EROSION AND SEDIMENT CONTROL PLAN

JELLINBAH COAL MINE

PREPARED FOR
JELLINBAH MINING PTY LTD

JANUARY 2026

ENVIRONMENTAL SOLUTIONS

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1 Introduction

AARC Environmental Solutions Pty Ltd (AARC) and Engeny were commissioned by Jellinbah Mining Pty Ltd (Jellinbah) to develop an updated Erosion and Sediment Control Plan (ESCP) in accordance with the requirements of the Environmental Authority (EA) EPML00516813 for the Jellinbah Mine.

The Jellinbah Mine (JM) is an existing open-cut mine which has been in operation since 1989 and is currently authorised to mine up to 7.5 Mtpa of run-of-mine (ROM) coal. JM is located within the Bowen Basin region of central Queensland, approximately 24 kilometres (km) north of Blackwater and 190 km west of Rockhampton, within the Central Highlands Regional Council and Isaac Regional Council areas.

1.1 Purpose

The ESCP has been developed to meet the requirements of the conditions of the EA:

> *C37 An Erosion and Sediment Control Plan must be developed and implemented for all stages of the mining activities on the site to minimise erosion and the release of sediment to receiving waters and contamination of stormwater.*
>
> *C38 Stormwater, other than mine affected water, is permitted to be released to waters from:*
>
> *(a) Erosion and sediment control structures that are installed and operated in accordance with the Erosion and Sediment Control Plan required by condition C37; and*
>
> *(b) Water management infrastructure that is installed and operated, in accordance with a water Management Plan that complies with conditions C30 and C34 inclusive, for the purpose of ensuring water does not become mine affected water.*
>
> *C41 All reasonable and practicable erosion protection measures and sediment control measures must be implemented and maintained to minimise erosion and the release of sediment.*

This ESCP forms part of the sites water management system, and therefore, should be read in conjunction with the most current version of the Jellinbah Mine Water Management Plan (Engeny 2024).

1.2 Scope and Objectives

The objectives of the ESCP are as follows:

- To develop guidance on assessing erosion risk associated with typical tasks occurring on JM and identifying the most appropriate controls for each type of task.
- To develop a risk assessment process for managing identified disturbance activities and locations at risk of erosion and sediment loss.
- To reduce erosion in the first instance and then to capture sediments from disturbed areas.
- Provide site operators with effective, tailored advice on erosion and sediment control, along with maintenance needs for sediment control structures.
- Implement a routine inspection and maintenance program for existing sediment control infrastructure. This involves ensuring the erosion and sediment control measures are adequately managed before and after the wet season, where flood risk is present.
- Implement and maintain the ESCP annually in conjunction with the Water Management Plan (WMP) for consistency and to ensure the shared objectives are met.

1.3 Relevant guidelines

The key standards and guidelines that have been used to inform the preparation and implementation of this ESCP include:

- Technical Guidelines for Erosion and Sediment Control in Mining: ACARP Project C29046 (Chrystal et. al. 2022).
- Best Practice Erosion and Sediment Control (International Erosion Control Association 2008).
- Managing Urban Stormwater – Soil and Construction – Volume 2E Mines and Quarries (Department of Environment and Climate Change NSW 2008).

1.4 Supporting documentation and data

The following supporting documentation and data was used for development of the updated ESCP:

- Water Management Plan (Engeny 2024);
- LiDAR survey of active and inactive mining areas dated October 2024;
- Aerial imagery dated October 2024;
- Mining lease statistics for mining and rehabilitation activities (spatial GIS files);
- Vinces Pit design documentation (Engeny, 2024);
- Soil and spoil material properties site-wide;
- Mackenzie North - Mackenzie River Anabranch Diversion Detailed Design Report (WSP, 2024);
- Topsoil Management Plan (AARC, 2023); and
- Progressive Rehabilitation and Closure Plan (AARC, 2023).

2 Site description

2.1 Background and current operations

JM is made up of three active mining areas and two currently inactive mine areas. The active mine areas consist of Jellinbah Central, Jellinbah Central North and Mackenzie North. Jellinbah South and Jellinbah Plains, which were previously mined, remain inactive but will resume activity in the future.

The main elements and activities of the JM are:

- clearing of any remaining vegetation in advance of mining;
- selective stripping of topsoil ahead of mining for to immediate reuse or stockpiling for future use in the rehabilitation program;
- mine spoil returned to the void or placed to form bunds, haul roads and hardstands or transported to out-of-pit spoil dumps located clear of the coal resource but within the boundary of the leases;
- mining of a high energy, low ash, low sulphur coal;
- operation of a Coal Preparation Plant (CPP) for coal washing where required;
- disposal of CPP coarse or dried rejects within in-pit tailings storage facilities;
- operation and maintenance of water management infrastructure; and
- progressive rehabilitation of inactive spoil dumps and other disturbance areas.

2.2 Climate

The regional climate at the Project is classified as sub-tropical and sub-humid, characterised by a wet, humid summer and dry winter. Data from the Emerald Airport weather station (35264) from 1992 to 2025 shows that January is the warmest month, with a maximum monthly mean temperature of 38.5°C and a minimum of 19.2°C. The coolest months are June and July, with a maximum mean temperature of 25.8°C and a minimum of 19.2°C (BoM 2025).

Local rainfall patterns derived from data obtained by the Bureau of Meteorology at Blackwater Airport station (35134), located approximately 30km from JM, indicates an average annual rainfall of 534.5 mm with a clearly defined wet season occurring between November and May. A high degree of rainfall variability is expected with high evaporation rates throughout the year. The estimated average pan evaporation is 2,040mm/year. Figure 2-1 indicates the monthly rainfall averages from the Blackwater Airport station using data from 2013-2025.

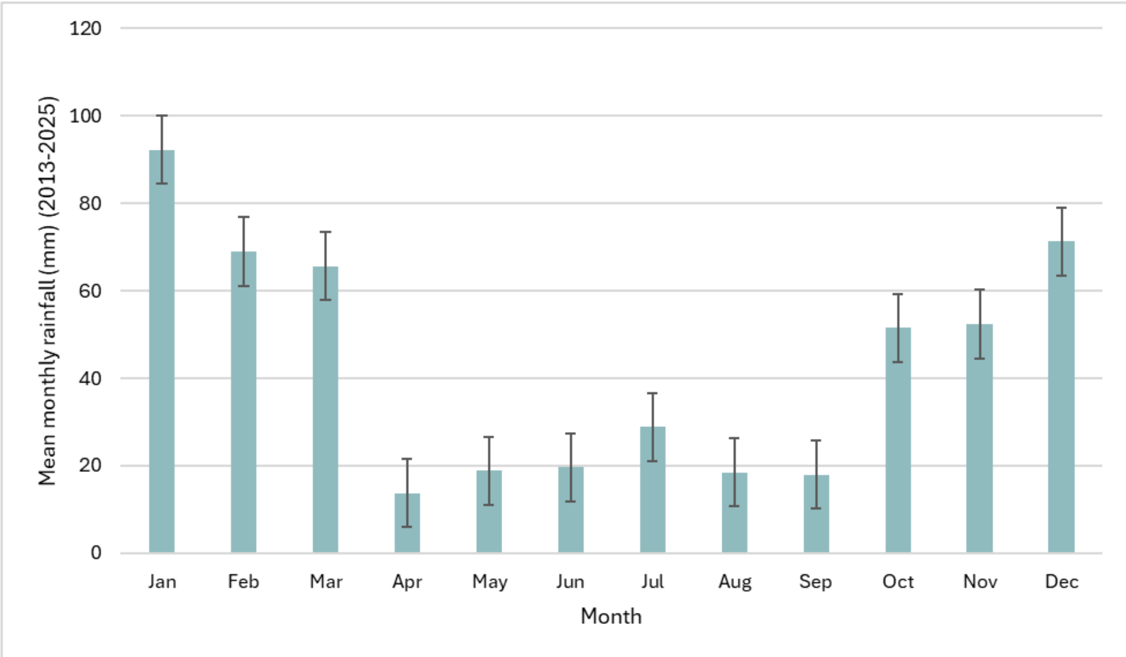

Figure 2-1: Rainfall averages from Blackwater Airport Station (BoM 2025)

2.3 Topography and surface hydrology

The JM is located east and north of Blackwater Creek near its junction with the Mackenzie River. The natural ground levels vary between 120mAHD and 140mAHD for Mackenzie North to Central North. Jellinbah Central and Jellinbah South are at a slightly higher elevation, between 140mAHD and 180mAHD approximately. Average pre-mining slope angle is 5% but varies from 2 to 10% across the site. The landform comprises gently undulating plains. The surrounding land is extensively cleared and used for grazing.

The Environmental Protection (Water and Wetland Biodiversity) Policy (EPP) Central Queensland Mapping (WQ1304 – Mackenzie River Sub-basin) identifies several watercourses (rivers/creeks) and lakes/reservoirs on and surrounding JM. Of these identified waterbodies, the receiving environment incorporates the Mackenzie River and Anabranch, Blackwater Creek, and Three to Five Mile Lagoon (Figure 2-2).

Mackenzie North drain into the Mackenzie River, and the Mackenzie River Anabranch, which joins the Fitzroy River approximately 220 km downstream of the mine. The Mackenzie River catchment encompasses an area of 19,985 square kilometres (km2) within the Fitzroy Basin. Jellinbah Plains drains to Mackenzie River to the north, Three Mile Lagoon to the north-west and Five Mile Lagoon to the north-east of the site. The Three Mile Lagoon and Five Mile Lagoon were linked by a local drainage feature in the pre-mining landscape. These lagoons provide shade and watering points for livestock and native fauna habitat.

Jellinbah Central drains westward into the ephemeral Blackwater Creek, before discharging into the Mackenzie River 10 km north-west of Jellinbah Central (upstream of the mine). Blackwater Creek passes to the south of the neighbouring Curragh North Coal Mine; however, the waterway does cross beneath a coal transfer conveyor connecting Curragh North to the Curragh Coal Mine 15 km south. Jellinbah South drains directly eastward into the ephemeral Twelve Mile Creek, before discharging into the Mackenzie River 60 km downstream of the Jellinbah site (downstream of Bingegang Weir).

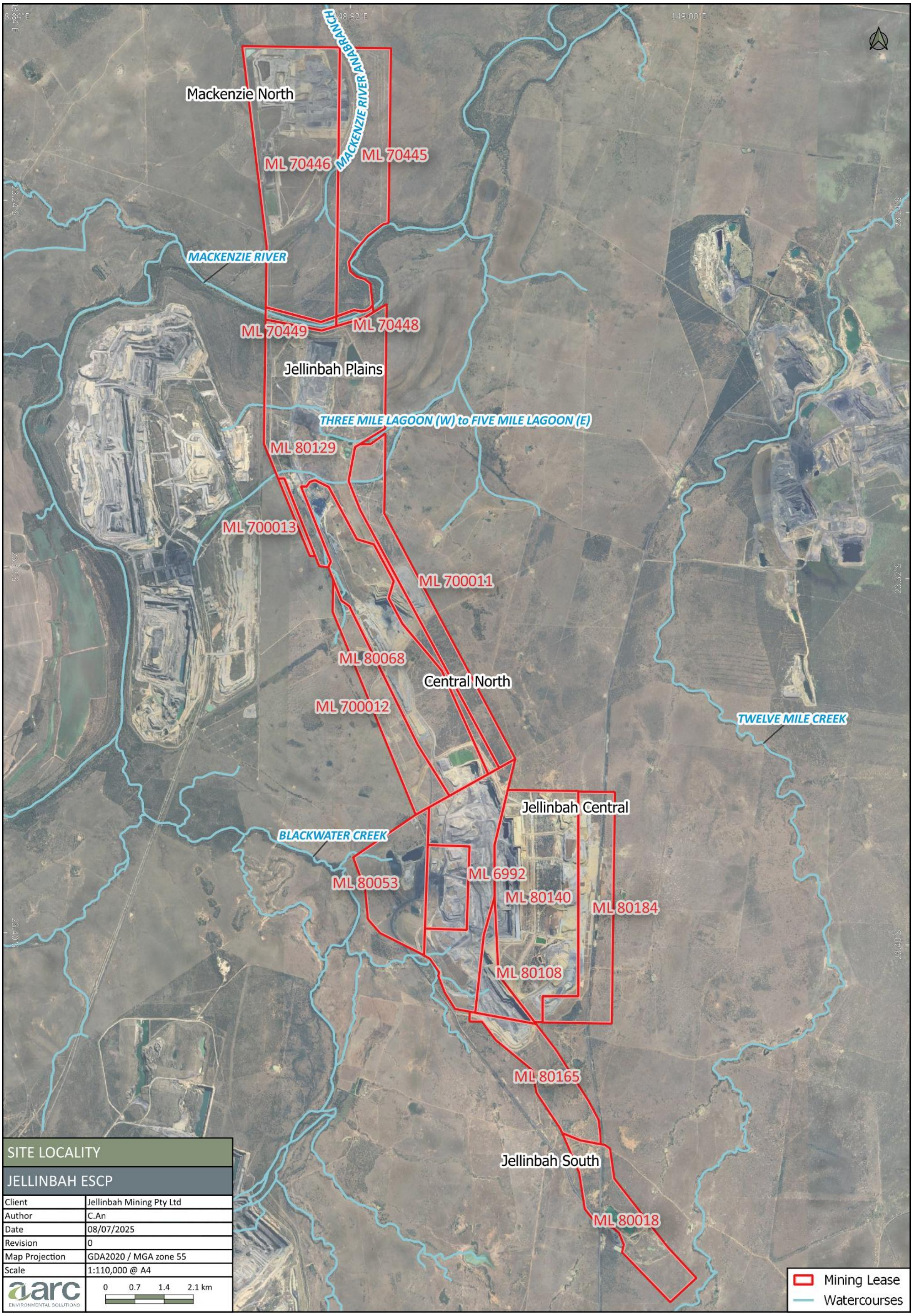

Figure 2-2: Site locality and watercourses

2.4 Land and soil

Although varied across the Project, soil types are primarily derived from three parent materials including (Ison Environmental Planners 1998):

- Sand to sandy loam, and light to medium clay soils developed on Cainozoic unconsolidated materials overlying Permian sedimentary rocks;
- Soils developed directly over sedimentary rocks, mainly sandstone and siltstone of Permian and Tertiary age; and
- Self-mulching black cracking clay soils developed on Alluvium.

Generally, soils within the project area are structurally competent in their natural setting, such as strongly structured alluvial clays or soils of sandy texture on gentle slopes, and are not considered at high risk of dispersion. A proportion of the soils display characteristics identified as increasing the susceptibility of the soil to erosion and dispersion (i.e. high exchangeable sodium percentage and low calcium to magnesium ratio).

The bulk of the overburden is typically comprised of clays and sands above siltstones and mudstones. Weathered overburden and interburden materials may be partly sodic and subject to surface crusting and high erosion rates if exposed directly to rainfall. Fresh overburden and interburden is typically sodic but non-dispersive. However, this fresh material has potential to become dispersive when under certain weathering conditions after mining. It should be noted that the overburden material is not considered acid forming or containing known contaminants.

