9-18**.

Table 9-18 SGCP Model Storage Capacities

Storage	Capacity To Spillway (ML)
Raw Water Dam	406
Dirty Water Dam	100
Sediment Dam South	582
Sediment Dam Central	394
Sediment Dam North	1,148
Pit Water Dam	24,220
Product Stockpile Dam	347
ROM Stockpile Dam	245
MIA Dam	160
ROM Dump South Dam	370
ROM Dump North Dam	577
ROM Dump X Dam	42
Dam A	201
Dam B	201

9.8.5.3. *Mine Water Management System Operating Rules*

Basic operating rules suitable for concept level design have been incorporated into the water balance model. It is expected that they will be subject to ongoing development and modification as more detailed information regarding aspects such as water make from the underground mine and groundwater seepage into the open-cut pits are verified and further refinement of the MWMS proceeds.

Supply to the CHPP, dust suppression and vehicle wash demands is based on the following priorities:

- Saline Water System
- Waste Rock Runoff System
- Raw Water System.

The potable water and underground demand are supplied solely from the Raw Water system. Details of the adopted operating rules in the model are outlined in **Appendix F—Surface Water**.

9.8.5.4. *Model Water Sources*

Various water inputs to the MWMS comprise:

- surface runoff
- groundwater from the open-cut/underground mine dewatering operations
- imported raw water from the pipeline water supply.

9.8.5.5. *Estimated Mine Water Demands*

Estimated water demands over the SGCP are summarised in **Table 9-19**. Average annual demand peaks around Year 10 at 5,172 ML/a.

Table 9-19 SGCP Water Demand Summary

	Average Annual Demand (ML/a)				
Demand	**Year 1**	**Year 4**	**Year 10**	**Year 20**	**Year 33**
CHPP	656	2,103	3,298	3,037	1,846
Haul Road Dust Suppression	336	456	889	917	1,051
Stockpile Dust Suppression	300	300	300	300	300
Potable Demand	62	84	84	84	84
Underground (Potable)	0	470	470	470	470
Misc. + Vehicle Wash	131	131	131	131	131
Total	**1,485**	**3,544**	**5,172**	**4,939**	**3,882**

9.8.5.6. Water Balance Model Results

Over the life of the SGCP, the average outflows and inflows of water are outlined below:

Outflows

- total water demand ranges between approximately 3,010 ML/a and 7,325 ML/a
- evaporation ranges between approximately 878 ML/a and 3,502 ML/a.

Inflows

- runoff yield contributes between approximately 1,250 ML/a and 2,210 ML/a
- groundwater inflows (to underground and open-cut pits) contribute between approximately 0 ML/a and 5,932 ML/a
- in the SGCP stages that the external water supply is operating, raw water requirements vary from approximately 656 ML/a to 1,258 ML/a.

Water balance modelling indicates that the mine will generally operate with a water deficit and will have to import water to make-up the balance.

Groundwater inflows from underground mine dewatering provides an important source of water for mine consumptive demands. However, it should be noted that the estimated raw water demands are heavily influenced by the groundwater inflow volume.

Should groundwater inflow estimates reduce, the demand for imported raw water will correspondingly increase. Alternatively water demand may be reduced by alternative processing requirements or alternative mining methods.

The volume stored in the storage will be constantly re-evaluated. In the event that water inventories become so high that the risk of future pit inundation is unacceptable, additional storage compartments may be constructed.

9.8.6. Water Quality

The conceptual MWMS has been devised to manage the potential impacts of the SGCP on surface water quality. Runoff and groundwater inflows entering the pits, is to be collected and used preferentially to meet the SGCP's water demands, so that the risk of off-site discharge is very low.

Runoff from waste rock emplacements is to be captured in sediment dams to remove suspended solids and also reused to supply site demands.

The proposed management measures will minimise impact on off-site runoff water quality, and as a result, no measurable adverse impact on riparian and ecological values of watercourses in the vicinity of the proposed SGCP due to changes in surface water quality are anticipated. For further information refer to **Appendix F—Surface Water Section 4.4.4**.

9.8.6.1. Construction

Potential impacts on water quality throughout the construction phase are summarised in **Table 9-20** and corresponding mitigation measures are provided. Residual impacts are expected to be minimal with the implementation of these management strategies. These mitigations are relevant for both the mine and infrastructure corridor areas.

Table 9-20 SGCP Water Quality Impacts and Mitigation Measures – Construction Phase

Construction Impacts	Mitigation Measures
Sediment from construction entering surface water runoff during rainfall events, discharged to watercourses reducing water quality	• Areas of disturbed or exposed soil will be minimised and managed to reduce sediment mobilisation and erosion • An erosion and sediment control plan will be prepared and executed • Disturbance by heavy earth moving equipment will be minimised especially in riparian areas • The number of passes over water crossings will be minimised • Topsoil will be stripped and stockpiled away from drainage lines • Bunds will be constructed to restrict flow velocities across the site • Vegetation clearing will not be carried out during heavy rainfall • Dust suppression measures will be adopted such as water sprays or stockpile covers • Vehicle washdowns will be located away from drainage lines or watercourses • Construction activities that will affect existing drainage lines and control measures will only be carried out after suitable stormwater management infrastructure has been installed on-site • Sedimentation dams will be constructed to capture dirty water runoff and used preferentially for dust suppression • Any site dewatering activities will be treated and/or appropriately managed • Diversion of watercourse will be either by low flow diversion or coffer dam with pumping • Groundcovers will be established to rehabilitate areas disturbed by road crossings and slope protection material will be used on road batters • Mitre drains will be used to divert runoff from road shoulders and table drains into sedimentation dams.
Potentially contaminated aqueous waste streams from temporary refuelling facilities, chemical storage facilities and vehicle washdown areas could enter into drainage lines	• Temporary and permanent chemical and fuel storage areas will be appropriately bunded in accordance with AS 1940 • All transfers of fuels and chemicals will be controlled to prevent spillage outside bunded areas • Bunds and sumps will be frequently drained and treated/disposed of appropriately • Contaminants and major spillage swill be collected by a licensed waste collection and transport contractor for disposal at an off-site licensed facility • Spill cleanup kits, in accordance with AS1940 and AS3780, will be located in appropriate locations, including inside machinery and vehicles • Refuelling will occur within bunded areas in accordance with AS1940 • In the event of a spill occurring, it will be controlled, contained and cleaned up to prevent the mobilisation of pollutants in drainage lines or watercourses • Site selection of storage and refuelling areas will minimise stormwater inundation and reduce the potential for clean runoff to mix with contaminated water • Wastewater from washdown areas will be directed through oil and grease separators and effluent directed to construction ponds for reuse.

Table 9-20 SGCP Water Quality Impacts and Mitigation Measures – Construction Phase (cont)

Construction Impacts	Mitigation Measures
Erosion and damage to sediment control infrastructure from significant rainfall events during construction.	• Construction works will be scheduled to minimise exposure to flooding during the wet season (October to April) • Stormwater management measures such as drainage diversion and flood defence bunds will be implemented before construction commences • Emergency response procedures and flood warning system • Infrastructure will be designed with floor levels above an appropriate AEP flood level • Monitoring equipment with telemetry system will be maintained on creeks, dams, discharge points • Flexible water management system will cater for a variety of conditions and operational needs - including sufficient storage capacity on-site • Dams and water management infrastructure (pumps and pipelines) will be monitored and maintained • Separation of clean and dirty water systems will be implemented • Standard operating procedures for water management will be implemented.

9.8.6.1. Operations

Potential impacts on water quality during the operation of the SGCP and infrastructure area are summarised in **Table 9-21** together with proposed mitigation measures. The residual impact on surface water quality is expected to be minimal with the implementation of these management strategies.

