BRISBANE OFFICE
164 Wharf Street
SPRING HILL, QLD 4000
P +61 7 3217 8772

E info@aarc.net.au
AARC.NET.AU

ACN. 620 818 920
ABN. 71 620 818 920

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Principal Sustainability

Kestrel Coal Resources

Level 22, 10 Eagle Street

Brisbane QLD 4000

By email: colleen.fish@kestrelcoal.com

Attention: Colleen Fish

Requirement notice item 6: Soil erodibility and soil loss rates

1.1 Background

To demonstrate compliance with the prescribed solution for required outcome 3 outlined in Clause 13 (1)(d) of the Regional Planning Interests Regulation 2014 (Qld), the Department of State Development, Infrastructure, Local Government and Planning has requested further evidence showing how the erosion figures provided in the Regional Interests Development Approval Application RPI22/008 Kestrel – LW500 were derived.

The following information is derived from studies encompassing the whole of mining lease ML70481, which encompasses the area relating to the LW500 application area. The soil loss figures provided here relate specifically to the soils within the footprint of LW500.

1.2 Pre- and post-disturbance rates of soil erosion

In describing the characteristics of the area the subject of the RIDA application, estimates of the likely pre-disturbance rates of soil erosion have been provided. The requirement notice has requested additional detail be provided on the erosion rate calculations and the parameters used to inform erosion modelling.

Pre-disturbance erosion rates have been estimated using the Revised Universal Soil Loss Equation (RUSLE) method; a method used to estimate average annual soil loss caused by hillslope and rill erosion. The equation is limited to making predictions for long-term annual soil loss. The equation is:

$$A = R \times K \times L \times S \times C \times P$$

Where:

- A is the predicted rate of soil loss in t/ha/year;
- R is the rainfall erosivity factor based on the total erosive power of storms during an average year and is dependent on local weather conditions;
- K is the soil erodibility factor;

- L is the slope length factor being the distance between the point of commencement of water runoff on the land and the point of sediment deposition or the point where runoff enters a well-defined channel;
- S is the slope steepness factor which allows for the effect of slope steepness on erosion;
- C is referred to as the cover and management factor which compares cropping practices, residue management, and soil cover to a standard clean fallow plot. C-factors for different agricultural uses and management practices are developed based on their observed deviation from the standard clean fallow plot; and
- P is the conservation or support practice factor and reflects the impact of support practices on the average annual erosion rate. It reflects the ratio of soil loss with contouring and/or strip cropping to that with straight row farming up-and-down slope.

The derivation of the various input factors is discussed in the following sub-sections, and the factors used to estimate soil loss rates for the area of LW500 are summarised in Table 1.

2.1 R, S and L factor derivation

Mean values for R, S and L for each soil type within ML70481 have been derived from the Queensland government's *Soils - universal soil loss equation series* (Department of Environment and Science 2019) which contains input R, S and L factor datasets developed for use in the RUSLE method. The dataset has been derived from soils data contained in the Australian Soil Resource Information System for predicting long-term average annual hillslope erosion rates across Queensland.

Median values for each of the R, S and L factors were determined using a vector analysis GIS tool to extract the available factor data within each soil type polygon. The median value was determined from the value of each datapoint within the individual soil polygons (unique mapping areas) for each factor. These values are summarised in Table 1.

2.2 K factor (soil erodibility) derivation

The soil erodibility 'K' factor of the RUSLE is a measure of the susceptibility of soil to erosion and is defined as the rate of soil loss per erosion index unit as measured on a unit plot maintained under continuous bare fallow. Given the time-consuming nature of determining erodibility strictly in accordance with this definition, estimation methods using soil attributes including particle size distribution, organic matter content and density of eroded soil have been developed. The specific basis of calculation of 'K' factor has been based on a footnote to the definition of soil erodibility within RIDA RPI16/002/RIO TINTO (applicable to adjoining areas within ML70481), and which states:

> *The soil erodibility 'K' Factor of the RUSLE is defined as the rate of soil loss per erosion index (EI30) unit, for a specified soil as measured on the unit plot. It intends to represent the long-term susceptibility of different soil to erosion due to inherent soil properties. The unit of the 'K' Factor is t/ha/h per ha/MJ/mm.*
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> *The original basis of the calculation was the soil erodibility nomograph of Wischmeier and Smith (1978), which estimates K from surface soil structure, organic carbon content and particle size distribution, and profile permeability. Wischmeier and Smith's M parameter (the particle size parameter) should be replaced by the method of Lu et al (2003) which accounts for the use of fully dispersed particle size data. The resultant K value is then adjusted using the wet sediment density adjustment equation of Loch and Rosewell (1992).*
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> *References:*
> *Loch RJ and Rosewell CJ (1992). Laboratory methods for measurement of soil erodibility (K factors) for the Universal Soil Loss Equation. Australian Journal of Soil Research, 30, 233-248.*
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> *Lu H, Prosser IP, Moran CJ, Gallant JC, Priestley G and Stevenson JG (2003). Predicting sheetwash and rill erosion over the Australian continent. Australian Journal of Soil Research, 41, 1037-1062.*