3 Existing catchments and structures

The design and details of the erosion and sediment controls (ESC) are outlined in this ESCP, whilst the WMP effectively manages the separation of mine-affected and non-mine affected catchments on site. The catchments and current water management infrastructure, including MAW and erosion and sediment controls, is shown in Figure 3-1 to Figure 3-5.

Through the annual update of the WMP the boundaries of mine-affected water (MAW) catchments are updated as the mine progresses. In conjunction with this review, the boundaries of clean water catchments are also reviewed and amended to ensure suitable ESC devices are implemented and appropriately sized, where required.

The generation of MAW is minimised in several ways. For areas ahead of open-cut mine pit progression, Jellinbah has strategically installed high wall bunding, suitable drainage channels, and contour banks in highwall areas to divert water from most topsoil stripped and cleared areas to sediment dams. This approach prevents surface water runoff from flowing into the pit, instead redirecting it to sediment dams and reducing MAW formation. MAW catchments are also reduced by the implemented Progressive Rehabilitation and Closure Plan (PRCP) schedule (P-PRCP-100738792). Mine design allows for runoff from partially or completely rehabilitated disturbed areas to be shed from site without being retained in the MAW system.

The WMP simulates catchment runoff using the Australian Water Balance Model (AWBM), and provides details of the model within the site water balance information (section 5.2.2 of the WMP). The AWBM land use catchment runoff parameters and landuse breakdown encompasses natural, spoil, hardstand and pits, rehabilitated spoil, and coal stockpile categories.

The water storage catchment landuse for spoil is currently the highest proportion across the total site catchment, indicating a high-risk water catchment. Hardstand and pits landuse hold the second highest proportion, whilst rehabilitated spoil and natural land use represent the third and fourth highest proportions respectively.

3.1 Definitions of water types

Clean runoff includes rainfall runoff from all areas that are not affected by coal or operational facilities. Sediment runoff includes runoff in which the only contaminants are dissolved or suspended sediments from areas such as partially or completed rehabilitated areas, general disturbance areas (e.g. pre-topsoil stripped and vegetation clearing areas), and spoil piles.

In accordance with the EA definition of MAW, these catchment areas contain the following activities:

a) pit water, tailings dam water, processing plant water;

b) water contaminated by a mining activity which would have been an environmentally relevant activity under Schedule 2 or Schedule 2A of the *Environmental Protection Regulation 2008* if it had not formed part of the mining activity;

c) rainfall runoff which has been in contact with any areas disturbed by mining activities which have not yet been rehabilitated, excluding rainfall runoff discharging through release points associated with erosion and sediment control structures that have been installed in accordance with the standards and requirements of an Erosion and Sediment Control Plan to manage such runoff, provided that this water has not been mixed with pit water, tailings dam water, processing plant water or workshop water;

d) groundwater which has been in contact with any areas disturbed by mining activities which have not yet been rehabilitated;

e) groundwater from the mine's dewatering activities; or

f) a mix of mine affected water (under any of paragraphs a) – f) above) and other water.

3.2 Current control structures

The design and function of the major site ESC structures is discussed here, and in the following sub-sections for current significant infrastructure developments. The site water management system at JM primarily includes storages which collect spoil and rehabilitated runoff, sediment control drains and clean water diversion drains.

Clean water and sediment diversion drains have been designed and constructed to divert clean catchment runoff away from operational areas to reduce the volume of mine-affected water generated. The drains have been constructed with different control methods where appropriate, such as the use of rock lining for stabilising the bed of steep channels or stabilising the drains by revegetation. These drains direct water away from areas disturbed by mining activities towards sediment traps and detention basins. Sediment basins assist in minimising the release of sediment to receiving waters by allowing total suspended solids (TSS) to settle out of the water prior to discharging to natural water courses.

Table 3-1 below describes the design characteristics for the larger sediment dams present on site. There are also numerous smaller sediment traps (see Figure 3-1 to Figure 3-5) that have not been described in Table 3-1 below. The sediment traps are generally smaller in size (operational capacity <5 megalitres) and are mostly located at the base of diversion drains or used as check dams throughout connecting channels to intercept and filter concentrated flows. Sediment traps predominantly assist to reduce the sediment load within runoff exiting rehabilitation areas, spoil and topsoil dumps. The sediment traps can be temporary and are often reclaimed as mining progresses and spoil dumps and rehabilitated areas expand.

Table 3-1: Sediment dam design characteristics

Sediment dam	Total area (ha)	Total est. operational capacity (ML)
MN North Dam	2.139	180
MN North West Dam	2.275	180
MN South Dam	8.307	30
Overflow Dam 1	4.526	141
Overflow Dam 2	16.55	221
OOP Main Dam	5.328	252
Clean Water Dam	5.564	55
South West Dam	1.773	40
South Dam	0.8554	11
NE Sediment Dam	2.108	70
LCR Dam	2.026	35
Central West Sediment Dam	3.120-	93

3.2.1 Central West Sediment Dam

The Central West Sediment Dam (located in ML70012) has been designed and constructed to support a catchment area of 560 ha. Runoff from spoil dumps and topsoil stripped areas is directed to diversion channels that flow into the dam. Rock chutes are installed at the base of steep gradient drains to dissipate the energy of concentrated water flows and prevent erosion. An outlet structure has been constructed on a pipe and culvert outlet from a spillway which directs clean water through a clean water diversion channel flowing to the diversion drain adjacent to Vince's Pit.

3.2.2 Vince's Pit Area

To accommodate future tailings storage requirements, in-pit tailings disposal will continue in a neighbouring shallow pit, currently referred to as Vince's Pit, to be located near Russell's Dam and Max Pit on ML80053. The project construction will unfold in two phases. During the first stage, the pit will be used as an operational mine pit before transitioning to the tailings facility in the second stage.

In support of the EA regulated structure conditions, a design and operational plan have been prepared for the stormwater infrastructure for Vince's Pit, particularly the design of the levee, and its function during Stage 1 of the construction (Engeny 2024). The levee is a regulated structure designed to provide a 1:1,000 Annual Exceedance Probability (AEP) immunity for the pit and is constructed to divert the overland flow of clean water away via the diversion drain. The engineered clean water diversion drain is rock chute lined, topsoiled and hydromulched to and enhance stability, reduce erosion and sediment loss.

The non-mine affected catchment reporting to the levee diversion drain includes significant water management infrastructure in the mine including Central Northern Drain and the overflows of Central West Sediment Dam. The spoil and topsoil stockpiles from the first stage of Vince's Pit construction have been designed and built to include catch drains and sediment basins for ESC. The catch drains redirect runoff towards sediment basins that have been constructed with specific storage volumes, dam levees, and spillways. The sediment basins are constructed at appropriate intervals around the stockpiles to accommodate the catchment area.