Table 9-21 SGCP Water Quality Impacts and Mitigation Measures – Operations Phase

Operations Impacts	Mitigation Measures
Failure of water storages, storage embankments, pipelines, levees or bunds has the potential to result in non-compliant discharge and environmental impacts for downstream receiving waters, ecosystems and landholders	• Design of water storages will utilise a Water Balance Model which considers all inputs and outputs which has run through a long-term period of climatic data to test storage capacities particularly in high rainfall wet seasons • Water storages will be designed in accordance with applicable guidelines • Monitoring equipment will be installed to monitor storage volume during operation combined with a water management system to prevent overfilling • Design and construction supervision of dam embankments will be undertaken by a Registered Professional Engineer of Queensland (RPEQ) • Regular dam inspections will be undertaken by RPEQ • Regular inspections will be undertaken during operation of water storages, tailings dam levels, integrity of embankment and spillways • Regular pipeline, drain, bund and levee inspections and maintenance will be undertaken during operation.
Erosion and sediment mobilisation from mining and processing operations can cause deleterious effects on downstream water quality and aquatic habitats.	• All PAF material will be selectively handled where practicable to ensure that the potential for ARD is limited. Once all PAF material has been placed, a cover of NAF material will be applied over the entire waste rock emplacement area to ensure that the PAF waste is not exposed • Potential impacts will be mitigated using appropriate design for erosion and scour protection and a comprehensive mine water management plan • Swales and buffer strips are proposed to provide stormwater filtration prior to discharge to receiving waters. Swales are open vegetated (generally grass) drains, whilst buffers or filter strips are grassed surfaces aligned perpendicular to the direction of flow, which ware used to filter particulate matter and associated pollutants from stormwater prior to its entry into adjacent receiving waters. Both swales and buffers provide water treatment through physical filtration of water through the vegetation and depending on the retention time some additional pollutants may be taken up by the vegetation • Progressive rehabilitation of waste rock emplacements will be undertaken to reduce erosion and sedimentation potential • An on-going monitoring program will be implemented to monitor the impacts of mine operations on the receiving watercourses. Site specific trigger values for assessing water quality data against are proposed to be developed based on the baseline monitoring program.

9.8.7. Stream Diversions

The objective for the hydraulic design of the new 4.4 km long Sapling Creek diversion is to establish a hydraulic behaviour that is similar to that of the existing creek system, so that the diverted channel is stable and supportive of revegetation, and to protect the upstream and downstream reaches from any detrimental changes in creek hydraulics.

The selected diversion alignment was determined by the constraints provided by the local topography, the existing channel geometry from the creek, the location of the proposed underground mine longwall panels, and the location of the flood protection levees (refer to **Figure 9-30**).

9.8.7.1. Design and Geometry

Previous studies of creek and river diversions in the Bowen Basin in Queensland (ACARP, 2002) have shown that the more frequent flood events (e.g. the 1:2 to 1:10 AEP events) generally have the greatest geomorphologic influence on re-shaping channel cross-sections and alignments. These more frequently occurring events concentrate the stream flow within the channel banks, and have the potential to produce velocities high enough to induce erosion within the channel. The less frequent flood events, such as the 1:100 AEP, tend to utilise the floodplain for floodwater attenuation, resulting in lower cross-sectional velocities and less potential for erosion (ACARP, 2002).

The new channel design has been developed to mimic the general geometry of the existing creek low flow channels while also maintaining acceptable hydraulic performance in terms of creek stability (minimal erosion or deposition risk). The channel shape will be generally consistent with the existing creek channels comprising a trapezoidal shape (flat bed), bank slopes at 1(V) in 3(H). Based on the channel dimensions in the adjacent reaches of Sapling Creek, the low flow channel will be approximately 4 m wide at the base and 1 m deep (top width 10 m). The proposed channel cross-section is compared to part of the existing Sapling Creek channel geometry in **Appendix F—Surface Water**.

9.8.7.2. Alignment

Alignment options for the Sapling Creek diversion are limited due to the underlying coal resource, mining activities, and the relatively steep topography in the immediate vicinity of the pit. The proposed diversion channel alignment of Sapling Creek was selected to reduce the potential for subsidence to cause irregular lowering of the channel increasing sediment deposition and reducing channel capacity. The Sapling Creek diversion alignment is shown in **Figure 9-30**.

9.8.7.3. Flow Velocity and Stream Stress

The low flow channel has been designed to meander within the constraints of the proposed diversion alignment. To maintain appropriate meandering, further investigation and optimisation of the proposed diversion channel meandering characteristics will be required including more detailed geomorphologic assessment and geotechnical investigations to assess the expected subsurface materials to confirm suitable (sustainable) channel meander characteristics.

These assessments will be undertaken as part of detailed design and in consultation with DNRM prior to the submission of the detailed design.

9.8.7.4. Stream Power

The assessment of stream power is considered to be a key parameter in evaluating the interaction of flow hydraulics and stream morphology. Stream power is the potential work that the flowing water performs to modify and reshape the stream. In general, the stream power should be evaluated holistically by comparing the stream power over the entire river reach. Typical river channels show a sinusoidal stream power where it is greater in some areas and less in others.

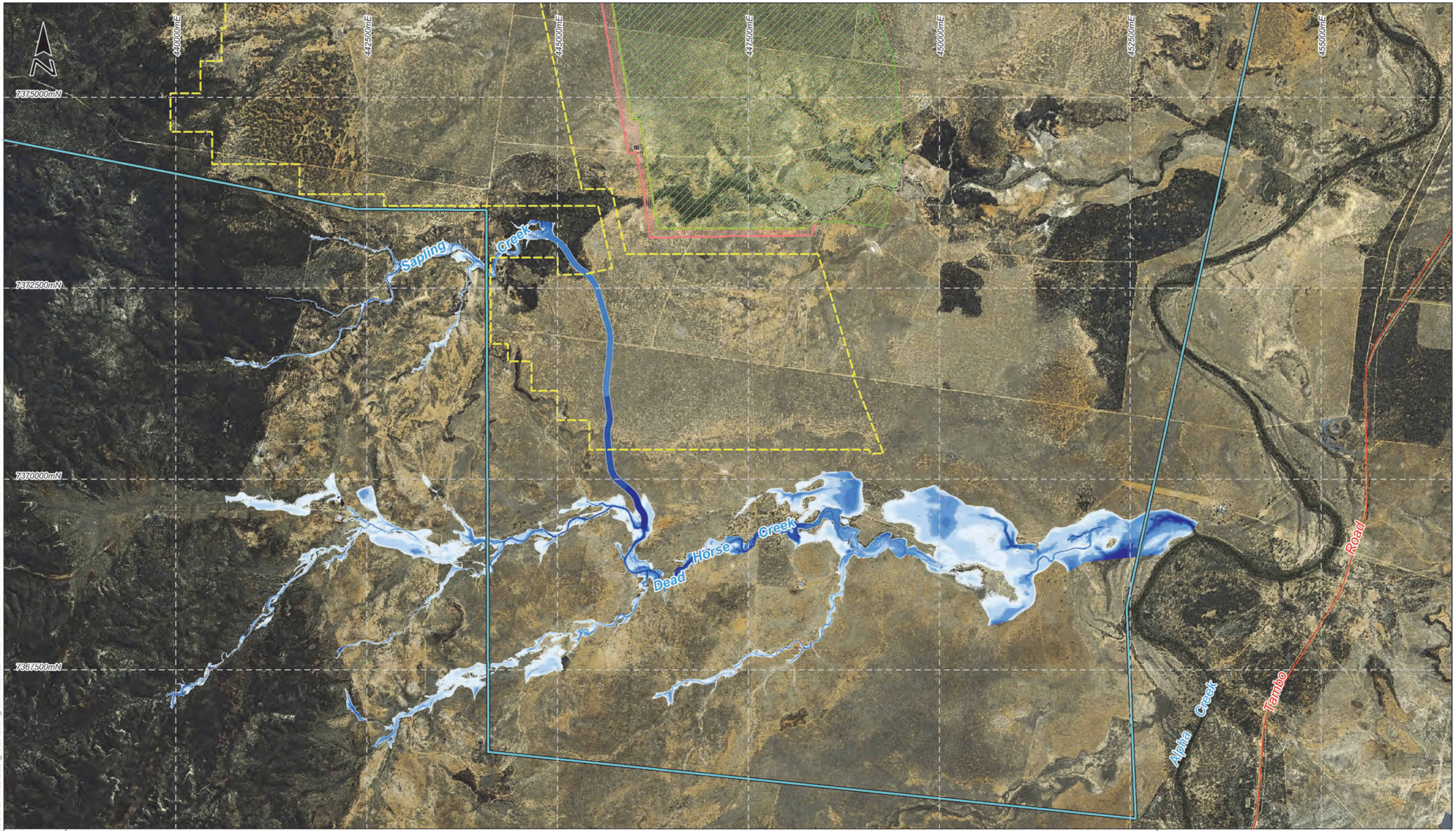
The estimation of stream power is most valuable for flows in the channel at the bank-full level. This recognises that bank-full flows can occur for extended periods in major flood events, occur more frequently than large floods, and that bank-full flows are relatively confined (whereas larger floods tend to spread out onto adjoining floodplain areas which dissipates energy and power).