> *Wischmeier WH and Smith DD (1978). Predicting rainfall erosion losses - a guide to conservation planning. Agriculture Handbook No. 537. United States Department of Agriculture, Washington DC.*

To meet this definition, a determination of RUSLE soil erodibility 'K' factors for all of the soils of ML70481 was undertaken in November 2018 (Titmarsh 2018). Titmarsh used the methodology developed by Loch and Rosewell (1992), and subsequently enhanced by Loch and Rosewell (1992) and others, as nominated by the basis of calculation cited above. It should be noted that, given the application of the RUSLE to hillslope sheet and rill erosion, soils with similar surface properties as identified by soils studies across ML70481 (MWH 2002 and 2011) have been aggregated and riparian soils excluded, with sampling being restricted to ML70481 soils classified as SCL. Table 1 provides the erodibility 'K' factors for the relevant LW500 area soils as per Titmarsh (2018).

Titmarsh (2018) notes that soil erodibilities across ML70481 are similar, but that this is not unexpected considering the soils and their parent material. Erodibilities compare well with published values for similar soils (e.g. Silburn 2011).

DSITI (2017), provides the most recent broadscale mapping of inherent soil erodibility however, the method used is not equivalent to the USLE K-factor derivation, but is a classification that describes a surface soil's stability or resistance to erosion. The scale of the dataset (1:250,000) is such that it is only reliable down to a sub-catchment level. The dataset suggests that all soils in the ML70481 area are categorised as being "moderately stable surface soils".

2.3 C and P factor derivation

For an assessment of pre- and post-disturbance soil erosion, the cover and management factor (C-factor) is the principal variable impacting the assessment results. The most recent studies (e.g. Yang 2014) show little variation of mean annual C-factors between cropping and grazing land uses (0.07 and 0.06 respectively with a derived C-factor for cultivated bare soil of 0.1). For this assessment, and assuming no change in land use pre- and post-disturbance, a C-factor of 0.06 for a grazing land use is considered appropriate.

For a hypothetical cropping land use, a C-factor of 0.085 is considered appropriate based primarily on the C-factors derived by Yang (2014) and adjusted from the base cropping factor to allow for temporal variation across a season where it is assumed that for a period of time, cropped land lies fallow.

A P factor of 0.5 has been used for this assessment for both pre- and post-disturbance land uses as a conservative estimate based on a low management input for either land use. The C and P factors used are shown in Table 2.

Table 1: RUSLE R, K, L and S factors for each ML70481 soil type

Soil Type	**Rainfall Erosivity Factor (R)** **MJ/mm per ha/hr/yr**	**Soil Erodibility Factor (K)** **((t.ha.h)/(ha.MJ.mm))**	**Slope Length Factor (L)**	**Slope Steepness Factor (S)**
B – Basalt (UMA190)	2034.89	0.034	1.416	0.155
B – Basalt (UMA192)	2034.65	0.034	1.284	0.109
Bvsb – Brown Very Shallow Basalt	2016.08	0.039	1.147	0.142

2.4 Calculated rates of pre-and post-disturbance soil erosion

Mean soil loss rates have then been derived by applying the RUSLE factors shown in Table 1 and Table 2 to the RUSLE equation.

Table 2 and Figure 1 present the mean soil loss estimates for the various soil types identified within the LW500 area. For the B and Bvsb soil types within LW500, the estimated pre-mining soil loss ranges from 0.29-0.45 t/ha/year. The mean pre-mining soil loss across the whole of the ML70481 area is 1.02 t/ha/year.

There are two small areas of type Bs soil which was not explicitly sampled/assessed to determine a soil erodibility factor on the basis that this soil type only differs from the B type with respect to depth to the C-horizon. As such this soil type is assessed to have the same range of erosion rates as shown for B type soils.

Using the C-factors proposed above for a hypothetical cropping land use, the estimated range of post-disturbance erosion rates would be 0.41–0.64 t/ha/year, with an average soil loss across the whole of the ML70481 area of 0.72 t/ha/year.

An assessment of these soil erosion rates is considered best guided by Lu et al. (2001) and Roswell (1996), which have attempted to quantify erosion rates across Australia. Against an average Australian erosion rate of 6.3 t/ha/year, the study suggested that:

- a low rate of erosion could be defined as less than 0.5 t/ha/year; and
- a high erosion rate could be defined as greater than 10 t/ha/year.