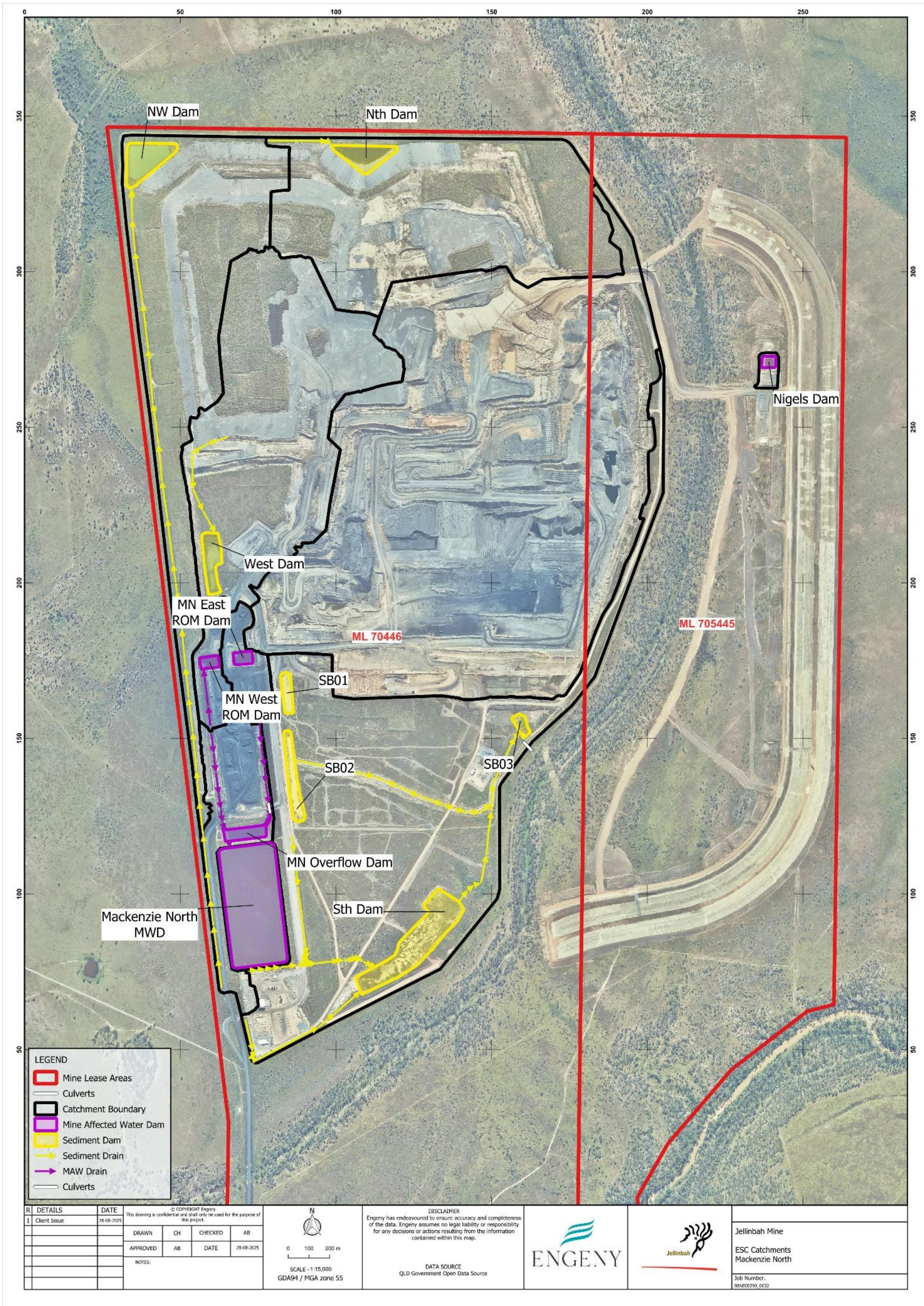

Figure 3-1: ESC Catchments - Mackenzie North

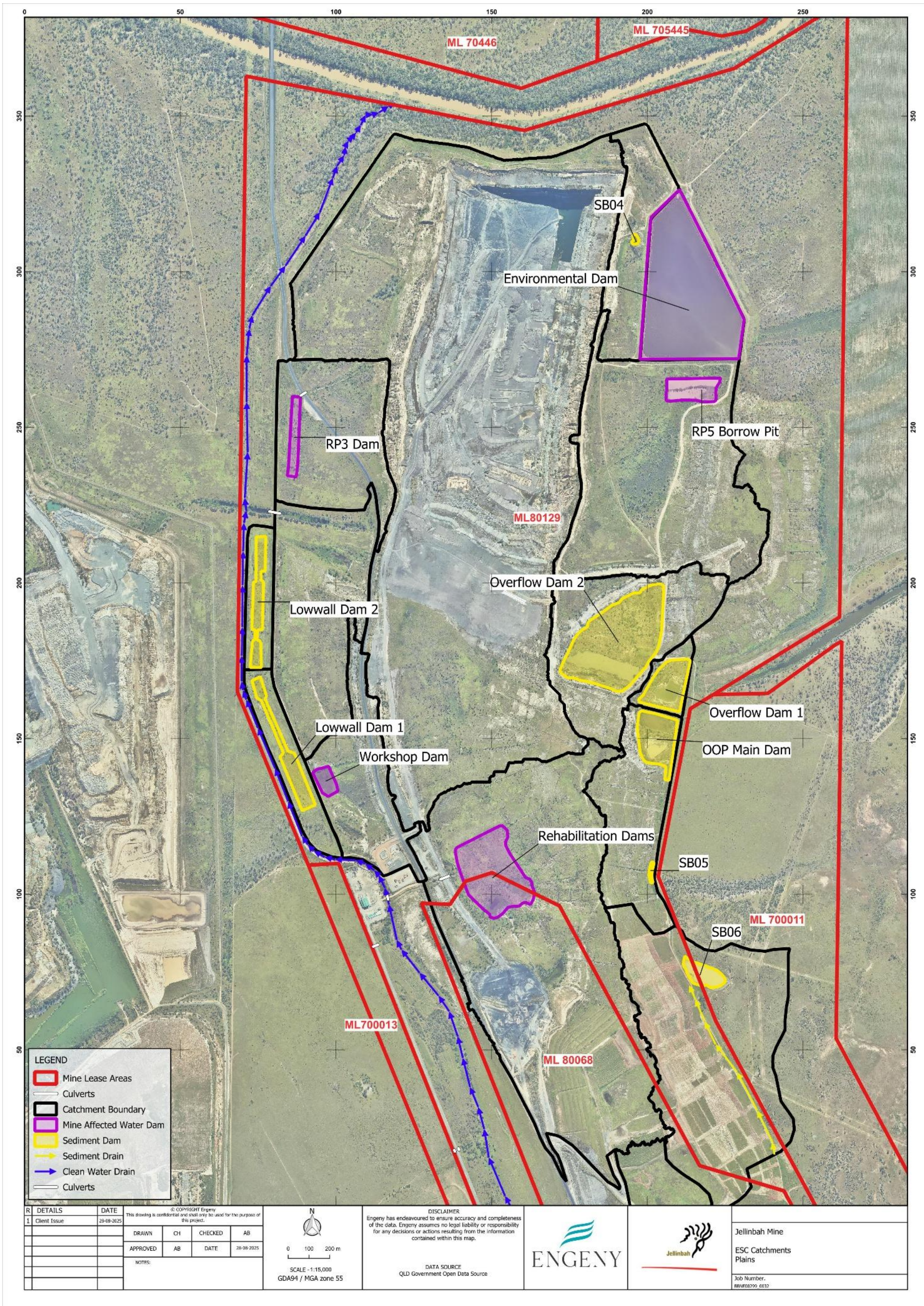

Figure 3-2: ESC Catchments - Jellinbah Plains

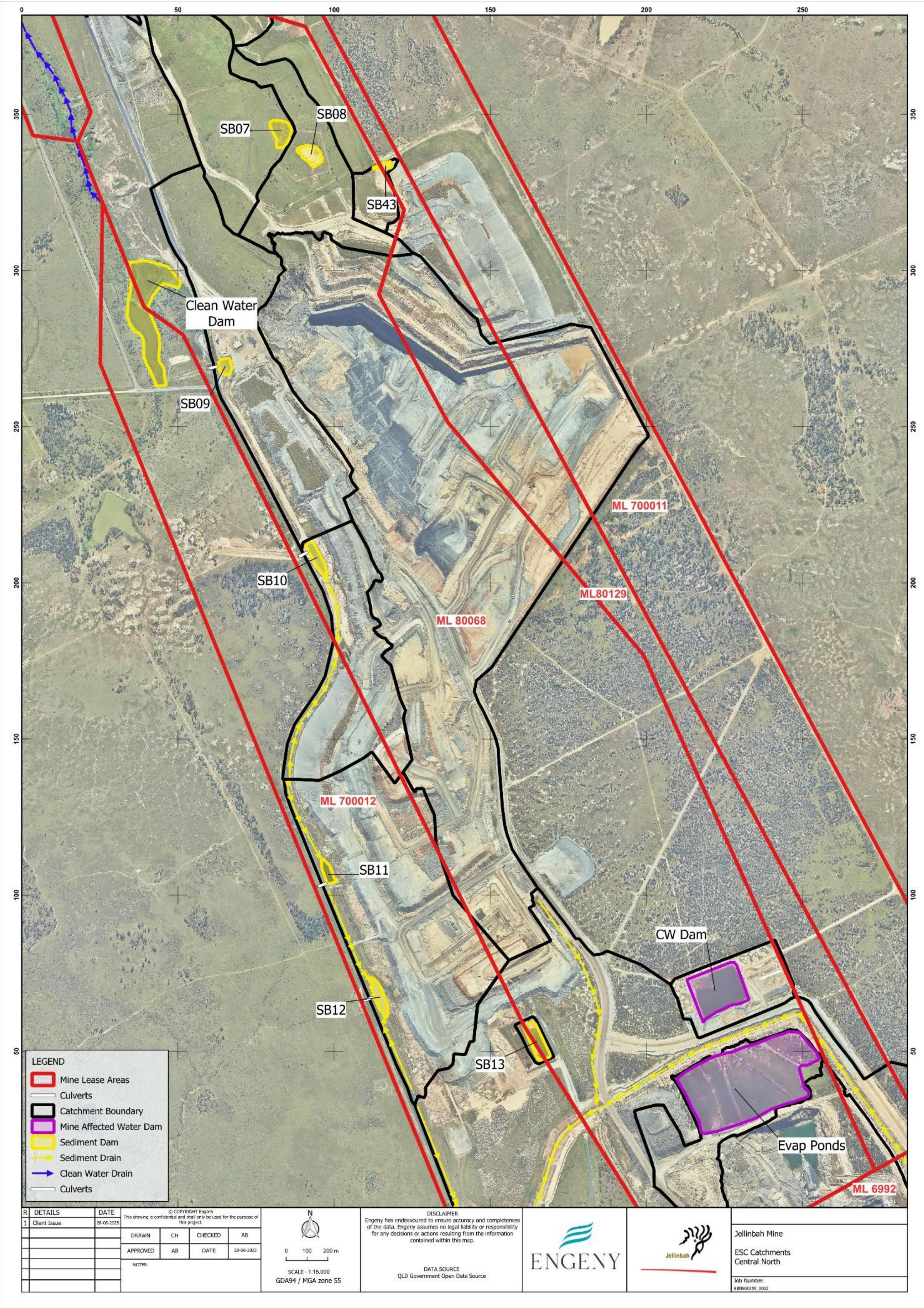

Figure 3-3: ESC Catchments - Central North

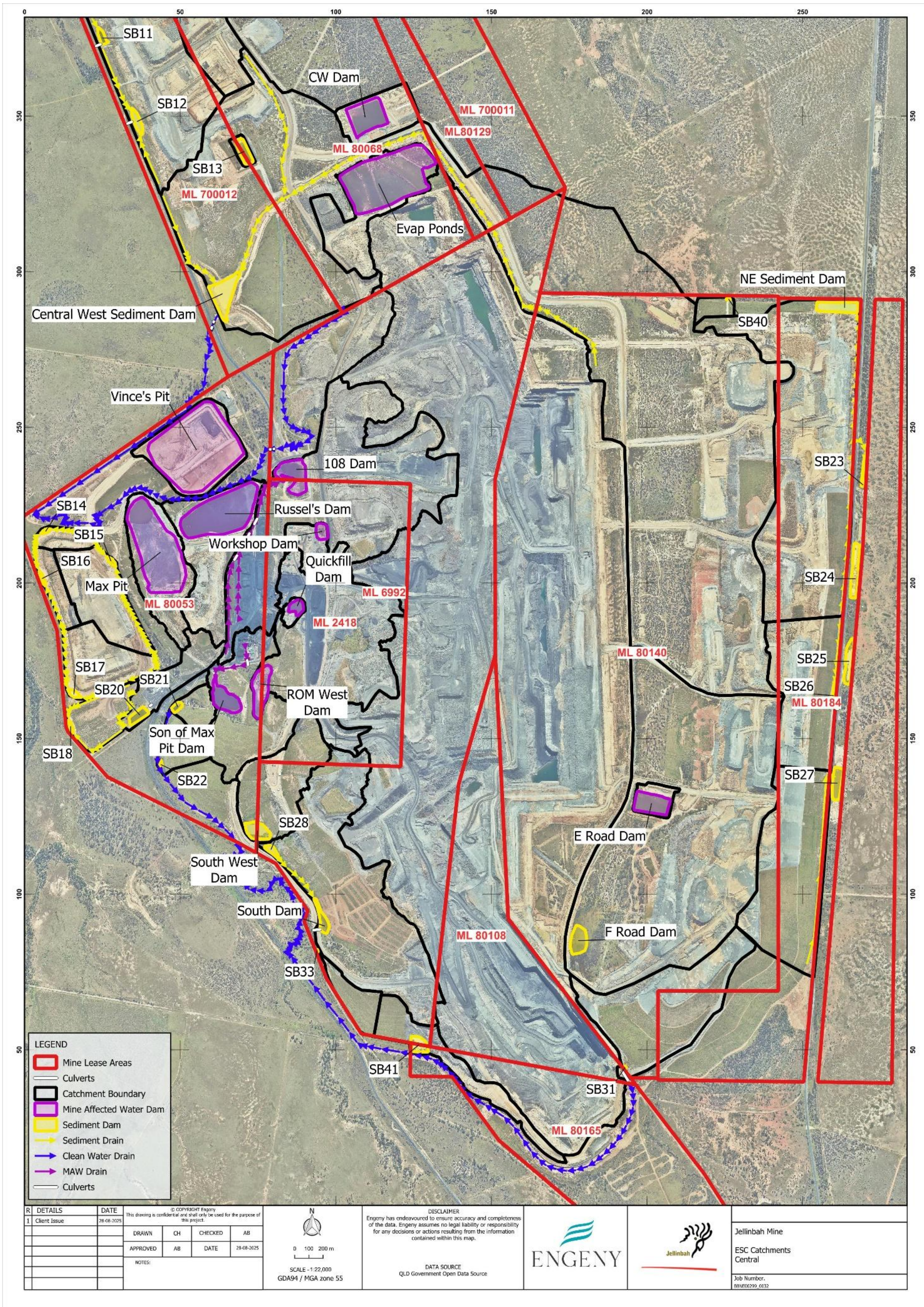

Figure 3-4: ESC Catchments - Jellinbah Central

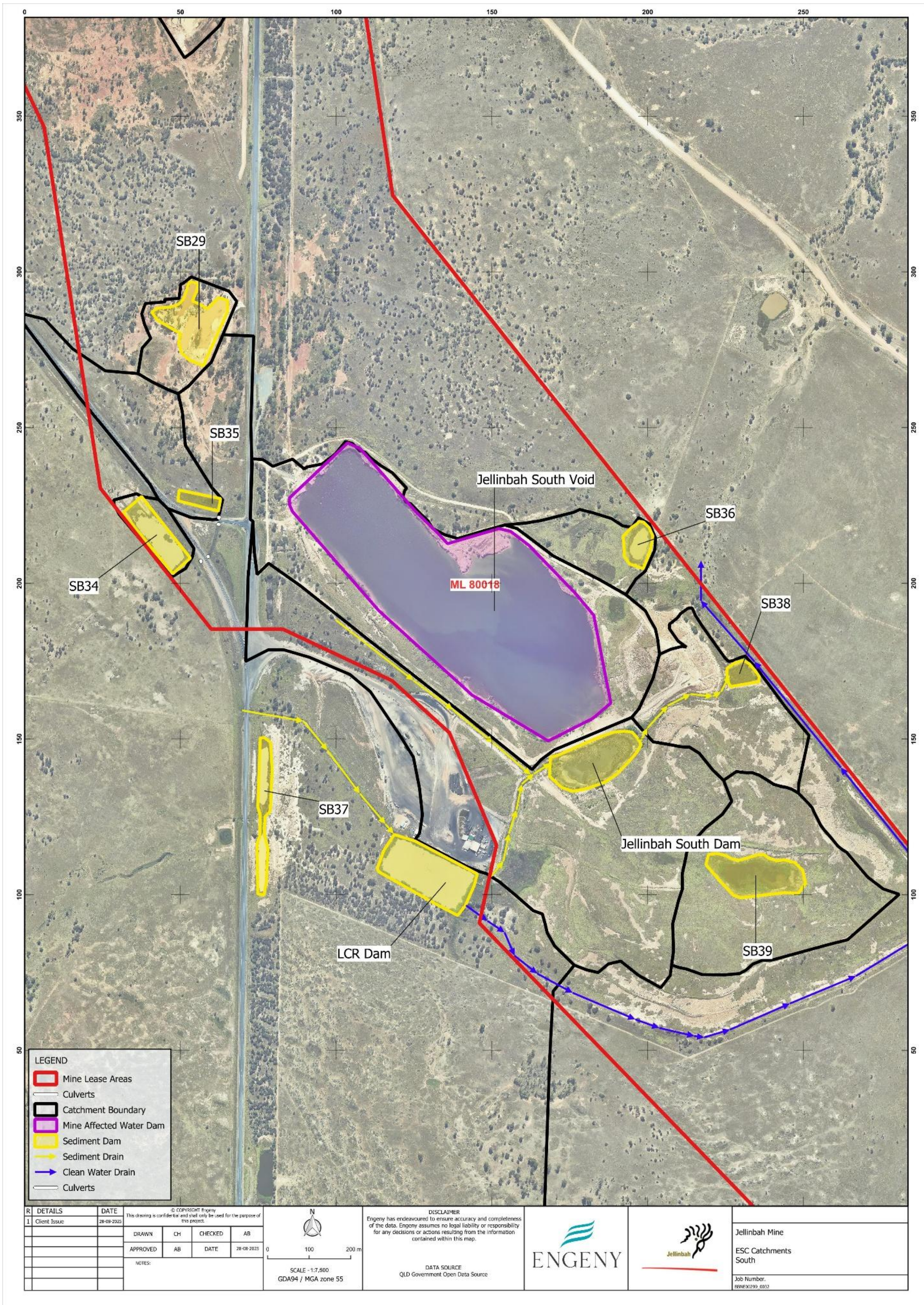

Figure 3-5: ESC Catchments - Jellinbah South

3.3 Erosion Risk assessment

The quantification of soil loss is critical for the design and implementation of ESCPs, including erosion risk assessments and the design of sediment control structures. The selection of appropriate erosion control measures depends on the expected erosion risk and the sensitivity of receiving waterways. The erosion risk is typically informed by the timing (likelihood and intensity of expected rainfall and wind conditions) and the degree of land stabilisation (vegetation cover, slope etc.) (Chrystal et. al. 2022).

A GIS based Revised Universal Soil Loss Equation (RUSLE) analysis has been used as a tool to quantify and estimate the soil loss rates across JM. This tool can be used to highlight high-risk areas and design suitable erosion and sediment control devices based on quantifiable information. The application of the GIS-based RUSLE methodology is recommended to implement on Queensland coal mining sites as it is straightforward and provides detailed spatial data that can be easily stored and updated (Chrystal et. al. 2022).

The hydrological and RUSLE estimation process produces high-resolution erosion volume data that can be assigned risk ratings for erosion risk mapping. The maps indicate the location of current sediment dams and MAW storages, including the associated catchment areas (see Figure 3-6 to Figure 3-10). The proposed erosion risk ratings are provided in Table 3-2.

Table 3-2: Erosion risk rating

Erosion risk rating	Soil loss (t/ha/yr)
Very Low	<= 5
Low	5 to 10
Medium	10 to 20
High	20 to 100
Very high	100 - 500
Extremely high	>500

The erosion risk mapping tool can be used to guide prioritisation of maintenance efforts and inspections during large storm events, and to inform additional ESC measures based on a quantifiable assessed erosion risk. However, this does not replace the need for design criteria based on storm intensity (Chrystal et. al. 2022). The tool can be applied by an appropriately qualified person in the application and assessment of erosion risk linked to:

- the selection of the most appropriate erosion control measure;
- the use of sediment basins;
- the selection of design standards applied for drainage and sediment control;
- periods when soil disturbance may occur on specific areas of land;
- the required time frames for site stabilisation and rehabilitation; and
- the design life of implemented controls.

This ESCP follows the proposed workflow for controls selection, from ACARP Project C29046, which includes modelling the sediment loss before and after implementing proposed controls to assess their suitability. From the erosion risk determined across JM, the extremely high-risk areas (red zones) should be considered first for the selection of appropriate controls before the lower risk categories. The GIS based RUSLE tool can be used to indicate the percentage of the area that the control in place will treat (e.g. will capture 50% of the runoff from the catchment area).

To determine the “residual” erosion risk, the relevant RUSLE parameter representing the selected control can be updated (i.e. vegetation cover). The RUSLE is then updated with the control in place to determine if the capture efficiency (e.g. 60% removal rate) is sufficient. This method requires understanding the capture efficiency of various controls. A standard rate can be applied for each control once more is understood about the removal rate. However, this will require further modelling, monitoring and field validation. The equation to determine the residual erosion risk after selecting a suitable control is as follows:

Selected control:

% capture efficiency x % area treated by the control x estimated sediment loss (t/ha/yr) of the catchment = sediment load removed (t/ha/yr)

New calculated sediment load:

estimated sediment loss (t/ha/yr) of the catchment – sediment load removed (t/ha/yr) = residual erosion risk

3.3.1 Erosion modelling

A sediment loss rate assessment for the Jellinbah Mine has been completed using the Revised Universal Soil Loss Equation (RUSLE) and in accordance with Best Practice Erosion and Sediment Control guidelines (IECA, 2018). RUSLE is an empirical-based modelling approach that predicts the long-term average annual rate of soil erosion.

RUSLE estimates the average annual soil loss using the following equation:

$A = R \times K \times LS \times C \times P$

Where:

A = average soil loss in tonnes per hectare per year;

R = rainfall-runoff erosivity factor;

K = soil erodibility factor;

LS = slope length and steepness factor;

C = cover-management factor; and

P = support practice factor.

Soil loss rates were calculated spatially for the entire Jellinbah ML based on topographic data, landcover information and other regional constants. Appendix B describe the methodology used to derive each of these factors specifically for Jellinbah Mine. The calculated soil loss in tonnes per hectare per year, calculated using the RUSLE equation is shown spatially cross the Jellinbah mining areas in Figure 3-6 to Figure 3-10. The mapped soil loss rates are used to show areas of high and low erosion that inform that require management.