Overall, the hydraulic conditions during bank-full flows have the greatest potential for stream erosion and reshaping of the channel alignment. Although stream power is a valuable and more direct indicator of hydraulic conditions relative to morphological stability (and more useful than velocity and shear stress), there are no firm scientific criteria to guide hydraulic design for stream diversions with respect to how much change in stream power is sustainable. The general approach for current best practice for creek diversions is to design the diversion to avoid excessive increases in stream power and to monitor performance of the diversion during its operation.

Large increases in stream power can result in an excessive imbalance of stream power causing the creek to reform itself (by meandering and changing the channel cross-section geometry) to reach an equilibrium regime. Large increases in stream power are typically the result of:

- increasing channel slope, resulting from a shortening of the channel between two points (e.g. cutting off a meander to straighten a channel)
- reducing the width and depth of the floodplain and the potential for flood attenuation in larger floods, thereby increasing flow depth and velocity (e.g. confining the floodwater to a smaller cross-section) and potentially increasing the duration of flow
- decreasing the channel resistance (friction) by reducing or eliminating vegetation or other flow obstructions.

Diversion channels reach equilibrium in stream power by increasing overall stream length by forming meanders, and by increasing the channel width and decreasing the channel slope by eroding and head cutting. To minimise the change in stream power, diversion channels need to have a similar cross-section (channel and floodplain), hydraulic roughness (bed conditions and vegetation) and channel slope as the existing creek system. **Appendix D** of **Appendix F—Surface Water** shows the modelling results of the post-developed Sapling Creek and Dead Horse Creek channels. The figures show each of the key hydraulic parameters listed in the Central Queensland Watercourse Diversion Guidelines for comparison with the guideline values and existing conditions.



S:\PROJECTS\AM001_STHGALILEE_EIS\GIS_MAPINFO\WSPACES\SECT_09\20120310_RENUMBERED\FIGS\FIG 9-30 SAPLING CR DIVERSION-HORIZONTAL ALIGNMENT.WOR

METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

LEGEND

- MLA70453
- Principal road
- Spoil Y33
- Underground Mine Foot
- Active Pit-Year 33

Q100 FLOOD DEPTH (m)

- 0.0 - 0.5m
- 0.5 - 1.0m
- 1.0 - 1.5m
- 1.5 - 2.0m
- 2.0 - 3.0m
- 3.0 - 4.0m
- >4m

Data Source: WRM Appendix E, Figure 2.8

Alpha Coal Pty Ltd

South Galilee Coal Project

Sapling Creek Diversion-Horizontal Alignment

1 0 1

Kilometres

Scale: 1:50,000 (A3)

03/10/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 9-30

9.8.7.5. Mitigation of Erosion

All natural creeks constantly erode and deposit sediment relative to the magnitude, frequency and variability of flows. It is the interaction of flow hydraulics and bed/bank erosion/deposition which alters channel geometry and flow hydraulics. These factors vary over time and location in the catchment.

The spatial context of a creek reach, relative to the broader catchment and associated landforms is also important for the creek's regime of erosion and/or sedimentation in a local reach. These factors relate to the supply of sediment from upstream, the flow parameters (velocity, shear stress and stream power), and the geometric influences (particularly gradient) for sediment transport within a stream reach.

Erosion is typical in the headwaters of catchments where gradients are steep, and the sediment supply from small upstream catchment area is limited. Deposition (accretion) is typical in lower reaches of catchments where there is substantial sediment supply from upstream and where gradients are flat allowing sediment to deposit and floodplain landforms to develop.

The middle reaches of catchments are typically in a 'net' balance (equilibrium) of erosion and sedimentation. However, these reaches can be dynamic over short-term periods in response to variability in flow hydrology, sediment supply and hydraulics. The dynamics of these reaches means that erosion can occur for some flows (typically floods) and deposition can occur for other flows (receding flows after prolonged rainfall).

The balance can also vary between erosion and deposition in individual flood events with erosion during the rising waters of a flood and deposition during the falling waters of a flood. Over the 'long-term' the cumulative hydrologic effect of frequent small flows and infrequent large flows results in a net balance of erosion and sedimentation.

It is not usually possible to evaluate and quantify the dynamics of short-term erosion and deposition cycles/variability (without extensive long-term data on stream geometry, sediment loads and flows over several decades). Hence, the stream power of stream hydraulics for the 'bank-full' flood flow is a valuable indicator of the 'net average' effect of variability in hydrology on the overall morphological stability of a river system.

The general implication for the stability of the proposed diversion is that some erosion and deposition within the diversion channel will occur and should be expected since the existing creeks exhibit this behaviour. A key issue in assessing the morphological stability of the diversion is the likely effect of erosion to adversely alter the diversion alignment and geometry by means of assessing the likely change to stream power for bank-full flows.

The recommended mitigation strategy to reduce the potential for excessive sedimentation and erosion is to monitor deposition and erosion at fixed control locations with periodic (e.g. bi-annual) photographic surveys:

- diversion channel
- confluences with Sapling Creek
- existing creek channels downstream of the diversion channel.

Evidence of impacts on the morphology of the creeks will trigger further investigations of the cause and identification of remedial strategies and/or works. Erosion mitigation strategies are discussed further in **Section 7.3.4.2** and **Table 7-12**.

9.8.7.6. Rehabilitation of Channel

The diversion channel when first excavated would be susceptible to erosion due to the exposed soil and the absence of vegetation or armouring to protect against erosion. Previous experience with diversion channel design and construction, and recommendations from the ACARP guidelines, show that constructing the diversion channel in stages and having a rehabilitation plan can increase the success of vegetation establishment and reduced the chance of excessive channel erosion.

Based on the current mine plan, the diversion channel would be constructed early in the mine development. Stabilisation measures, such as rock riprap or similar works, would be constructed as part of the diversion channel to protect the channel from erosion following construction and commissioning, allowing for vegetation to progressively establish along the diversion channel.

Quickly establishing deep healthy root systems for both artificial and naturally established native plants will be critical to the ecological success of the diversion. Site preparation requirements, as a prerequisite for vegetation establishment, will be different for each substrate condition.

The proposed stream diversion mitigation strategies are designed so that any dispersive soils encountered in the diversion channel excavation will not be left exposed. Surface exposures of dispersive soils will be either treated to minimise dispersion potential, or covered with topsoil so that the dispersive substrates are not left exposed. These measures are aimed at minimising adverse impacts of direct rainwater on diversion surfaces.