Against this guidance, erosion rates for the LW500 area would be categorised as low for both the pre- and post-disturbance scenarios, and well below the average Australian erosion soil loss rate. Coupled with the soil erodibility data provided at Section 2.3, the erosion risk for the LW500 area at Kestrel is classified as low.

Table 2: Pre-disturbance Crop/Cover and Conservation Practice Factors and Predicted Soil Loss

Soil Type	**Crop/ Cover ManagementFactor (C)**	**Conservation Practice Factor (P)**	**Mean Soil Loss (tonnes/ha/yr)**
B – Basalt (UMA190)	0.06	0.5	0.45
B – Basalt (UMA192)	0.06	0.5	0.29
Bvsb – Brown Very Shallow Basalt	0.06	0.5	0.38

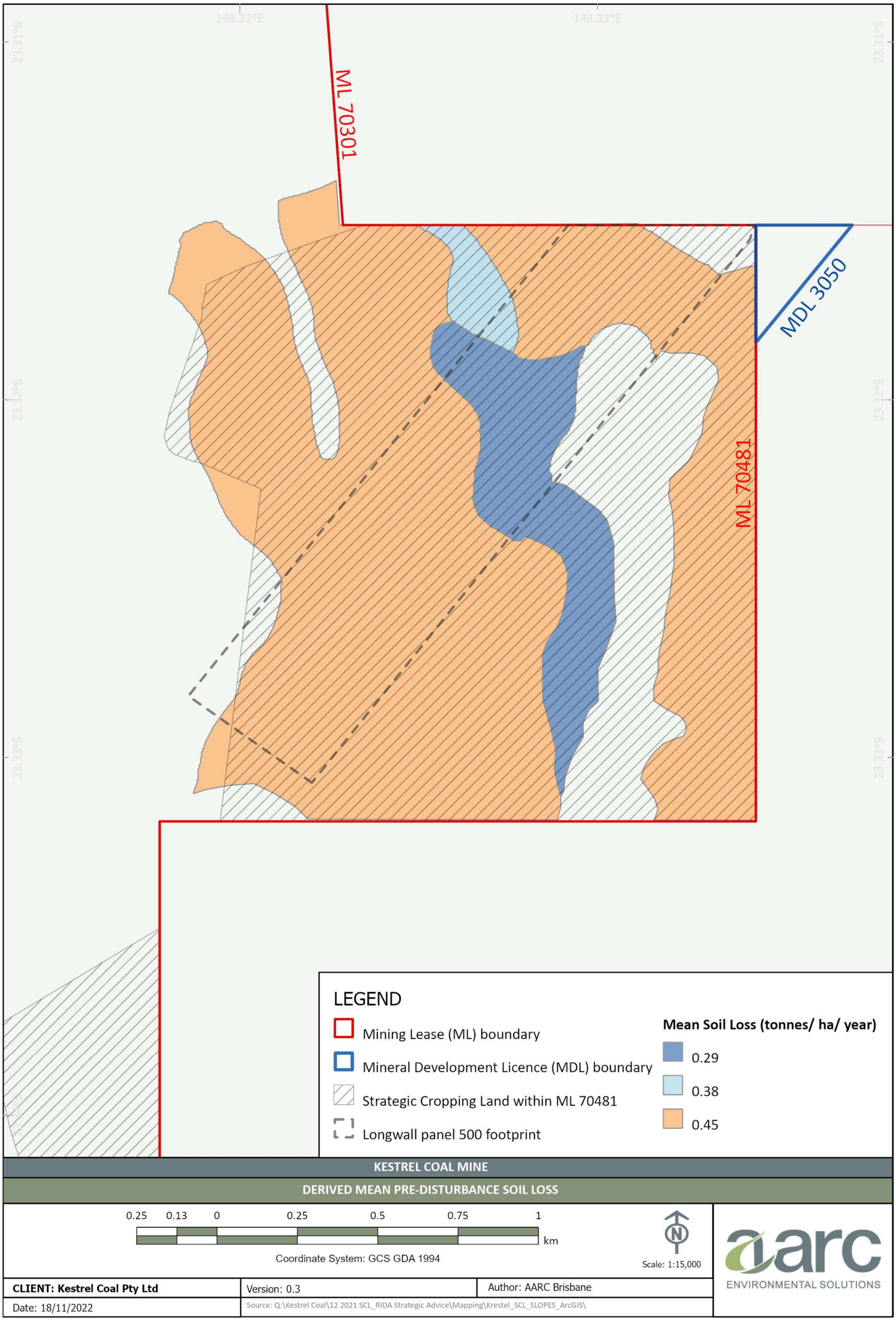

Figure 1: Derived pre-disturbance soil loss (tonnes/ha/yr)

2.5 References

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Yours sincerely

Stuart Ritchie
BE (Agr.), MEM
Director/Principal Consultant