The soil loss rate was then averaged for each existing sediment dam catchment and summarised in Table 3-3 to show catchments with high sediment loads where maintenance should be prioritised. Estimated soil loss rates for sediment dams vary between 5 and 200 tonnes/ha/year (low to very high risk), while estimated soil loss rates for flat natural areas surrounding the mine typically vary between 1 and 5 tonnes/ha/year (Very Low Risk). The sediment dam locations and catchment areas used for the analysis and are also shown in Figure 3-6 to Figure 3-10.

The annual sediment load has been also calculated for each of the sediment dams to help prioritise maintenance effort. The soil loss rate is multiplied by the catchment area to determine the tonnes per year (on average) expected to report to each storage. The sediment load risk was classified as Low for a load <1 kt/year, medium for a load of 1 kt/year to 10 kt/year, and high for a load of >10 kt/year. The calculated sediment load can be used to infer the required sediment storage volume assuming a soil density (~1.4 t/m3).

Table 3-3: ESC Storage Sediment Load Risk

Storage	Catchment area (ha)	RUSLE erosion rate (t/ha/year)	Erosion Risk Rating (Refer Table 3-2)	Estimated annual sediment load (kt/year)	Sediment Load and Maintenance Risk
Jellinbah Central					
Central West Sediment Dam	560.0	136.9	Very High	76.7	High
F Road Dam	223.1	187.0	Very High	41.7	High
NE Sediment Dam	140.8	205.9	Very High	29.0	High
SB11	86.2	138.6	Very High	11.9	High
South Dam	98.4	105.6	Very High	10.4	High
South West Dam	33.6	81.7	High	2.7	Medium
Workshop Dam	8.6	9.3	Low	0.1	Low
SB13	2.1	75.2	High	0.2	Low
SB14	5.9	121.0	Very High	0.7	Low
SB15	27.1	87.4	High	2.4	Medium
SB16	8.2	121.9	Very High	1.0	Low
SB17	21.9	135.4	Very High	3.0	Medium
SB18	13.7	56.2	High	0.8	Low
SB20	16.0	69.5	High	1.1	Medium
SB21	7.3	29.5	High	0.2	Low
SB22	10.0	19.0	Medium	0.2	Low
SB26	47.1	163.5	Very High	7.7	Medium
SB27	63.3	103.0	Very High	6.5	Medium
SB31	56.2	114.8	Very High	6.5	Medium
SB32	11.4	18.1	Medium	0.2	Low
SB33	9.2	24.0	High	0.2	Low
SB40	3.8	65.3	High	0.2	Low
SB41	22.2	106.8	Very High	2.4	Medium
SB42	13.6	17.0	Medium	0.2	Low
Central North					
SB07	41.3	9.8	Low	0.4	Low
SB08	31.1	48.3	High	1.5	Medium
SB09	61.3	170.7	Very High	10.5	High

Storage	Catchment area (ha)	RUSLE erosion rate (t/ha/year)	Erosion Risk Rating (Refer Table 3-2)	Estimated annual sediment load (kt/year)	Sediment Load and Maintenance Risk
SB10	41.8	200.2	Very High	8.4	Medium
SB43	5.5	85.9	High	0.5	Low
Mackenzie N					
Sth Dam	182.5	29.9	High	5.5	Medium
Nth Dam	106.9	140.1	Very High	15.0	High
NW Dam	93.7	151.8	Very High	14.2	High
Lowwall Dam 2	9.1	30.6	High	0.3	Low
Overflow Dam 2	44.3	48.8	High	2.2	Medium
Overflow Dam 1	6.4	94.1	High	0.6	Low
Lowwall Dam 1	13.0	95.4	High	1.2	Medium
OOP Main Dam	29.9	112.4	Very High	3.4	Medium
Workshop Dam	28.1	141.9	Very High	4.0	Medium
SB04	22.0	92.4	High	2.0	Medium
SB06	78.1	15.9	Medium	1.2	Medium
Jellinbah South					
SB35	7.2	2.3	Very Low	0.0	Low
SB29	4.2	5.4	Low	0.0	Low
SB30	0.8	5.6	Low	0.0	Low
LCR Dam	1,030	5.6	Low	5.8	Medium
SB40	1.0	7.7	Low	0.0	Low
Jellinbah South Dam	37.4	9.0	Low	0.3	Low
SB36	3.8	10.7	Medium	0.0	Low
SB38	9.7	12.7	Medium	0.1	Low
SB39	16.2	14.1	Medium	0.2	Low
SB34	1.9	36.4	High	0.1	Low

3.3.2 Sources of erosion and sediment loss

Activities considered to be a potential source of erosion and sediment loss have been identified across JM. Table 3-4 describes these sources along with the nature of the hazard and the potential risk associated. It is intended that Table 3-4 is updated with additional sources which may become apparent with progressing mine life and changing environmental conditions.

Table 3-4: Potential sources of erosion and sediment loss

Standard activity/location	Description	Erosion risk rating (no mitigation)
Flood levees	Surface water runoff and flooding can result in erosion from concentrated runoff on the slopes.	Low – high risk
Coal stockpiles/ROM Pad and handling equipment areas	Stockpiles of coal are susceptible to wind and water erosion.	High risk
Water management structures (e.g. dams, diversions and drains etc.)	Water erosion can result from concentrated runoff on the slopes of constructed embankments and in drainage channels.	Low – very high risk
Construction/maintenance of unsealed heavy and light vehicle access	Exposed soil surfaces on disturbed land leads to increased runoff velocities with greater potential for erosion and sediment loss.	Low – medium risk
Topsoil stockpiles	Exposed stockpiles leads to increased runoff velocities with greater potential for erosion and sediment loss.	Low – very high risk
Pre-strip areas (vegetation cleared) and topsoil stripped areas	Exposed soil surfaces on disturbed land leads to increased runoff velocities with greater potential for erosion and sediment loss.	Low – medium risk
Active spoil dumps	Stockpiles of overburden / interburden containing unconsolidated material with varying levels of saline and sediment pre-disposition. Exposed areas susceptible to storms and weathering	Medium – extreme risk
Progressively rehabilitated areas (e.g. infrastructure, spoil dumps, etc.)	Rehabilitated spoil consisting of unconsolidated overburden / interburden with varying levels of saline and sediment pre-disposition. Exposed areas above the natural ground level without surface preparation layers (i.e. topsoil, mulch) or vegetation cover are susceptible to water erosion.	Low – high risk