Sections of the diversion channel which are cut into softer alluvial material would require a different set of parameters for vegetation establishment. In particular, instability of topsoil placed on the channel banks can result in young plants being scoured out. Even though soft when wet, the banks can also be compacted during construction thus restricting initial root establishment. Rapid and deep root development must be encouraged.

To overcome this problem, adequate soil depth could be created by adding rock cover and infilling with weed free, non-dispersive soil. In addition, in sections of the alluvial channel where there are dispersive soils (if found), geotextile could be placed on the bank before capping with fractured rock. In these sections, the depth of the rock/soil mix could be increased to allow for restricted root growth through the underlying geotextile.

Weeds are another potential impediment to vegetation establishment. Weeds can quickly out-compete slower establishing native species. Diligent weed control, particularly in the stripping, stockpiling and re-spreading of topsoil will be a high priority. Basic machinery hygiene will be maintained. Grazing animals may also damage newly revegetated areas and will be excluded by fencing if necessary.

The design of the diversion channel will consider protection strategies. Protection strategies such as rock armouring should be considered for the bed and banks so that the changes in flow direction do not create scour potential.

9.8.8. Mine Flood Protection

9.8.8.1. Design Construction and Maintenance of Levees

Levees are proposed to prevent flow down the Tallarenha Creek tributaries into the mining area, and a north-south channel collects flow and diverts it north around the pit back to Tallarenha Creek. During operations, the levees will be designed to protect the pit from flooding in the 3000 year (y) ARI flood event. Before mine closure, the levees will be upgraded to protect the pit from flooding up to the Probable Maximum Flood. The channel will be sized in accordance with the hydraulic performance criteria specified in the document, *Central West Water Management and Use Regional Guideline: Watercourse Diversions* (DERM 2008).

The proposed extents of the flood protection levees are shown in **Figure 9-31**. Consideration has been given to the range of options that could be implemented to recover flooded mine pits in an environmentally responsible manner. For example a flooded mine pit could be recovered with minimal environmental impact if the flood water is appropriately treated to acceptable water quality standards prior to discharge to the waterways, or could be recovered by constructing regulated dams to allow dewatering of the mine pits.

The nominal 3000 y ARI level of flood protection will be further reviewed as part of detailed design and subject to a detailed risk assessment including various consequences that may arise from different methods to recover the mine pit(s) in the event of an extreme flood. Discussions will be held with DEHP during the detailed design phase to agree on an appropriate risk based level of flood protection.

A geotechnical investigation will be required at the detailed design phase to characterise the subsurface conditions of the levees to estimate the extent of excavation required to construct a suitable cut-off from piping (i.e. formation of an erosion hole from one side of the levee to the other) of the levee foundation. The levee foundation would likely require excavation to rock or an impervious cut-off wall would need to be constructed. The investigation will also identify sources of material that are suitable for construction of the levee embankments. The levee would be designed to impound water for long durations during flooding and would also need to resist erosion from flooding and direct rainfall.

LEGEND

- MLA70453
- Sedimentation Dam
- Dirt Dam
- Active Pit, Year 33
- Spoil, Year 33
- Underground Mine Footprint
- High Wall Channel and Levees
- Low-wall Channel Levees
- Haul Road
- Road
- Proposed Road
- Railway Loop

Q100 FLOOD DEPTH (m)

- 0.0 - 0.5m
- 0.5 - 1.0m
- 1.0 - 1.5m
- 1.5 - 2.0m
- 2.0 - 3.0m
- 3.0 - 4.0m
- >4m

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SouthGalilee

Data Source: WRM, AMCI, Imagery (+/- 50m) - GoogleEarth. Topography (250k) - Geoscience Australia

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South Galilee Coal Project

Proposed Flood Protection Works

03/10/2012

1 0 1
Kilometres

Scale: 1:50,000 (A3)

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 9-31

S:\PROJECTS\AM001_STHGALILEE_EIS\GIS_MAPINFO\WSPACES\SECT_09\20120310_RENUMBEREDFIGS\FIG 9-31 PROPOSED FLOOD PROTECTION WORKS.WOR

Borrow pit locations have been identified next to each levee location. The levee embankment would be designed for the following:

- slope stability
- erosion from flooding in the creeks and from direct rainfall
- piping failure in the foundation
- piping failure through the levee embankment
- ease of maintenance, including sufficiently wide crest for light and heavy vehicle access, if desired, and flat batter slopes for vegetation maintenance.

The flood protection levee banks will be regulated structures with conditions administered through the EA. This will require design to be undertaken by a suitably qualified and experienced engineer and certification of the design and construction of the levee bank.

The EA conditions will also require certified annual surveillance inspections by a suitably qualified and experienced engineer and an obligation for the EA holder to rectify deficiencies identified in the annual surveillance outcomes.

The recommended mitigation strategy to minimise the potential for increased erosion/sedimentation is to monitor erosion and deposition at fixed control locations with periodic (e.g. bi-annual) photographic surveys. Evidence of impacts on the morphology of the creeks will trigger further investigations of the cause and identification of remedial strategies and/or works.

9.8.8.2. Mitigation of Excess Sediment and Erosion

An Erosion and Sediment Control Plan will be developed and implemented throughout construction and operations to control erosion at the source.

Progressive rehabilitation of the waste rock emplacements will minimise the potential generation of erosion. This is detailed more in **Section 5—Rehabilitation and Decommissioning**.

9.8.9. Flood Plain Management

Mine-induced subsidence will result in the formation of pools in the Tallarenha Creek main channel. Subsidence of the floodplain areas and tributaries will also result in flood flows pooling in the subsided areas.

A monitoring plan will also be established over the underground subsidence area surrounding Tallarenha Creek. The purpose of the plan will be to identify subsidence-induced changes to the creek profile and floodplain drainage patterns that could prevent flow draining downstream. If these impacts are identified through aerial and ground survey of the area, channels will be constructed to direct flows downstream.

9.8.10. Subsidence Mitigation

9.8.10.1. Existing Water Users

Changes in the profile of Tallarenha Creek that may potentially affect the movement of sediment through downstream QMAN areas is intended to be mitigated by engineering works designed to maintain free-draining stream channels post subsidence (refer to **Appendix D** of **Appendix F—Surface Water**).

The establishment of a monitoring plan over the subsidence impacted areas of Tallarenha Creek will allow the identification of any changes to drainage that could have downstream impacts, and their mitigation through further channel engineering works (refer to **Appendix D** of **Appendix F—Surface Water**).

9.8.10.2. Ponding

In order to mitigate the effects of ponded water from self-contained catchments, the progressive reestablishment of free drainage in the subsidence area will be completed, as far as practicable. This will include the construction of excavated trapezoidal drainage channels.

These will be designed with sufficient capacity to cater for contributing catchments and with stable batter slopes. These channels will enable drainage of subsidence troughs along pre-existing drainage lines. Excavated material from the channels will be used for filling in any nearby ponding areas.

9.8.10.3. Cracking

Subsidence-induced cracking will enhance infiltration in the affected catchment areas. However, it is expected that these areas will be self-sealing within 1 wet-season of subsidence occurring. As a result, if the free drainage is maintained, it is unlikely that additional infiltration losses will significantly impact on downstream streamflow.

A post subsidence drain and waterway monitoring program will be implemented and surface cracks within drains and waterways that have not naturally filled after approximately three storm events will be sealed with clay.

9.8.10.4. Natural Channels

As part of the subsidence monitoring program, the ponding volumes and/or surface area extent of ponding will be monitored over time.