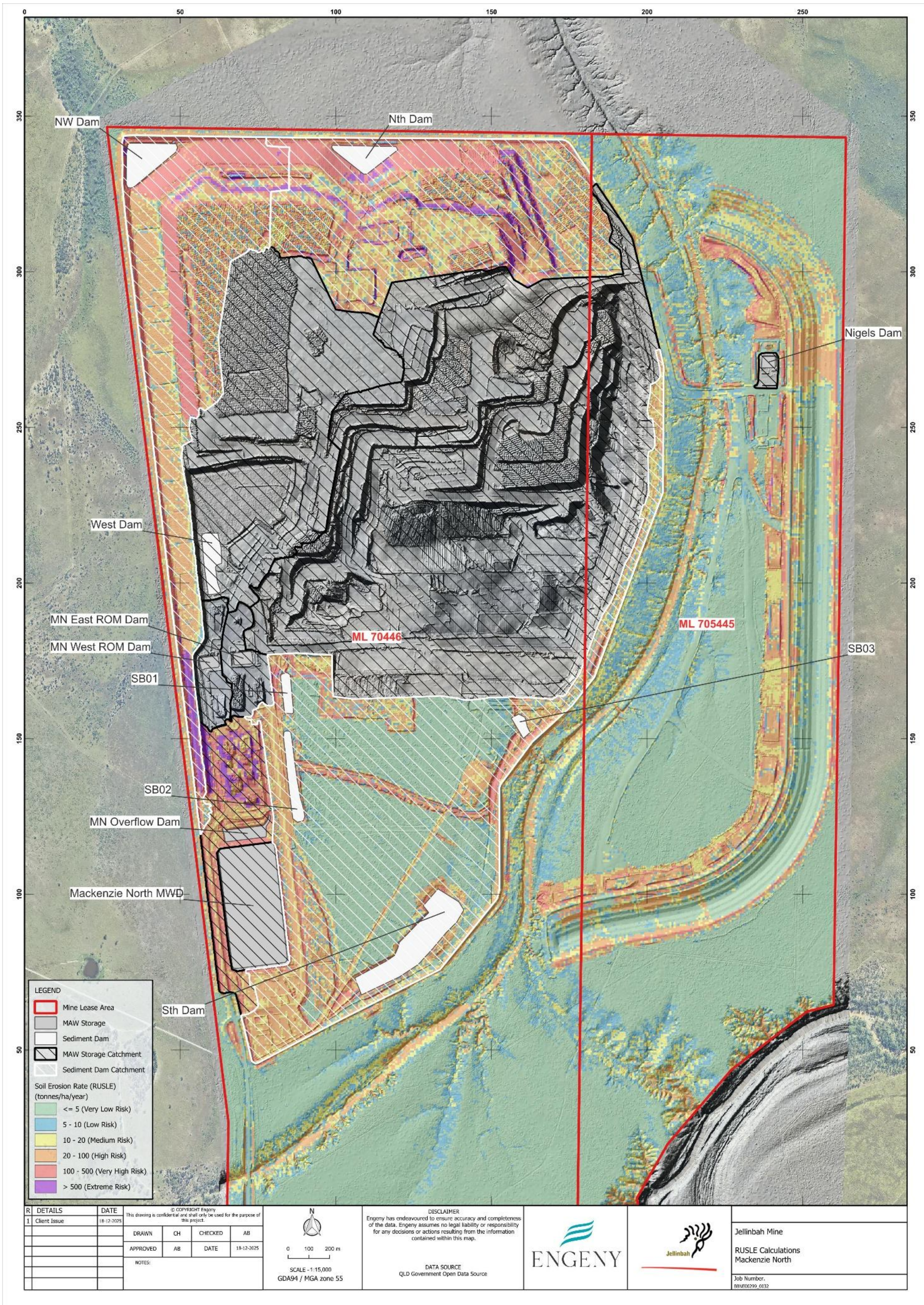

Figure 3-6: RUSLE Calculations: Mackenzie North

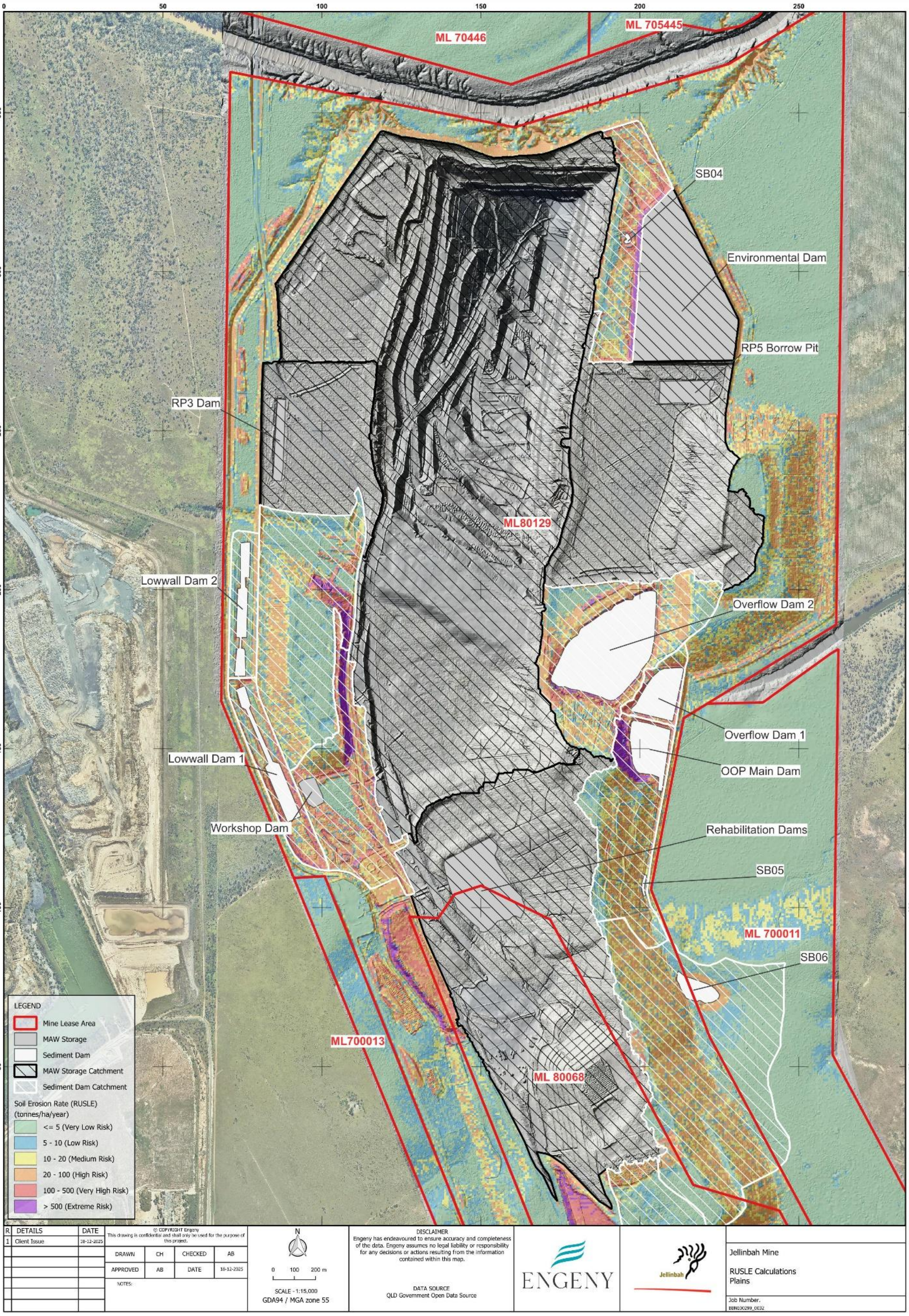

Figure 3-7: RUSLE Calculations: Plains

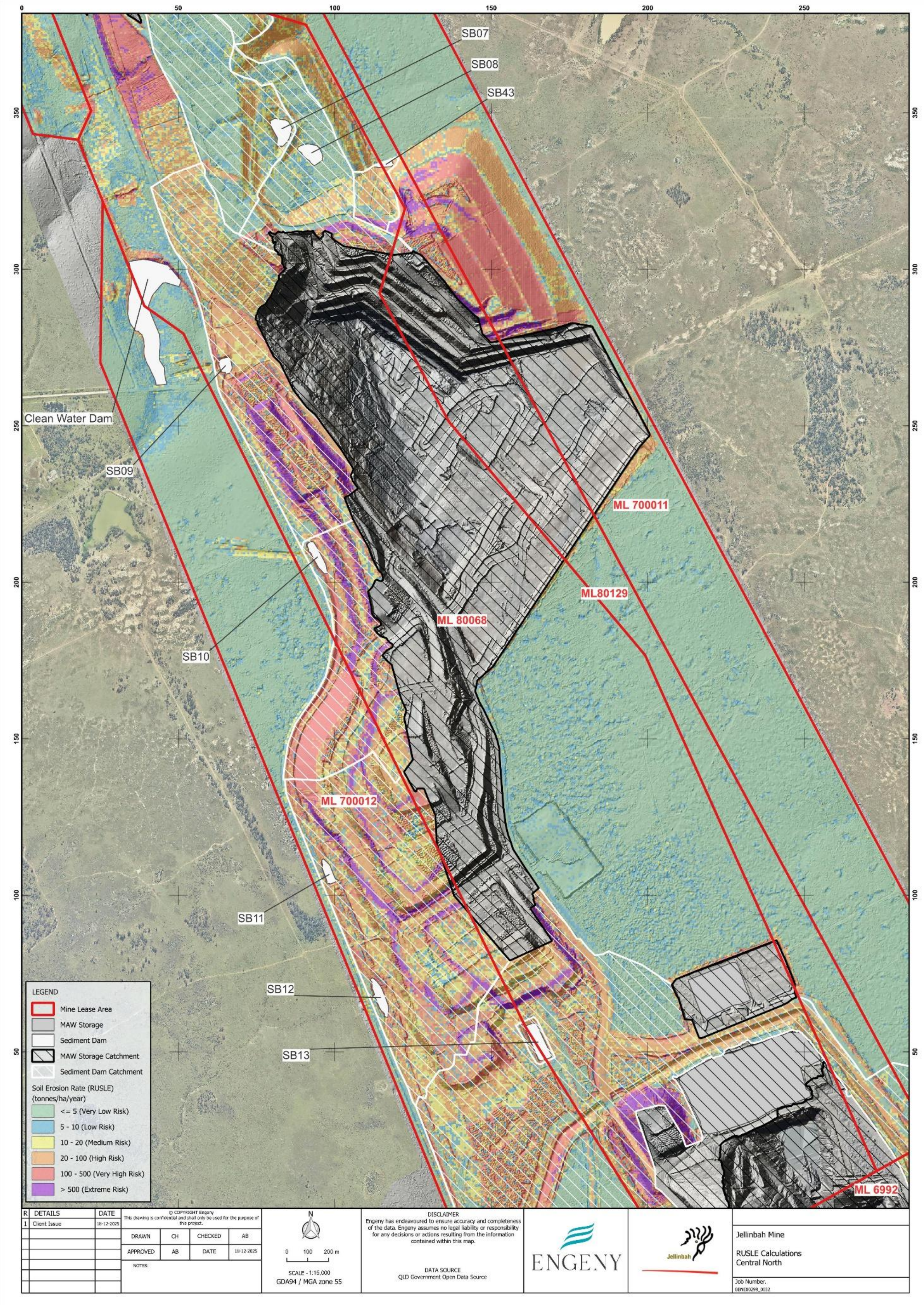

Figure 3-8: RUSLE Calculations: Central North

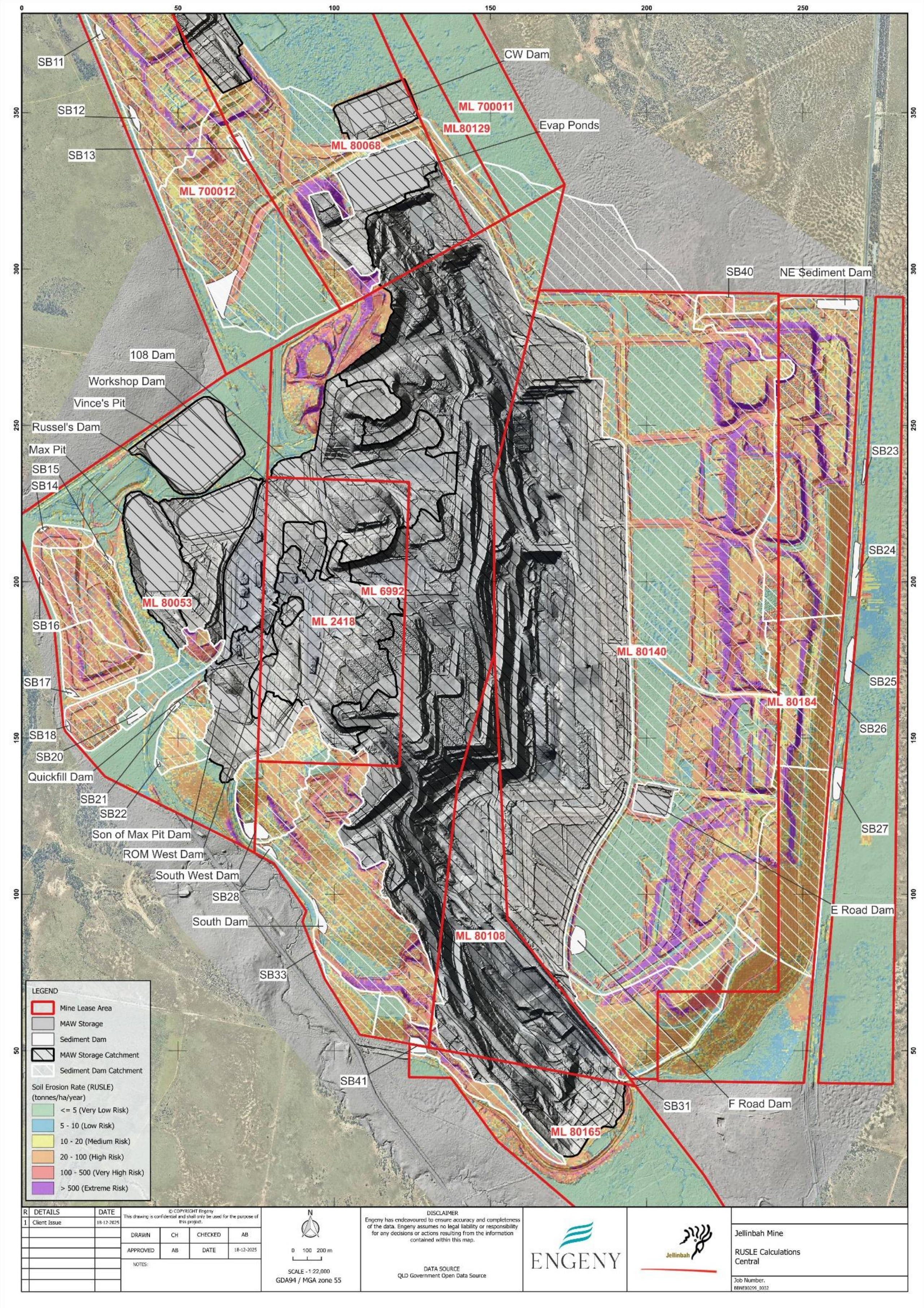

Figure 3-9: RUSLE Calculations: Central

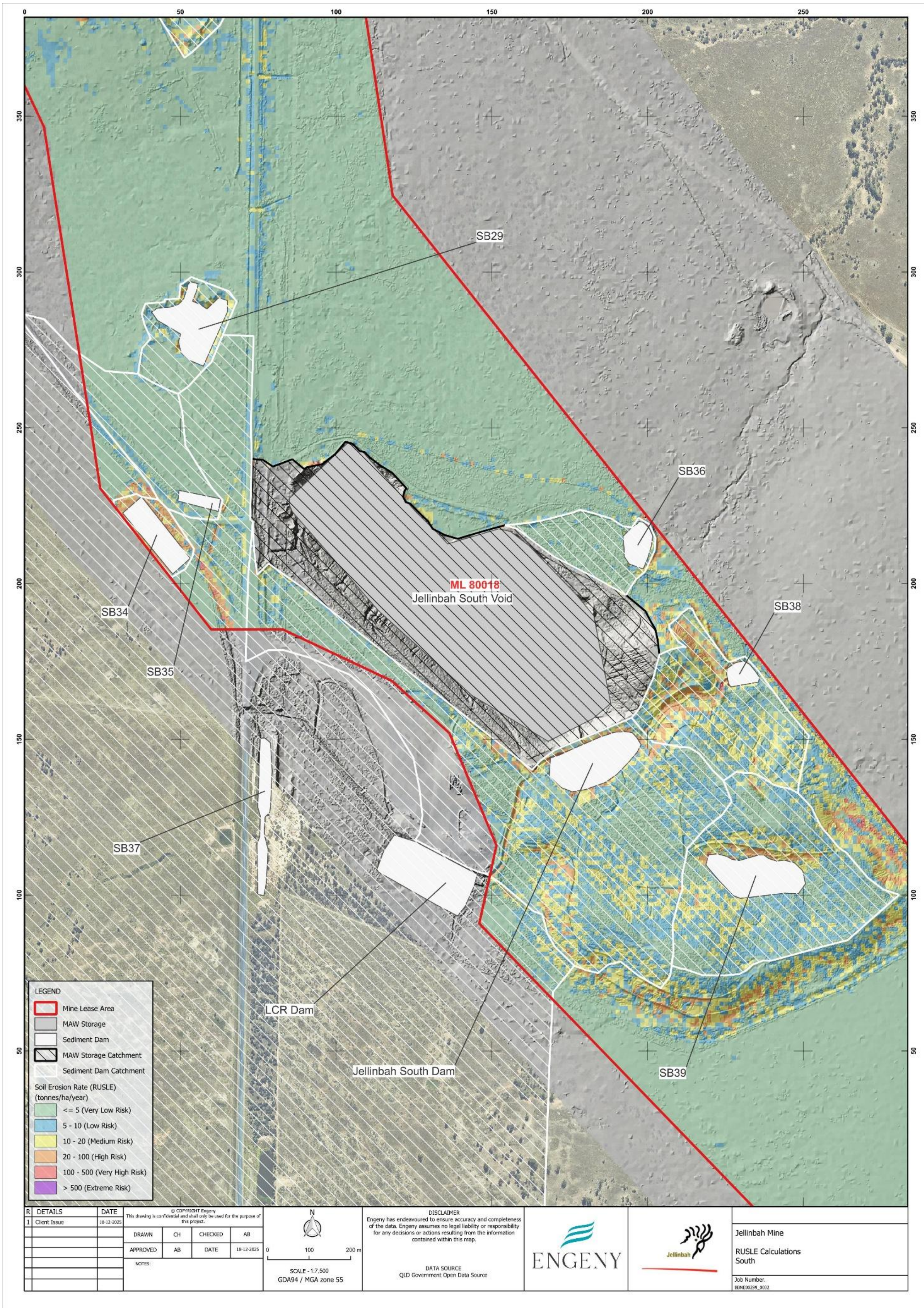

Figure 3-10: RUSLE Calculations: South

4 Planning and implementation

4.1 Principles

The ACARP Project C29046 (Chrystal et. al. 2022) and Volume 2E Mines and Quarries (Department of Environment and Climate Change NSW 2008) outline fundamental principles of ESC that should be integrated into disturbance planning. ESC planning and design needs to be suitable for site conditions, such as the climate, soil type, vegetation, and topographic features. These principles are summarised as follows:

- plan for erosion and sediment control during the project's design and before any earthworks begin, including assessment of site constraints;
- assess the soil and water implications of a project at the planning stage;
- prioritising the implementation of erosion and sediment control according to implementation priority, i.e. drainage, erosion and lastly sediment control;
- creating flexible plans to meet site conditions;
- minimise the area of soil disturbed and exposed to erosion;
- maximising sediment retention on site;
- minimising the containment of clean water and potential contamination by diverting non-MAW around disturbance/mining activities;
- conserve topsoil for later site rehabilitation (in a stabilised stockpile);
- monitoring and auditability of implemented erosion and sediment control controls; and
- rehabilitate disturbed lands as soon as land is available.

4.2 Timeline of events

ESC must be implemented for all stages of mining, from planning to construction, operations, and rehabilitation. Before any disturbance activities start, a Ground Disturbance Permit (GDP) must be completed. The purpose of the GDP is to identify and resolve any potential environmental, community, or infrastructure issues related to the proposed works.

As part of completing the GDP, a site-specific ESCP should be developed if an expansion or new clean water catchment is proposed. The disturbance-specific ESCP is to consider the following elements:

- the proposed staging of the works and the proposed controls;
- watercourses, catchments and approved release points, where appropriate;
- the location and extent of all stockpiles and the controls proposed to divert clean water around the stockpiles and the containment system;
- clean water and sediment diversions drains; and
- the proposed staged erosion and sediment controls, including the location, dimensions, details and staging of all works for all stages of the activity.

Appropriate control selection and design are discussed further in section 4.3. However, development activities will generally occur in the following order:

1) Construction of diversion drains (typically upslope of disturbance areas) – these will only be constructed where they will significantly reduce the catchment reporting to disturbance areas.

2) Construction of sediment dams/traps where required to provide for temporary retention of runoff from disturbance areas. Where practicable, existing dams, existing farm dams and non-operational open cut voids will be preferentially utilised for this purpose.

3) Construction of collection drains (downslope of or within disturbance areas) where required to convey runoff to sediment dams or other storage facilities.

4) Construction of sediment fences (downslope of disturbance and stockpile areas) where required.

5) Construction, pre-stripping or mining works will only take place once erosion and sediment control measures are in place.

4.3 Control Selection

A treatment train approach is the combined application of drainage, erosion and sediment control measures and is required for effective erosion and sediment control. Drainage design standards for temporary drainage works are detailed based on the anticipated design life while permanent works must be designed in accordance with the local stormwater drainage standards. It is common practice to design drainage structures based on an applied design storm, i.e., typically a 10% AEP design storm (Chrystal et. al. 2022; Landcom 2004).

Sediment control has limited efficacy and should only be implemented once options for drainage and erosion control have been exhausted. The aim of erosion control is to establish a stable landform through surface cover that prevents soil loss, while drainage control measures aim to prevent erosion (Chrystal et. al. 2022).

Where the current controls (i.e. sediment dams and drains) and catchment areas have been determined to be a medium to high risk, due to the estimated sediment loss of the area, improvement measures should be planned and implemented to reduce risks.

A description of potential ESC devices applicable to mining activities is provided in Table 4-1. This list is not exhaustive and specific solutions need to be developed to achieve erosion and sediment control objectives.

Table 4-1: Drainage, erosion and sediment control devices

Control	Description	Typical use
Drainage control		
Catch drains / flow diversion banks / levee banks	Low gradient drainage control. Earth mounds or similar structures are the most common physical control measures. The size of these structures is determined by the size of their catchment area.	• Divert flow around disturbed areas, stockpiles and cut batters. • Convey runoff to sediment traps/basins. • Intercept sheet flow and manage flow velocities down a sloped area. • These structures should not be constructed out of dispersive or highly erodible materials.
Open/diversion channel	Parabolic or trapezoidal cross-section with channel lining/ check dams were required.	To divert clean flow around disturbed areas. Direct flow into ESC devices.
Straw bale flow diversion bank	Low gradient control for temporary diversions (days/weeks)	Reduce channel velocities or divert low flows.
Chute	Steep gradient flow diversion	Typical outlet structures used to convey water from relatively flat longitudinal drains down a steep slope to a sediment basin or outlet device.
Check dams	Typically installed at regular intervals which are closer together on steeper slopes. They can be made from various materials including graded rock, sandbags, or fibre rolls (coir logs)	• Used in channels to trap sediment and control flow velocities by creating small ponds upstream of the dam. • They prevent minor gully erosion, particularly in new channels where vegetation has not yet been established.