In the event that natural channel erosion and sedimentation does not reduce the volume of channel bed depressions (and consequent ponded water volumes), remedial works to reinstate an evenly graded bed profile (i.e. free draining channel) can be considered as a contingency measure. This would involve excavating the 'high' points in the subsided channel bed profile, typically between the blocks where subsidence is less than the subsidence that occurs within the blocks. If required, the works would be completed to match the existing channel characteristics including geometry, substrate and vegetation. Excavated bank areas would need temporary erosion matting to protect the works until vegetation is established.

If this contingency measure is required within on-site water courses, it will be necessary to seek approvals to obtain a Riverine Protection Permit under the *Water Act 2000*.

It should be noted that this contingency measure with excavation to drain pooled areas would be extensive and necessitate significant disturbance to the drainage system and vegetation. It would therefore be adopted as a last resort option that will only be considered if triggered by the subsidence monitoring program and demonstrated that unsustainable deleterious effects on environmental values and downstream water resources availability would occur if the works were not undertaken.

9.8.10.5. Diversion Channels

A conceptual design of the diversion has been prepared for impact assessment purposes (refer to **Appendix D** of **Appendix F—Surface Water**). The design was prepared to the hydraulic design criteria set out in the *Central West Water Management and Use Regional Guideline: Watercourse Diversions* (DERM 2008) were not exceeded.

The design will be the subject of further detailed studies to be conducted as part of the Definitive Feasibility Study (DFS) and as part of the diversion licensing process under the *Water Act 2000*.

Potential alignment options for the proposed Sapling Creek diversion are limited due to the locations of the underlying coal resource, associated mining activities, and the relatively steep topography in the immediate vicinity of the pit. The selected preliminary alignment is shown in **Figure 9-30**. The adopted alignment is the shortest possible, but because the outlet is located relatively high in Dead Horse Creek, the resultant slope is significantly less than the diverted reach of Sapling Creek. The slope of the diversion is approximately 0.1 % while the adjacent reach is at 0.39 %.

The diversion will be constructed as a compound trapezoidal channel, with a narrow, shallow channel conveying low flows. Channel meanders will be provided if required to mimic conditions in the existing channel. Based on the channel dimensions in the adjacent reaches of Sapling Creek, the low flow channel will be approximately 4 m wide at the base and 1 m deep (top width 10 m).

In the absence of detailed geotechnical studies, the preliminary channel sideslope design is 1V:3H. In practice, the upper sections of the cut slope may need to be benched to achieve appropriate stability. Erosion of the channel will be managed through revegetation with native grasses and locally occurring trees and shrubs.

9.8.10.6. Levees

Protection of the mine from flooding up to the design flood event is critical to the operation of the mine for the duration of the mine life. As such, the levee embankment alignments would be aligned on top of the un-subsided areas to the west of the proposed open-cut pits.

These reaches of levee embankments would be assessed for cracking on a periodic basis and reconstructed where cracking had the potential to create a piping risk and jeopardise the integrity of the flood protection levees. However, this is not expected to be an issue as the levees would not be undermined.

9.8.11. Ecological Impact Mitigation

If mine induced groundwater drawdown that affects ecological systems is identified, mitigation through the Proponents 'make-good' commitment will be made, which could include artificial recharge of affected areas with water from alternative water sources, such as surface water.

9.8.12. Final Void Surface Water Interaction Mitigation

The total catchment area that will report to the final void will be 1,421 ha. The catchments flowing to the void will include:

- the pit floor itself (328 ha)
- the natural catchment upslope (west) of the highwall and east of the diversion (11 ha)
- the in-pit overburden (1,082 ha - which will have been shaped to its final profile, topsoiled and revegetated).

The final void will not fill due to the above catchment area. The final void will be protected from flood events by the proposed diversion channels, which will become part of the final landform.

9.8.13. Long-term Change Mitigation

As mentioned in **Section 9.6.9**, the impacts of climate change (if any) on surface water the SGCP are difficult to assess. During the mine life, it is not expected that climate change impacts would significantly affect operations in terms of surface water management.

Monitoring of the MWMS performance will identify any potential needs to respond to climate change impacts.

9.8.14. Monitoring Programs

The proposed surface water monitoring for the SGCP will include surface water quality monitoring and monitoring of stream diversion performance. The proposed monitoring programs are outlined in this Section.

9.8.14.1. Surface Water Quality

Two programs are proposed for surface water quality monitoring. A baseline monitoring program and an on-going water quality monitoring program are proposed to assess the impact of the SGCP mine and infrastructure corridor operations on the receiving environment. Both programs would be undertaken in accordance with the DEHP *Monitoring and Sampling Manual 2009*, which provides guidance on techniques, methods and standards for sample collection, sample handling, quality assurance and control, and data management.

9.8.14.1.1. Baseline

The baseline monitoring program has already commenced as part of this EIS and is proposed to continue until the mine is operational. As limited site specific background water quality data is available, the monitoring program will be used to establish a data set for developing site specific water quality trigger values.

Data collected from reference sites are used to estimate percentile values, which in turn are used to derive guidelines. For SMD waters the 20th and 80th percentiles are used. Reference monitoring sites are considered to be a suitable benchmark for comparison and are subject to minimal disturbance (QWQG, 2009).

9.8.14.1.2. Operations

The on-going monitoring program will be implemented to measure the impact of mine operations by monitoring watercourses upstream and downstream of the mine site and will be required to measure compliance with the EA conditions. The data will also allow performance reviews of various management plans and mitigation measures implemented to protect the values of the watercourses in the SGCP area.

The locations for the on-going program are chosen to demonstrate that the quality of water entering the site is the same as water leaving the mine site. The baseline monitoring sites are proposed to be continued in the on-going program for event based sampling. This will allow direct comparison of the water quality prior to and during operations at identical sites. It is noted that some monitoring sites may become inaccessible or inundated as the mine is developed, hence replacement sites with similar characteristics should be established where practicable.

Monitoring points will be provided at locations where contaminants could potentially be released from the MWMS at concentrations that could cause environmental harm in the receiving waters. Monitoring points will also measure receiving water quality upstream and downstream of the release points.

Table 9-22 lists the contaminant release points from the mine water management system and the associated receiving waters (**Table 9-23** and **Figure 9-32**).

Table 9-22 Contaminant Release Points

Release Point	Contaminant Source and Location	Monitoring Point	Receiving Waters
SGCP RP1 (Discharge Point 1)	Dirty Water Dam	Low Level Pipe Outlet	Tallarenha Creek
SGCP RP2 (Discharge Point 2)	Pit Water Dam	Low Level Pipe Outlet	Tallarenha Creek
SGCP RP3 (Discharge Point 3)	Sediment Dam North	Low Level Pipe Outlet	Tallarenha Creek
SGCP RP4 (Discharge Point 4)	Sediment Dam Central	Low Level Pipe Outlet	Tallarenha Creek
SGCP RP5 (Discharge Point 5)	Sediment Dam South	Low Level Pipe Outlet	Sapling Creek/ Alpha Creek

LEGEND

- MLA70453
- Access Roads
- Tracks
- Rivers
- Town/Community
- Sedimentation Dam
- Dirty Water Dam
- Sapling River Diversion
- Proposed Monitoring Points
- Active Pit, Year 33
- Spoil, Year 33
- Underground Mine Footprint
- Proposed Internal Road
- Haul Road
- Coal Handling Facilities

METSERVE Mining & Energy Technical Services Pty Ltd

SouthGalilee

Data Source: WRM, AMCI, GoogleEarth, MS Bing Maps. Geoscience Australia - Topography

Alpha Coal Pty Ltd

South Galilee Coal Project

Proposed Receiving Water Monitoring Points

0 5

Kilometres

Scale: 1:100,000 (A3)

04/10/2012

Proj. : MGA Z55
Datum: GDA 1994

FIGURE 9-32

S:\PROJECTS\AM001_STHGALILEE_EIS\GIS_MAPINFO\WSPACES\SECT_09\20120310_RENUMBERED\FIGS\FIG 9-32 PROPOSED RECEIVING WATER MONITORING POINTS.WOR