Control	Description	Typical use
Outlet structure and spillways	Energy dissipation. Rock is generally used.	• Energy dissipator on pipe and culvert outlets. • Used at outlet of chutes and slope drains to dissipate flow energy and control scour.
Rock lining - riprap	Durable, well-graded riprap (rock) used for stabilising the bed of steep channels	• Must ensure that design meets flow capacity of the drain. • When applied correctly prevents scour of underlying material.
Erosion control		
Revegetation	Soil stabilisation and protection. Also used for progressive rehabilitation.	• Stabilisation of temporary and long-term stockpiles. • Stabilisation of dam banks, diversion channels, and drains. • Includes turfing and temporary seeding.
Light mulching	Hay mulch or hydromulch – an effective means of short-term erosion control.	• To reduce flow velocities and increase infiltration. • To control raindrop impact, water loss, and assists seed germination on newly seeded soil. • Stabilisation of dam banks, diversion channels, and drains.
Gypsum application	Gypsum reclaims alkaline soils, enhances soil properties, reduces soil erosion and runoff, and lessens nutrient and carbon losses.	• Erosion and sediment control for exposed soil. • Used as an ameliorant for progressive rehabilitation.
Contour deep ripping	Deep ripping along contours improves infiltration of sheet flow and increases surface roughness thereby reducing runoff.	• Used to relieve soil compaction and improve water infiltration on exposed dispersive subsoils and the dispersive topsoil stockpile. • This measure should be undertaken in conjunction with gypsum application.
Sediment control		
Sediment fences/barriers	Temporary devices used to intercept sheet flow. Sediment fencing should be installed around the extent of the disturbance area where sediment-laden water could potentially enter clean downstream receiving waters.	• Use only as a last line of defence in combination with other temporary stabilisation techniques. • Intercept sheet flows, creating small ponds of water upstream, and acting as minor sediment dams.
Check dams	Improves runoff quality by intercepting concentrated flows and captures bed loads. Check dams capture sediment without changing channel design.	• Intercepts and filters concentrated flows by creating small weir structures, reducing flow velocities and allowing bed loads sediments to settle behind the structures. • Channel banks less than 1V:2H, channels with a slope greater than 1V:100H and less than 1V:10H. Catchment areas <2 ha.
Sediment traps - vegetative buffer	Improves runoff quality by intercepting and filtering sheet flow. Intercepts and filters surface water runoff before it enters a waterway. Should ideally be located	• Not to be applied as a standalone measure.

Control	Description	Typical use
	adjacent to any receiving waters or riparian vegetation.	• Use in conjunction with sediment fences to improve performance when large amount expected. • Only suitable for small catchments and low gradient slopes.
Sediment traps	Sediment traps are an interim measure to minimise the movement of material.	• Sediment traps act as settling areas to manage particulates. • Ideally their role in erosion control should diminish over time as the mine is rehabilitated or stabilised by other methods.
Sediment basins	Areas of low topography, occurring either naturally or by excavation, where excess storm water can be retained and allowed to dam. They may have water flows directed into them via diversion banks, contour and/or levee banks. If the freeboard volume in sediment dams approaches design capacity between rainfall events, options for dewatering include recycling water for mine activities (e.g. dust suppression, irrigation or moisture conditioning of earthworks) and transfer to mine water storages should be considered.	• Sediment control, used as a last line of defence after drainage and erosion controls are in place. • Captures and detains sediment laden runoff for a sufficient period to allow the settlement of sediments. • Not effective for dispersive soils. • Not as effective during large storm events. • Numerous design considerations.

Proposed ESC and management strategies for identified at-risk activities and areas are described in Table 4-2 (refer to Appendix A for general diagrams of ESC measures). Monitoring and maintenance programs have also been described. Further details regarding monitoring and review are provided in section 5.

4.4 Sediment basin design

The detailed design and sizing of a sediment basin should be carried out by an appropriately qualified person to ensure it has sufficient capacity and that the water released meets regulatory standards for quality. The actual capacity of a sediment basin includes the combined volume of the sediment settling storage (the live storage zone) and the sediment storage (the dead storage zone) as illustrated in Appendix A.

The settling storage zone is designed to capture the maximum sediment load during a nominated design rainfall event, while the sediment storage zone is used to accumulate and store settled sediments between de-silting events. The design principles for the sediment settling storage vary depending on the existing soil classification, such as coarse, fine, or dispersive.

Analysis of laboratory results for soil types across JM, and review of the TMP for soil management unit descriptions, is recommended to understand the soil texture groups most applicable:

- Type D soils contain a significant proportion of fine (< 0.005 mm) dispersible materials that will not settle unless flocculated. Not all particles that are finer than 0.005 mm are dispersible.
- Type C soils comprise majority coarse-grained material (< 33% finer than 0.02 mm) and will settle relatively quickly in a sediment basin.
- Type F soils comprise mostly fine grained (≥ 33% finer than 0.02 mm) and require a much longer retention time to settle in a sediment basin.

JM typically requires containment sediment dams due to dispersive and fine soils. Sediment dams with large sediment loads (large catchment or soil loss rate) are to be designed to contain the 1:10 AEP 24-hour design rainfall event (~134mm rainfall) with an additional 20% volume allowance for sediment storage. This approach has been adopted for recently constructed sediment dams including the NE Sediment Dam and Central Sediment Dam and resulted in a storage volume of **0.78 x total catchment area**. This method should be used for the conceptual planning of new sediment dams for JM and refined in detailed design based on catchment specific risks.

4.4.1 Implementation of basin type

A containment system is recommended for fine and dispersive materials. This system is designed with low design criteria, e.g. 24-hour, 50%, 20% or 10% AEP to retain a nominated design rainfall depth and is based on a risk-based approach. Options for management of retained water include:

1) Treatment with settling agents and allow to drain under gravity. Note that flocculants can cause environmental harm if not managed appropriately and therefore need to be carefully considered and managed appropriately. Design considerations include flocculant management and retention requirements.

2) Treat as you would MAW and pump to other water storage structures within the onsite mine water system. Design considerations include the retention requirements, pump out rates, site water balance, EA release conditions.

3) Provide an extended settling time based on sediment settlement analysis and monitor before actively releasing. The required sediment settling period is based on the settling velocity of the target sediment size. Releases must consider the catchment size and the flow regime of the receiving waterways.

A flow-through system is recommended for medium to coarse sediments, to retain surface water runoff and allow for settlement before passively releasing to the environment within a specified period. This option considers the catchment area of the basin, and the minimum design capacity criteria recommended as follows, adapted from Landcom (2004) and Chrystal et. al. (2022):

- Sediment settling volume zone: Capacity to store the runoff produced from the 80th percentile, X-day rainfall event/depth mm (e.g. 5 to 10 days).
- Sediment storage zone: Two months calculated soil loss estimated using RUSLE, or as per the method in section 4.4.2 below.

The number of days rainfall event/depth (mm) is essentially a management period and considers the time to achieve effective settlement and flocculation.

4.4.2 Sediment storage

The provision of adequate storage depends on the soil loss volume from the contributing catchments and the desilting frequency. The sediment storage capacity can be quantified by applying the GIS based RUSLE methodology to the contributing catchment of the sediment basin to estimate the sediment runoff volume (t/ha/year) over the desired maintenance period (Chrystal et. al. 2022):

$$\text{Sediment storage volume, } V_2 = \frac{0.001 \times RUSLE}{f \times \rho}$$

Where:

V_2 = sediment storage volume (ML)

A = Contributing catchment area (ha)

RUSLE = Soil loss volume (t/year)

f = desired maintenance frequency per year (times/year)

$\boldsymbol{\rho}$ = soil density (~1.4 t/m3)

The following options should be investigated if the criteria result in an excessively large sediment storage volume:

- Reduce the catchment area;
- Introduce supplementary erosion control measures;
- Increase the sediment desilting removal frequency.

Sediment basins should generally be desilted when sediment levels accumulate to half the basin depth. The volume of accumulated sediment requires regular monitoring by measuring the sediment level.

4.5 Sediment dam dewatering

If the available freeboard volume in sediment dams is approaching the required design capacity between rainfall events, water will be released only if the total suspended sediment (TSS) content meets the recommended criterion of 50 mg/L (Landcom, 2004) or the natural waterway TSS (testing required). Dewatering would occur to well-grassed areas where sufficient grassed buffer exists to prevent the migration of sediments to watercourses.

Flocculant addition will be used, if required, to meet the recommended Landcom (2004; 2008) criterion. Alternatively, sediment dams would be dewatered to mine water storages or stored water used directly for mine activities such as dust suppression, irrigation and moisture conditioning of earthworks.

Table 4-2: Proposed controls and mitigation measures

Standard activity/location	Proposed controls and mitigation measures	Inspection and maintenance program
Flood levees	• Flood levees are designed and constructed around operational areas or significant infrastructure development projects to provide immunity for a 1:1000 year Annual Exceedance Probability (AEP). • Levees are topsoiled, mulched, and revegetated.	• Pre wet season monitoring of levee condition by Registered Professional Engineer of Queensland. • Monitoring of levee following flood events and routinely during the wet season for early identification of erosion. • Major modifications should be inspected by a qualified engineer.
Infrastructure areas: • Workshop areas • Construction/maintenance of unsealed heavy and light vehicle access	• Runoff from infrastructure areas is collected in diversion channels, sediment traps, sediment basins, and MAW dams (for runoff from workshop areas). • Exposed surfaces to be stabilised with non-dispersive materials	• Existing infrastructure areas, and road bunds, should be inspected for erosion damage. • Sediment to be settled prior to water being reused or evaporated. • Diversion channels, sediment dams and other control devices should be inspected during the wet season, in particular following heavy rainfall events to monitor for failures.
Active spoil dumps	• Catch drains / flow diversion banks • Diversion channels • Check dams • Sediment traps • Sediment basins • Progressive rehabilitation as areas become available in accordance with PRCP Schedule: o Recontouring spoil dumps o Gypsum application o Contour ripping o Revegetation	• Control devices should be inspected following heavy rainfall events, and during the wet season, to assess condition, water retention and transport capacity. • Spoil areas are inspected to assess evidence of erosion. • Laboratory testing of physicochemical parameters to determine appropriate erosion controls and spoil placement. • Testing sediment basins for TSS. • Sediment deposits are to be removed prior to the wet season from sediment control devices.
Progressively rehabilitated areas	• Rehabilitation in accordance with the PRCP Schedule with required landform development drainage, and erosion controls applied. • Runoff from rehabilitated spoil is collected in catch drains, flow diversion banks, diversion channels and sediment traps.	• Laboratory testing of topsoil and spoil quality to maximize vegetation establishment and minimize any potential soil erosion. • Determine if any type of amelioration is needed (e.g gypsum) • Sediment traps and drains are inspected during the wet season to assess TSS, condition, water retention and transport capacity.

Standard activity/location	Proposed controls and mitigation measures	Inspection and maintenance program
		• Sediment deposits are to be removed prior to the wet season. • Control devices should be inspected during the wet season, in particular following heavy rainfall events to monitor for failures. • Recontoured spoil areas are inspected to assess erosion impacts. • Eroded areas to be repaired with non-dispersive materials and revegetation.
Coal stockpiles/ROM Pad and handling equipment areas	• Runoff from coal stockpiles collected in MAW catch drains/flow diversion banks and dams prior to being recycled or evaporated. • Dams and drains designed and constructed with appropriate water retention and transport capacity by an appropriately qualified person	• ROWIT survey completed annually. • Regulated structures inspected and maintained annually. • Complete annual pre-wet season inspection schedule. • Routine monitoring of dam water levels and quality. • Water management infrastructure inspected for erosion. • Sediment deposits removed prior to the wet season. • Infrastructure managed in accordance with WMP.
Water management structures (e.g. dams, diversions and drains etc.)	• Levee banks/bunds of sediment basins revegetated and mulched. • Drainage channels: o Use appropriate channel lining and energy dissipation measures, including energy dissipation structures at drainage outlets. o Drain design minimises water velocity. o Rock lining and/or revegetating, mulching and topsoiling steep channels where required. • Sediment basins designed by an appropriately qualified person following design criteria. Outlet structures installed where required.	• The diversion drain and embankments should be inspected for bank erosion and sediment accumulation prior to and following heavy rainfall events during the wet season. • Water management structures inspected during the wet season and maintained where required.
Topsoil stockpiles	• Catch drains / flow diversion banks. • Diversion channels. • Revegetation of topsoil stockpiles for long term stockpiling. • Placing stockpiles strategically for protection from wind erosion near vegetation buffers. • Sediment traps. • Sediment fences.	• Stockpiles monitored for erosion from surface runoff or wind erosion. • Stockpiles inspected for vegetation growth. • Laboratory testing of topsoil quality to maximize vegetation establishment and minimize any potential soil erosion.

Standard activity/location	Proposed controls and mitigation measures	Inspection and maintenance program
		• Control devices should be inspected during the wet season, in particular following heavy rainfall events to monitor for failures.
Pre-strip areas (vegetation cleared) and topsoil stripped areas	• Catch drains / flow diversion banks • Windrow vegetation debris along the contour. • Divert clean water run-off away from disturbed areas. • Direct run off from cleared areas to sediment dams. • Restrict clearing to areas essential for the works. • Minimise length of time material is exposed. • Sediment fences. • Sediment traps.	• Control devices should be inspected during the wet season, in particular following heavy rainfall events to monitor for failures.

4.6 Topsoil and spoil management

A Topsoil Management Plan (TMP) has been developed by AARC (2023) for Jellinbah. The TMP provides the soil types at the site, methods for salvaging and stockpiling soils, approaches for applying topsoil in rehabilitation, and an inventory of topsoil quantities.

As per the TMP, topsoil stripping is to be conducted prior to the disturbance of land required for mining activities in a progressive manner to reduce erosion and sediment generation, minimise the stockpile volumes and enable direct use in rehabilitation works.

To limit erosion and control sediment loss the following management measures are recommended:

- stripping depth should be conducted as per recommendations from Table 5 of the TMP (AARC 2023);
- stockpiles should be placed away from drainage areas, roads, machinery, and stock grazing areas;
- stockpiles should be strategically located to maximise protection from prevailing winds and the threat of wind erosion (e.g., adjacent to cleared vegetation stockpiles and existing vegetation buffers);
- it is recommended that topsoil stockpiles do not exceed above 2 metres (m) in height;
- stockpiles should be constructed with appropriate embankment grades to limit erosion of the outer pile face;
- if the period of stockpiling is greater than one growing season or six months, the stockpiles may need to be ripped and seeded to limit erosion and maintain seed viability; and
- overland runoff onto stockpile sites should be minimized, and control measures, such as runoff collection drains and dams, should be constructed as required.

4.7 Progressive rehabilitation

Jellinbah undertakes progressive rehabilitation of disturbed areas, as soon as practicable, in accordance with the PRCP Schedule. Progressive rehabilitation reduces erosion risk of disturbed areas, and minimises sediment loss within clean water catchments. Temporary sediment traps and dams are used to capture runoff, until the required ground cover has been established successfully across final landforms.

ESC measures are implemented throughout the stages of each rehabilitation milestone to be achieved, from landform development to meeting revegetation criteria. For example, the final landform design for spoil dumps (see section 4.7.1) includes drainage controls such as recontouring to defined slope lengths and gradients, and the installation of horizontal benches to break up continuous slopes and dissipate surface water flow.