Table 9-23 Proposed Receiving Water Monitoring Points

Monitoring Point	Description	Water Level (Flow)	Water Quality Sampling Frequency	Full suite as per note below
SGCP TCU	Tallarenha Creek (Upstream Monitoring Point)	•	Continuous and during flow event	Daily During Release
SGCP TCD	Tallarenha Creek (Downstream Monitoring Point)	•	Continuous	Daily During Release
SGCP SCU	Sapling Creek (Upstream Monitoring Point)		During event flow	Daily During Release
SGCP SCD	Sapling Creek (Downstream Monitoring Point)		During event flow	Daily During Release
SGCP DCU	Dead Horse Creek (Upstream Monitoring Point)		During event flow	Daily During Release
SGCP DCD	Dead Horse Creek (Downstream Monitoring Point)	•		Daily During Release
SGCP ACU	Alpha Creek (Upstream Monitoring Point)	•	Continuous	Daily During Release
SGCP ACD	Alpha Creek (Downstream Monitoring Point)	•	Continuous	Daily During Release
SGCP HC	Highwall Channel (Downstream Monitoring Point)			Daily During Release
SGCP LC	Lowwall Channel (Downstream Monitoring Point)	•		Daily During Release

Gauge boards will be provided at all dams to allow storage water levels and volumes to be monitored and enable inflows and outflows to be estimated. Automatic monitoring equipment may be installed at key storages.

The event-based sampling will enable quantification of discharge water quality from the site and any potential corresponding impact on receiving waters. On-site monthly sampling from the water storages allows for any potential problem areas with respect to potential pollutant generation to be identified in advance, facilitating appropriate remedial action.

In addition to the above water quality and streamflow monitoring points, a monitoring system will be established in the Sapling Creek Diversion and in Dead Horse Creek downstream of the Sapling Creek Diversion outlet. The purpose of the monitoring points will be to establish baseline creek conditions and monitoring ongoing performance during both operations and following mine closure. The monitoring program will be designed considering the recommendations in the ACARP program 'Monitoring and Evaluation Program for Bowen Basin Diversions' (ID&A 2000).

The monitoring program will include regular assessments of the geomorphic condition following flow events, and will include collection of site photographs, aerial photographs, land aerial survey data. The monitoring of the stream diversion would extend from pre-construction to licence relinquishment and comprises four components as shown in **Table 9-24**.

The goal of the monitoring program is for the diversion to be considered as a reach or stream operating in dynamic equilibrium in order to achieve diversion licence relinquishment. Application for diversion licence relinquishment will occur at mine closure and depend on outcomes of the monitoring program.

Table 9-24 Diversion Monitoring Requirements

Monitoring components	Objective
Baseline monitoring	To establish a baseline data set that can be used for comparison when applying for licence renewal and relinquishment. This occurs one year before construction and is to establish data that be used for comparison to assess the performance of the diversion.
Construction monitoring	To demonstrate works have been undertaken to specification.
Operations monitoring	To monitor and evaluate the diversion's performance to ensure it is operating in dynamic equilibrium. Occurs for 10 years after construction.
Relinquishment monitoring	To attain licence relinquishment by demonstrating the diversion is operating in dynamic equilibrium and not adversely impacting on adjoining reaches. Occurs for 10 years after operations preceding application for relinquishment.

Following comparison of monitoring data post construction with the baseline data, an evaluation of the stability of the diversion channel (i.e. dynamic equilibrium) and sustainability of the diversion will be undertaken. The evaluation of the channel would include the performance of the diversion for small and large flood events.

If the diversion does not appear to have reached a dynamic equilibrium, mitigation measures will be identified and implemented towards a goal of achieving sustainable long-term stability.

9.8.14.1.3. Decommissioning

After mining has ceased and decommissioning and rehabilitation works are complete, the Proponent will seek to relinquish the SGCP leases. Prior to relinquishment, the Proponent will discuss the nature, scope and resourcing of an ongoing surface water monitoring program with the administering authority and any parties with ongoing interests in the surface water resources and infrastructure associated with the site if required. This program may be a continuation of that outlined for operational mining, or an agreed variation, depending on the circumstances at the time.

9.8.14.2. Subsidence

A monitoring program will also be established over the underground subsidence area surrounding Tallarenha Creek. The purpose of the program will be to identify subsidence-induced changes to the creek profile and floodplain drainage patterns that could prevent flow draining downstream.

If these impacts are identified through aerial and ground survey of the area, channels will be constructed to direct flows downstream.

A subsidence monitoring program and corrective actions will be initiated to:

- document changes to the drainage systems as the underground mining progresses
- document any changes to catchment and creeks due to subsidence
- document effectiveness of any mitigation measures
- provide triggers in the event that further stream restoration or mitigation measures are needed to maintain or restore stream stability.

The subsidence monitoring program will monitor erosion, sedimentation, and surface cracking. Mapping of the downstream and upstream active subsidence zone will be undertaken to determine if erosion and sedimentation is occurring in the channel to an unsustainable level and/or any significant surface flow losses into cracks are occurring between longwall blocks. The mapping will be used to evaluate the significance of subsidence impacts on the creek environment and trigger the need for any corrective action.

The monitoring strategy will include:

- annual photographic survey of each channel reach downstream and upstream of subsidence panels at and between the longwall panels to provide a benchmark for future reference
- annual Global Positioning System (GPS) mapping and photographic documentation of surface cracking that has occurred during subsidence until it is demonstrated that cracks are effectively sealed
- repeat surveys (as above) after three flood events have passed through subsidence areas (at which time a reasonably balanced regime of erosion and deposition cycles along the channels should become evident) to provide a secondary benchmark for future reference
- aerial survey of the mine lease during the dry season to document the size and potential volume of channel bed depressions (water ponding areas) within subsidence areas and to identify any lateral shifting or sedimentation within the stream beds
- in the event that significant erosion and sedimentation is occurring at rates that are not sustainable in the stream systems (i.e. visual loss of riparian vegetation, or rapid bank erosion and undercutting) or in the event that pooled areas are not decreasing between aerial surveys, a stream restoration program will be developed by a qualified fluvial geomorphologist and administered.

The subsidence monitoring program for potential concerns regarding the ponding of water in channel should be supplemented with periodic ecological surveys to assess responses of vegetation communities, diversity, resilience, and habitat potential.

9.8.15. Post Mining

At mine closure, a final void will remain, and the drainage system will be largely as proposed for Year 33. Dams will be decommissioned, and rehabilitated catchments will drain from the project via the proposed high-wall and low-wall channels, which will become part of the post-mine drainage system. The potential long-term impact on downstream streamflow is summarised in **Table 4.8** of **Appendix F—Surface Water.** At watercourse confluences, suitable dumped rock erosion protection will be provided if required to prevent excessive erosion.

Cross-drainage works at the infrastructure corridor will remain as well as the scour protection works to limit localised erosion.

9.8.16. Cumulative Impact Mitigation

Depending on the arrangement of the downstream projects, there will be some potential for cumulative impacts on downstream streamflow.

However, given the contribution to streamflow from the catchment containing the SGCP relative to large downstream and adjacent catchments, the percentage cumulative reduction in flows is expected to be minor.

9.9. GROUNDWATER MANAGEMENT AND MITIGATION MEASURES

The SGCP has the potential to impact on groundwater resources. Mitigation and management measures to be implemented, to reduce or eliminate the risks identified, are required to:

- ensure no detrimental impact on the availability and suitability of groundwater for agricultural use (stock watering)
- prevent adverse changes to groundwater quality as a direct result of the mine project outside the mine footprint
- promptly address landholders concerns over impacts on their groundwater supplies
- to ensure the zone of influence of the final void, of both groundwater level changes and hydrochemistry, will be managed and maintained after mining ceases
- protect cultural heritage or spiritual values associated with surface water features that are maintained by groundwater (if any)

- ensure no alteration of the diffuse recharge areas so as to ensure recharge during the life of the mine and after mining ceases.

9.9.1. Dewatering Impacts Mitigation

If dewatering causes any detectable, detrimental groundwater impact to landholders as a result of the SGCP, the Proponent will seek to establish mutual agreements with the impacted parties to provide an alternate water supply. These agreeements will cover duration of the impact on groundwater use, over the life of the mind and beyond.

The Proponent is also committed to undertaking regular monitoring of groundwater levels to identify any detrimental impact due to drawdown before it is experienced by the groundwater user, allowing the arrangement of short-term measures to be put in place, and avoiding periods of reduced groundwater supply.

Any indication that predicted impacts differ from actual impacts will be addressed with the recalibration of the hydrogeological model. The addition of data collected over a period of mining should result in improved accuracy of the model. Informed by the results of the groundwater monitoring program, the numerical model will improve as a planning and design tool over the life of the mine.

To maintain existing water usage rates, the following mitigation measures will be undertaken as required:

- inlet valves within bores will be lowered in order to maintain sufficient head of water above the pump. This may increase the cost of extracting groundwater from bores
- new pumps may be required if existing pumps are not powerful enough to lift groundwater from the increased depth beneath the surface
- in some situations, bores may need to be deepened or relocated in order to provide sufficient long-term water supply
- provision of piped water sourced from the mine (i.e. surplus water from the mine pit void dewatering program, depending on quality).

Under the *Water Act 2000*, DNRM has authority to direct a licensee to provide and maintain alternative water supplies for other holders of water entitlements who are materially impacted by the granting of a licence. The SGCP will develop alternate water supply agreements with landholders who will potentially be impacted by mine dewatering.

Landholders who have groundwater supplies that are materially impacted by the operation, to a degree where groundwater is not able to be used for its pre-mining beneficial use (in terms of quality and/or quantity) will be provided with an alternate water supply of comparable yield and quality. The Proponent has made a commitment to 'make-good' affected groundwater supplies. The specific arrangements for affected properties will be discussed with relevant landholders if they occur, with a view to reaching a mutually acceptable agreement. Deepening of bores is a viable option as saturated aquifer conditions remain below the water table that is drawn down by mine dewatering (i.e. the Colinlea Sandstone underlying the D seams remains an effective aquifer).

9.9.2. Subsidence Mitigation

The impacts associated with longwall mining include the alteration of aquifers and the potential for increased dewatering impacts. These impacts are as a result of the mining method to be employed and, thus, cannot be altered.

Predictive groundwater modelling has provided predictions regarding:

- groundwater ingress
- optimum dewatering strategies
- assessing drawdown impacts adjacent to the mine.

These model predictions will enable the compilation of detailed dewatering scheme(s) required to ensure the safe mining conditions and the effective removal of excess groundwater. Groundwater monitoring will be conducted to assess any alteration in groundwater level (compared to model predictions) and hydrochemistry (mixing of groundwater). This monitoring data will aid in the regular model assessment and refinement.

9.9.3. Mitigation of Groundwater Recharge and Discharge Impacts

Groundwater investigations (**Appendix G—Groundwater**) have determined that the Alpha township bores and nearby production bores will not be materially affected by the SGCP, with potential drawdown being estimated at 1 to 2 m.

No detrimental impact to neighbouring bores or surface water in the vicinity of the SGCP has been determined through modelling. In the long-term, evaporation from the final void will exceed groundwater inflow rates, resulting in a groundwater sink and no potential groundwater migration off-lease. It is not likely that any mitigiation will be required.

All water, waste, fuel and chemical storage facilities will be designed, constructed, and operated to prevent seepage, thus the risk to the groundwater resources is limited. Monitoring will be conducted to validate seepage control measures.

9.9.4. Mine Waste and Water Infrastructure Mitigation

The potential risks associated with seepage from mine waste and water infrastructure will be minimised via the appropriate design and construction of chemical, fuel and mine waste storage facilities. The groundwater monitoring program will validate the effectiveness of these seepage controls measures. Hence, the risk of these potential impacts will be reduced and managed appropriately.

Potential seepage from water and waste storage facilities will be monitored using down-gradient groundwater monitoring bores. Seepage controls will be implemented to prevent and mitigate seepage impacts should it occur.

In the event of groundwater impacts being identified, mitigation measures will include:

- contamination source removal and/or repair to the mine waste containment system, as required
- investigate containment system integrity and other potential areas/sources of seepage
- installation of interception trenches or bores to intercept seepage.

9.9.5. Ecological Impact Mitigation

There are no sensitive groundwater dependent ecosystems to be impacted from mining, therefore no specific groundwater monitoring program is proposed for ecological impact assessment. However, a general monitoring program is required for tracking the response of the aquifer system to mining and to check on model predictions.

9.9.6. Great Artesian Basin Impacts Mitigation

There is no predicted reduction in groundwater contributions to the GAB from the Clematis Sandstone as a result of mining, therefore no specific mitigation measures are proposed. However, groundwater monitoring will be implemented to monitor the potential impacts of the SGCP over the mine life.

A 'worst case' modelling setup, one that over-estimates impacts, has demonstrated drawdown in the Clematis Sandstone in the order of 5 m during mining, which would recover post-mining. Maximum drawdown in the GAB units further west is within the dynamic, seasonal range of only 2 to 5 m. Given that the depth to the water table is well in excess of 10 m, these variations are not regarded as warranting any specific mitiogation or management. For further detail on this modelling and analysis, see **Appendix G—Groundwater**.

9.9.7. Induced Flow Mitigation

There are no predicted impacts from induced flow as a result of the SGCP, hence no specific mitigation measures are proposed. Groundwater monitoring will be implemented to monitor the potential impacts from induced flow of the SGCP and mitigation measures will be developed if required, depending on the potential issue at the time.

9.9.8. Final Void Groundwater Interaction Mitigation

As mentioned in **Section 9.7.11**, there are no predicted deleterious effects from the final void post mining. A post mining monitoring program will be implemented to monitor potential impacts from the final void for verification.

9.9.9. Groundwater Monitoring Programs

Groundwater monitoring will be undertaken to allow assessment of the potential groundwater level and groundwater quality impacts on the local and regional groundwater and surface water regimes. Groundwater monitoring will ensure compliance with water licence (for dewatering) conditions with regards to water level impacts, and groundwater quality compliance with EA conditions resulting from the EIS and EM Plan processes. A Groundwater Management Program (GMP) will be prepared and submitted for review in accordance with SGCP approval conditions and any groundwater-related licences. The plan will be designed to monitor groundwater levels and quality to confirm the extent and magnitude of impacts from mine dewatering, including consideration of any triggering of the application of management responses (e.g. mitigation measures), which will also be detailed in the GMP.

Monitoring of groundwater levels and quality will be undertaken during all stages of mining (continuing the pre-construction monitoring program, and extending through construction, operation and rehabilitation periods). The monitoring frequency will range from weekly to monthly during early stages of active dewatering, and may increase to quarterly to annually during later mining and post mining stages. The groundwater monitoring will also be used to validate the numerical model, and to help support other mining and environmental management activities.

The information will be used for environmental compliance reporting. In particular, the groundwater quality monitoring will include analysis of the following parameters: pH, dissolved oxygen, EC, TDS, iron, aluminium, arsenic, magnesium, molybdenum, selenium, calcium, sodium, chloride and sulfate. Analysis will be undertaken at an accredited laboratory. Water quality data will be evaluated as part of the annual reporting process and will aim to identify any potential mining related impacts.