Once the landform has been constructed to design specifications, surface preparation activities require soil to be of suitable quality, ameliorants and hay mulch to be applied where required, and deep ripping along contours. These are additional ESC measures that assist in managing sediment loss until the successful establishment of vegetation.

The revegetation plan design provides for the rapid establishment of a fast-growing ground cover crop during the early phase immediately following landform construction of disturbance. The cover crops reduce sediment loss and act to minimise erosion until slower growing native vegetation can establish.

Revegetation is a highly effective control tool for reducing erosion risk and sediment loss. The effectiveness of established ground cover, resulting in a lower residual erosion risk, can be measured by following the methodology outlined in section 3.3.1. Rehabilitation milestone criteria require rehabilitated areas to achieve total vegetative groundcover targets appropriate to the slope of the final landform (see section 4.7.1). Completed areas are monitored annually to evaluate the progress of revegetation actions, and record any evidence of erosion to be repaired.

4.7.1 Final landform design

The final landform surfaces for spoil dump areas will be designed to avoid water concentration down slopes, eliminating the need for maintenance-heavy contour banks and drains. Horizontal benches of 10-15 meters wide will break continuous slopes, typically installed every 15 meters of vertical height. The bench design aims to prevent water accumulation that could cause erosion.

Permian waste will be preferentially placed on the outer surface of sloped landforms. Target slope grade < 17% and a maximum length of 133m between benches. When Tertiary or Quaternary waste is used on the outer surface, the slope design will be 10% with a maximum length of 220 meters between benches. A temporary berm will be placed at the top of the slopes to minimize runoff, remaining in place until at least 70% vegetation cover is achieved on both the crest and sloped areas.

To ensure long-term erosion stability, achieving self-sustaining ground cover is recommended as follows:

- Slopes 0 to 5% vegetative groundcover ≥ 55%
- Slopes over 5 to 10%, vegetative groundcover ≥ 70 %
- Slopes over 10%, vegetative groundcover of at least 80%

High ground cover is crucial for preventing erosion and establishing stability. The sensitivity analysis conducted as part of the PRCP indicated that acceptable erosion rates (less than 10 t/ha/yr) can be achieved under various slope conditions, even with different types of ground cover or soil treatment.

5 Monitoring and review

5.1 Monitoring and maintenance

Maintenance and monitoring are essential for demonstrating ongoing regulatory compliance. Most ESC are designed to operate during less intense and more frequent rainfall events, while some are built to withstand more intense and less frequent rainfall. It is crucial to ensure that erosion and sediment controls remain functional and are not compromised by damage or excessive wear. An indicative maintenance schedule based on typical climate patterns experienced in Queensland has been provided in Figure 5-1 (Chrystal et. al. 2022).

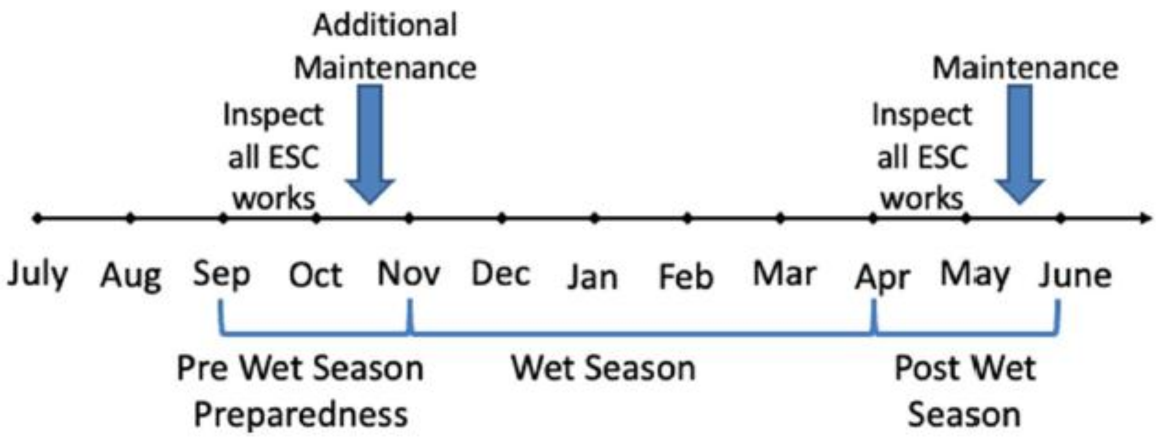

Figure 5-1: Maintenance schedule (Chrystal et. al. 2022)

Inspections should be undertaken post any significant rainfall event (e.g. greater than 25 mm of rainfall in 24 hours). Storm event monitoring of ESC must be carried out in response to two types of extreme weather events:

- Trigger storm event – rainfall depth received within 24hour period will require site personnel to inspect and document the conditions of critical ESC (high risk areas).
- Significant storm event – rainfall depth received within 24hour period will require site personnel to inspect and document the conditions of critical and non-critical ESC (all risk areas).

Monitoring and inspections of the ESC will include:

- Photographs;
- Summary of identified maintenance requirements for each device;
- Observational notes on any evidence of erosion or scouring;
- Inspections of water levels, silt build-up, and the presence of hydrocarbons; and
- Monitoring of TSS concentrations,

If the type and/or location of ESC structures are identified during inspections as being ineffective, the control structures will be modified. De-silting of ESC structures will be carried out as necessary to ensure the efficiency and capacity of the structure is maintained. This will be determined through visual assessment.

5.2 Records and reporting

5.2.1 Internal

Inspection checklists and audits performed on ESC across site will be stored within the Jellinbah intranet.

Areas of significant visual degradation, within a defined clean water or sediment dam catchment, should be reported to the Environmental Superintendent and Jellinbah management as soon as possible.

5.2.2 Regulatory authority

After becoming aware of any incident which results in the release of contaminants not in accordance, or reasonably expected to be not in accordance with the conditions of the EA, an Approved Delegate will notify the Department of the Environment, Tourism, Science and Innovation (DETSI) in writing or by telephone as soon as practicable (as per the EA Schedule A Conditions). This may occur in the event that a failure of an ESC device results in the release of MAW to the receiving environment from JM.

5.3 ESCP Review

This document will be reviewed annually alongside the WMP, or earlier if circumstances require it. The review will consider:

- evaluation of existing catchments and structures (as per Section 3 and sub-sections);
- opportunities for improvement identified in inspection checklist records;
- any amendments to relevant legislation, policy and guidelines;
- the risk assessment approach and any updates required for data inputs;
- any changes to mine plans, mining activities or construction/mining/rehabilitation works; and
- the findings of new research and trials.

5.3.1 Plan performance criteria

The performance of the ESCP will be evaluated during the annual review. Relevant performance criteria to be considered during the annual review are:

- no significant build-up of sediment in the sediment dam system and drains as a result of erosion of sediment from rehabilitation activities;
- no degradation of water quality and biological integrity of the receiving environment;
- turbidity and suspended solids levels not to exceed the EA Conditions for MAW release limits;
- no evidence of sediment being deposited offsite; and
- no failure of ESC devices.

5.4 Roles and responsibilities

The role and responsibilities for the implementation of the actions in the ESCP are outlined in Table 5-1.

Table 5-1: Roles and responsibilities

Role	Responsibility
General Manager / SSE	Ensure resources are available to implement the contents of this plan.
Environmental Superintendent	• Implement the contents of this plan. • Facilitate ESCP reviews. • Train staff in environmental awareness, site issues and requirements of the ESCP. • Facilitate the monitoring and implementation of requirements outlined in the ESCP. • Report non-conformances with the ESCP to Technical Services Manager (TSM) and ensure corrective actions are closed out. • Advise TSM and other management on EA Condition requirements and provide advice to assist with achieving compliance. • Report environmental incidents to DETSI • Investigate environmental incidents and liaise with DETSI, where necessary.
Manager Mine Services	• Risk owner and governance • Blueprinting • Structural integrity • Capital upgrades and major maintenance • Review of inspection checklists • Legislative and EA compliance
Employees	• Be familiar with the contents of the ESCP and consider its implementation in relation to works. • Undertake erosion and sediment control works in compliance with requirements outlined in this ESCP. • Report visual degradation or apparent non-conformance with this ESCP or approved plan for construction, operational or rehabilitation works within the same work shift as observed.
Contractors	• Undertake corrective action as soon as practicable. • Be familiar with the contents of the ESCP and consider its implementation in relation to works. • Prepare, design and plan for construction, operational and rehabilitation works in compliance with the requirements of the ESCP. • Undertake works in compliance with the ESCP approved Jellinbah. • Report any non-conformance/environmental incidents within the same work shift as noticed.
Mine Services Supervisor	Routine minor maintenance of ESC structures
Manager Mine Production & Maintenance	Closure planning

6 References

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Landcom (2004) Managing Urban Stormwater Soils and Construction ("Blue Book"). Volume 1: Soils and construction. Fourth Edition. NSW Office of Environment and Heritage.

Landcom (2008) Managing Urban Stormwater Soils and Construction ("Blue Book"). Volume 2E: Mines and Quarries. NSW Office of Environment and Heritage.

Appendix A. ESC design drawings

The standard drawings consist of diagrams displaying typical installation layout and dimensions and specifications for the materials, installation, maintenance and removal of ESC measures. These drawings are provided by Book 6 of Best Practice Erosion and Sediment Control (International Erosion Control Association 2008).

Diversion Banks and Drains

The purpose of diversion structures is to intercept water runoff and to divert it at low velocities either around disturbed land or into sediment control structures for treatment. To minimise the level of erosion, the velocity of runoff water can be reduced by implementing controls such as rock structures which are further described below.

Design and dimensions of diversion banks and drains in relation to slope are shown below.

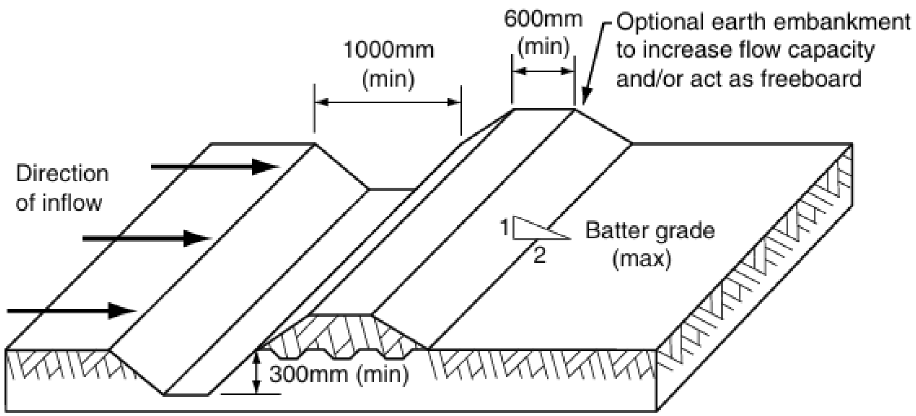


Figure 1 - Typical profile of diversion channel with bank

INSTALLATION

1. REFER TO APPROVED PLANS FOR LOCATION, EXTENT, AND CONSTRUCTION DETAILS. IF THERE ARE QUESTIONS OR PROBLEMS WITH THE LOCATION, EXTENT, OR METHOD OF INSTALLATION, CONTACT THE ENGINEER OR RESPONSIBLE ON-SITE OFFICER FOR ASSISTANCE.

2. ENSURE ALL NECESSARY SOIL TESTING (e.g. SOIL pH, NUTRIENT LEVELS) AND ANALYSIS HAS BEEN COMPLETED, AND REQUIRED SOIL ADJUSTMENTS PERFORMED PRIOR TO PLANTING.

3. CLEAR THE LOCATION FOR THE CHANNEL, CLEARING ONLY WHAT IS NEEDED TO PROVIDE ACCESS FOR PERSONNEL AND CONSTRUCTION EQUIPMENT.

4. REMOVE ROOTS, STUMPS, AND OTHER DEBRIS AND DISPOSE OF THEM PROPERLY. DO NOT USE DEBRIS TO BUILD ANY ASSOCIATED EMBANKMENTS.

5. EXCAVATE THE DIVERSION CHANNEL TO THE SPECIFIED SHAPE, ELEVATION AND GRADIENT. THE SIDES OF THE CHANNEL SHOULD BE NO STEEPER THAN A 2:1 (H:V) IF CONSTRUCTED IN EARTH, UNLESS SPECIFICALLY DIRECTED WITHIN THE APPROVED PLANS.

6. STABILISE THE CHANNEL AND BANKS IMMEDIATELY UNLESS IT WILL OPERATE FOR LESS THAN 30 DAYS. IN EITHER CASE, TEMPORARY EROSION PROTECTION (MATTING, ROCK, ETC.) WILL BE REQUIRED AS SPECIFIED WITHIN THE APPROVED PLANS OR AS DIRECTED.

7. ENSURE THE CHANNEL DISCHARGES TO A STABLE AREA.

MAINTENANCE

1. DURING THE SITE'S CONSTRUCTION PERIOD, INSPECT THE DIVERSION CHANNEL WEEKLY AND AFTER ANY INCREASE IN FLOWS WITHIN THE CHANNEL. REPAIR ANY SLUMPS, WHEEL TRACK DAMAGE OR LOSS OF FREEBOARD.

2. ENSURE FILL MATERIAL OR SEDIMENT IS NOT PARTIALLY BLOCKING THE CHANNEL. WHERE NECESSARY, REMOVE ANY DEPOSITED MATERIAL TO ALLOW FREE DRAINAGE.

REMOVAL

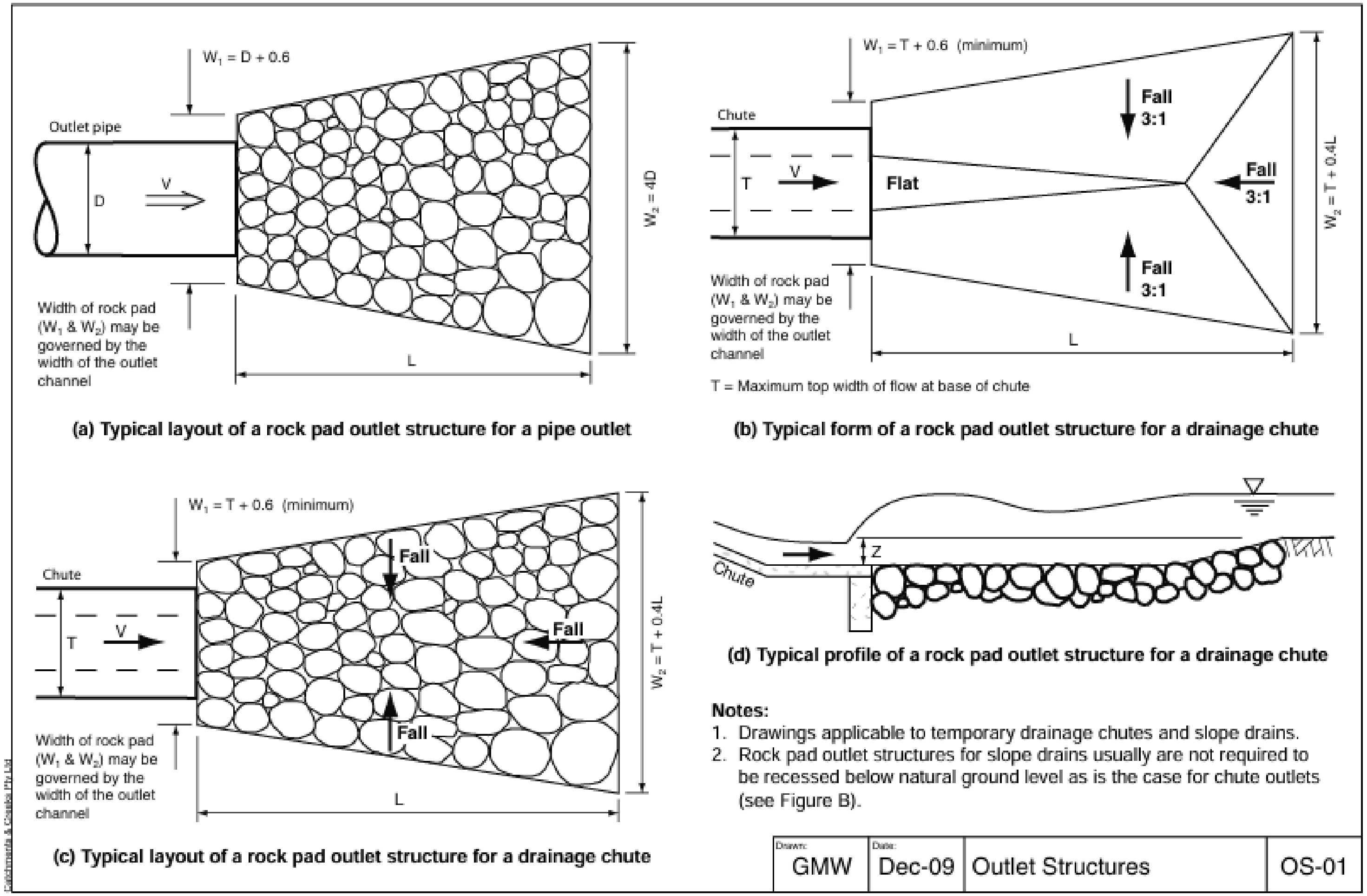
1. WHEN THE CONSTRUCTION WORK ABOVE A TEMPORARY DIVERSION CHANNEL IS FINISHED AND THE AREA IS STABILISED, THE AREA SHOULD BE APPROPRIATELY REHABILITATED.

2. DISPOSE OF ANY COLLECTED SEDIMENT OR FILL IN A MANNER THAT WILL NOT CREATE AN EROSION OR POLLUTION HAZARD.

3. GRADE THE AREA AND SMOOTH IT OUT IN PREPARATION FOR STABILISATION.

4. STABILISE THE AREA AS SPECIFIED IN THE APPROVED PLAN.

Rock structures can also be used in areas where temporary control is required but can also be used as a permanent erosion and sediment control. The rocks receive the initial force of the flow and disperse it, slowing down the flow and therefore minimising the erosion potential, similar to the hay bales. Rock structures can be used in two ways, one is at the outlet of pipes or culverts where the rocks are simply placed under and around the outlet, and the other is rock lining within channels at intervals to slow the flow further.



(a) Typical layout of a rock pad outlet structure for a pipe outlet

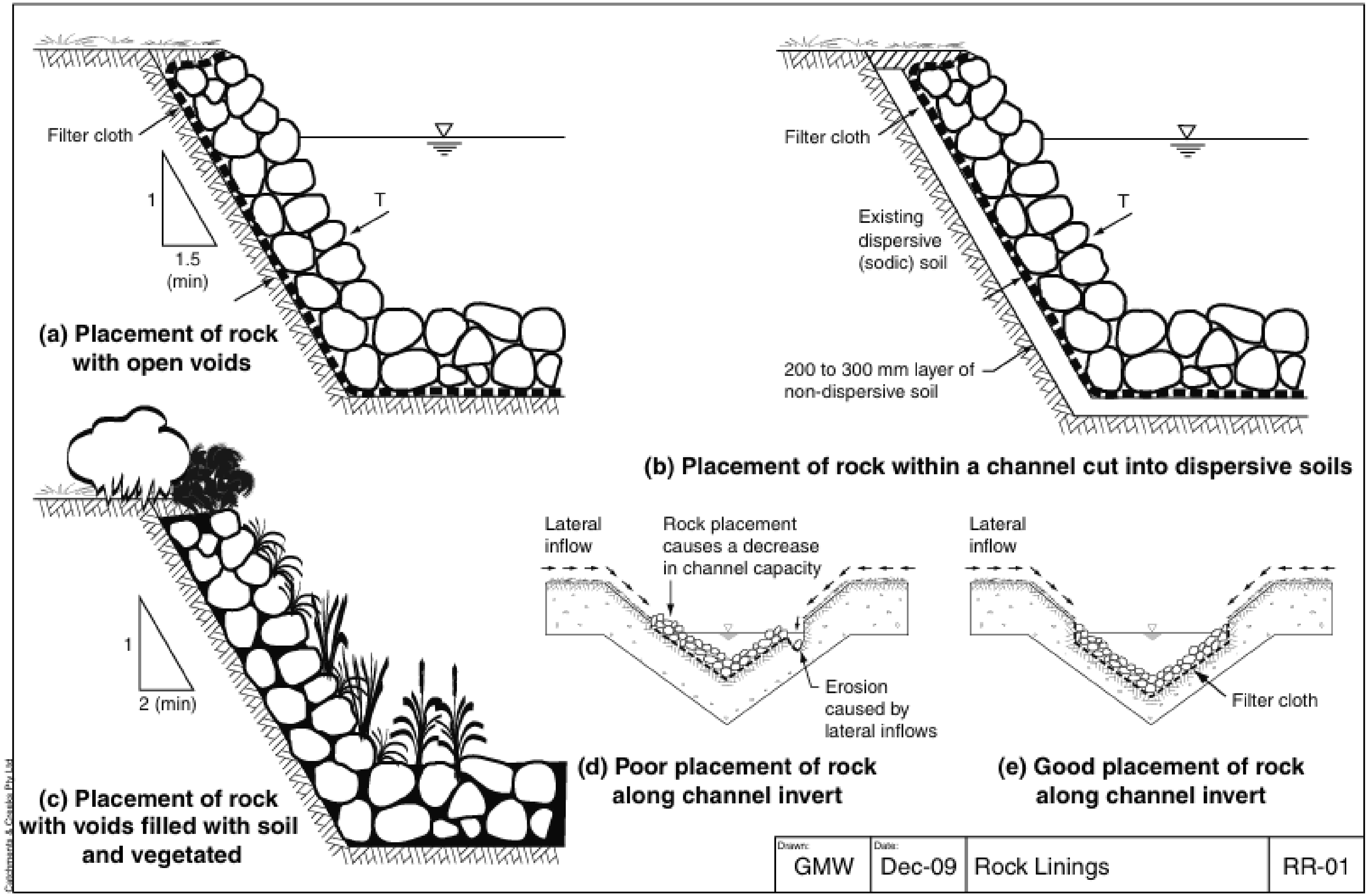
(b) Typical form of a rock pad outlet structure for a drainage chute

(c) Typical layout of a rock pad outlet structure for a drainage chute

(d) Typical profile of a rock pad outlet structure for a drainage chute

Notes:

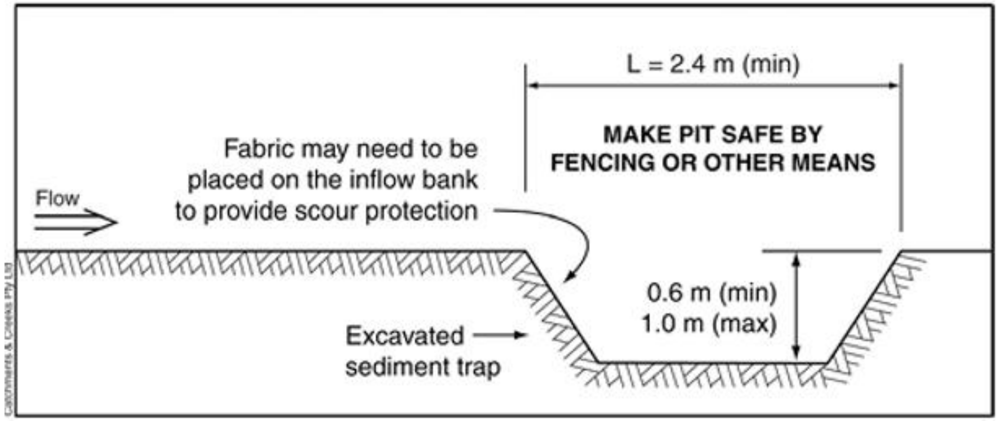
1. Drawings applicable to temporary drainage chutes and slope drains.
2. Rock pad outlet structures for slope drains usually are not required to be recessed below natural ground level as is the case for chute outlets (see Figure B).

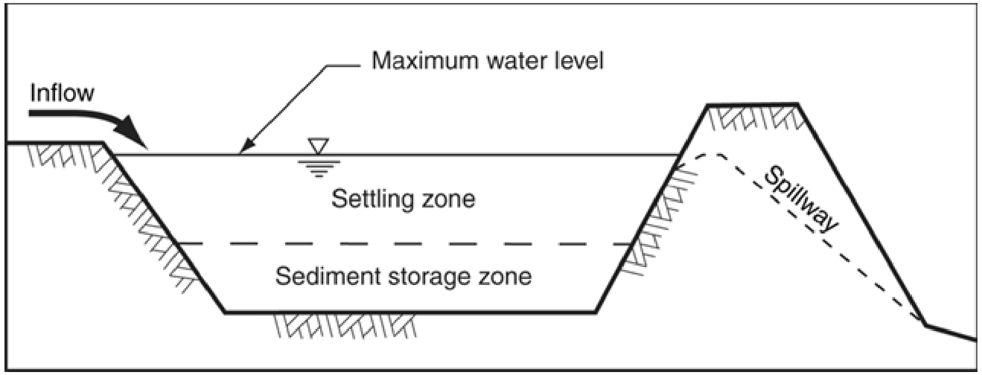

Filter cloth
1
1.5
(min)
T
(a) Placement of rock with open voids
Filter cloth
Existing dispersive (sodic) soil
T
200 to 300 mm layer of non-dispersive soil
(b) Placement of rock within a channel cut into dispersive soils
1
2 (min)
(c) Placement of rock with voids filled with soil and vegetated
Lateral inflow
Rock placement causes a decrease in channel capacity
Erosion caused by lateral inflows
(d) Poor placement of rock along channel invert
Lateral inflow
Filter cloth
(e) Good placement of rock along channel invert
Drawn:
GMW
Date:
Dec-09
Rock Linings
RR-01
Catchments & Creeks Pty Ltd

Sediment Dams

Sediment dams and traps may be small for temporary use (e.g. less than 6 months), or larger and expected to be used for a longer period of time. Bank slopes of these structures are typically 1:3 (V:H).

Small, temporary sediment dams are used to capture water and sediment runoff from disturbed areas to allow the sediment to settle and the clean water to evaporate or released from the system. These temporary dams are constructed to treat runoff water from rehabilitation or disturbed land for sediment until vegetation establishes. The minimal dimensional requirements of an excavated sediment trap located within a minor drainage path is shown below (Catchments & Creeks Pty Ltd 2010).





Appendix B. RUSLE Calculation

A1.1 Erosion modelling

A sediment loss rate assessment for the Jellinbah Mine has been completed using the Revised Universal Soil Loss Equation (RUSLE) and in accordance with Best Practice Erosion and Sediment Control guidelines (IECA, 2018). RUSLE is an empirical-based modelling approach that predicts the long-term average annual rate of soil erosion. RUSLE estimates the average annual soil loss using the following equation:

$$A = R \times K \times LS \times C \times P$$

A = estimated average soil loss in tons per hectare per year

R = Rainfall-runoff erosivity factor

K = soil erodibility factor

LS = slope length factor

C = cover-management factor

P = support practice factor

Rainfall-runoff Erosivity Factor (R)

The rainfall-runoff erosivity factor (R), which represents the potential for soil erosion due to rainfall and runoff, it quantifies the erosive force of rainfall. An R factor for the site was adopted from the CSIRO R Factors DEM file (Viscarra Rossel, et al.) which mapped the relevant catchments at Jellinbah Mine as having an approximate R factors of 2,220 in the south to 2,360 in the north.

Soil Erodibility Factor (K)

The soil erodibility factor, representing the susceptibility of a particular soil type to erosion taking into account factors such as soil texture, organic matter content, soil structure, and permeability.

An initial sediment loss estimate was conducted with a sitewide K value (K = 0.025 t/ha/h per ha/MJ/mm). This value was derived from the CSIRO factors that references geological surface mapping scaled at 1 in 100,000.

In order to calibrate the modelled sediment loss against the actual sediment loss the K factors was broken down differently for each land use with the exemption of the “dam” land use which was kept as, 0.025, as this area has no associated soil components. The K factors were derived from an empirical equation by Sharpley and Williams (1990) cited by Ghosal and Bhattacharya in A Review of RUSLE Model. The equation aims to modify the K value though equating percentages of soil make up into four (4) categories. The percentage fraction of soil components was informed from historical soil samples from site.

Slope Length Factor (LS)

The Slope Length factor (LS) is a topographic factor, which considers the slope length and steepness of the land, indicating the effect of slope on soil erosion. LS factors were derived from latest spatial data dated March 2025 provided by Jellinbah. Within each catchment an average (mean) LS Factor was developed for each land use sub catchment using the System for Automated Geoscientific Analyses (SAGA) tools available in QGIS.

Cover-Management Factor (C)

The cover and management factor considers the effect of land cover and land management practices on soil erosion. It accounts for factors such as vegetation cover, tillage practices, and conservation measures. Due to uncertainty in vegetation ground coverage across the site a factor of 1 was used for no vegetation and a factor of 0.1 was used for vegetated areas determined from aerial imagery. A C factor of 0.1 is equal to either 60%

newly established cover or 40% long established cover from the relationships outlined in IECA (Table 3.2) shown below.

Table E9 – C-factors for newly established grass cover [1]

Type and height of raised canopy	Canopy cover	Type of cover	Ground cover (%)					
			0	20	40	60	80	95
No appreciable cover	0	Grass	1.00	0.45	0.22	0.10	0.03	0.00

Note: [1] Landcom (2004)

Table E10 – C-factors for long established vegetative cover [1]

Type and height of raised canopy [2]	Canopy cover [3]	Type of cover [4]	Ground cover (%)					
			0	20	40	60	80	95
No appreciable cover		G	0.45	0.20	0.10	0.04	0.01	0.00

Support Practice Factor (P)

The support practice factor reflects the effectiveness of erosion control practices such as terracing, contouring, and grass strips in reducing soil erosion. The support practice factors have been aligned with IECA guidelines for P-factors with the land use's associated P-factors shown below:

Active mining and disturbance - 1.3

Waste dump - 1.2

Rehab and undisturbed areas – 1.0

Hardstand - 0.8