9.9.9.1. Monitoring Network

Groundwater monitoring bores have been established within the SGCP MLA (refer **Section 9.5.6**), and further work will progress on the bores listed in **Table 9-25**. These bores are currently open exploration holes that will be converted into groundwater bores by installing casings with screened intervals positioned against the major fractured zones in the Bandanna Formation, coal seams and the Colinlea Formation. Some locations will have nested multilevel bores. The locations were selected to monitor groundwater levels and quality along the SGCP boundaries and down gradient of the final pit void.

Monitoring of groundwater levels and quality should be undertaken from the existing local farm bores (assuming negotiation with landholders is successful). The groundwater monitoring bore network may be expanded in due course to areas surrounding MLA if triggered by the GWMP.

Table 9-25 Proposed SGCP Monitoring Program Bore Locations

Hole Name	Easting (MGA)	Northing (MGA)	Comments
BH06	444010	7374020	Located on southern boundary of MLA and will remain undisturbed for 10 years, so this will also provide useful background information, including monitoring the impact on groundwater from waste rock dumps.
BH21	446111	7378014	To monitor dewatering of southern operations and baseline for future mining. Located at eastern boundary and will remain undisturbed for 25 years.
BH33	441533	7382067	Will remain undisturbed for at least 25 years.
BH42	445067	7384006	To monitor dewatering of the northern operations. Located on the northern boundary and may remain undisturbed throughout the mine life.
BH85	445501	7381000	To monitor dewatering of the northern operations. Will also provide background data prior to expansion and will likely remain undisturbed throughout the mine life.
BH34	444148	7382453	Located near northern proposed "dirty water" dam, and will likely remain undisturbed through the mine life.
SP142	445299	7374183	Located near southern proposed "dirty water" dam, and will likely remain undisturbed. Will also be useful to monitor the impact on groundwater from waste rock dump.
BH27	442900	7379447	Located in the middle of the model domain and possibly will remain undisturbed for 20 years.
CK110	446300	7380050	Located on eastern side of operation and will be useful to monitor groundwater impact from waste rock dump. May remain undisturbed for 10-15 years.
BH05	442094	7374161	Located at south western corner and will remain undisturbed for 10 years.
BH18	440058.000	7378132.000	Located at western side and may remain undisturbed for 15 years or more.
CK177	439044	7380762	Located at western side and may remain undisturbed for 25 years or more.
BH39	438973	7383544	Located at north western corner and will remain undisturbed for 25 years or more
CK226	442113	7378175	Located at the middle of the mining domain and will remain undisturbed for about 15 years.

9.9.9.2. Operations

During mining, dewatering volumes will be measured and recorded regularly and the volumetric rates compared to the model-predicted rates to confirm the modelling predictions. In areas particularly where drawdowns are predicted in third party bores, detailed and regular monitoring will be conducted.

Multi-level piezometers will be installed to the west of the mine site to measure groundwater levels and monitor mining influences. Shallow piezometers will be installed in the fractured zone above the longwall panels to monitor changes in water table elevations. Additionally, if available, groundwater levels will be obtained from neighbouring mine monitoring networks so that widely distributed water levels will be available for regional evaluation. In summary, the groundwater monitoring program will monitor groundwater conditions for changes as a result of mining and should include consideration of aquifer definition and interactions, strata hydraulic properties, pore pressure distributions and groundwater quality.

The monitoring data will be used to:

- assess drawdown predictions from the groundwater model on an annual basis, provide data for model updates as required. This process will support validation of the model and its predictions of potential impacts
- confirm the impacts of groundwater drawdown on existing groundwater users and other identified environmental values, and develop specific mitigation/management plans through consultation with landholders and/or negotiation of alternative water supply agreements
- review the performance of the groundwater monitoring network, and guide appropriate optimisation of the monitoring network during the life of the mine
- assess compliance with Water Licence and EA conditions
- where issues of non-conformance are identified, the monitoring will allow for an assessment of mitigation and remediation measures.

To further assess groundwater resources in the context of cumulative/potential mining impacts, and develop the optimum management strategies, the following commitments regarding groundwater monitoring and compliance reporting are made:

- groundwater monitoring and sampling will be conducted by suitably qualified and experienced professionals in accordance with the current edition of the Monitoring and Sampling Manual (DERM, 2011), or subsequent updated versions; and the AS/NZS 5667.11:1998 Australian/New Zealand Standard for water quality – sampling Part 11; guidance on sampling groundwater
- an annual review of the monitoring data will be conducted by suitably qualified and experienced hydrogeologists, and will include assessment of groundwater level and quality data, and the performance of the monitoring network
- all groundwater-based complaints will be investigated and a register kept of the nature of the complaint, the results of assessment, and any actions taken, and the register will be made available to the regulating authority upon request.

9.9.9.3. Monitoring Program

Groundwater bore levels will be measured quarterly during the pre-mining and mining operation period. Following cessation of mining, groundwater levels will be measured quarterly for the first two years and annually during the rehabilitation period. During these periods, water levels from surrounding domestic bores will also be collected at least annually (at times corresponding to the quarterly groundwater measurement periods). If possible, the SGCP water levels will be supplemented with groundwater levels collected at nearby coal mines.

The SGCP mine water management system is discussed further in **Section 9.8.2.**

9.9.9.4. Post Mining Monitoring

After mining has ceased and decommissioning and rehabilitation works are complete, the Proponent will relinquish the SGCP mining lease. Prior to relinquishment, the nature, scope and resourcing of an ongoing groundwater monitoring program will be discussed with the parties with whom it has had alternate water supply agreements. This program may be a continuation of that outlined for operational mining, or an agreed variation, depending on the circumstances at the time.

Post-mining groundwater monitoring would be undertaken within monitoring bores that were installed during the operational phase of the SGCP.

9.9.10. Cumulative Impact Mitigation

As discussed in **Section 9.7.12**, cumulative impacts from the SGCP are expected to be minimal in the context of other potential mines in the area. The groundwater monitoring program will provide information on impacts, and mitigation measures will be produced if required.

ANNEXURE A QUEENSLAND QUARRY MATERIAL ALLOCATION NOTICE SEARCH RESULTS

QUARRY MATERIAL ALLOCATION NOTICE

Water Act 2000

Queensland Government

Notice Number	300254
Effective From	1 September 2011 **Expiry Date** 31 August 2016
Holder	BROWN DOG CONTRACTING P.L.
Date of Original Issue	2 September 2011
Location of Allocation	LAGOON CREEK
Location Description	Bed of Lagoon Creek within Lot 1 BF72 and Lot 2 SP136836
Total Allocation	225000 cubic metres
Maximum Extraction Rate	45000 cubic metres in any twelve (12) month period, or part thereof, commencing from the date this Notice takes effect.

This Allocation Notice is subject to the terms endorsed hereon or attached hereto.

Issued at Emerald **this** SECOND **day of** SEPTEMBER 2011

Jim Reeves
DIRECTOR-GENERAL
DEPARTMENT OF ENVIRONMENT AND RESOURCE MANAGEMENT

Client No: 42746 File No: EME/190/650(0073)
State Government Offices, 99 Hospital Road, PO Box 19, EMERALD, 4720
Telephone: (07) 4987 9300 Facsimile: (07) 4987 9333

Queensland Government

Schedule of Conditions

1
The allocation holder must give the chief executive, within 7 days after the end of each month, a written return in the approved form for all quarry material removed by the holder, in the month.

2
The allocation holder shall keep a record of daily extractions on site at all times. This record shall be made available for inspection upon request of an authorised officer of this Department.

3
The allocation holder is required to comply with any conditions relating to the development approval authorising the works to remove quarry material under this allocation notice.

4
The nominated removal rate for this notice is:
Yearly: 45,000 m^3

End of Schedule of Conditions