Appendix 12.

SLR Consulting Australia (2020c) *Application of Lime in Construction – Brief Summary.* Memorandum from SLR Consulting Australia to the Department of Primary Industry and Resources, Northern Territory Government, October 2019.

NORTHERN TERRITORY GOVERNMENT

Department of **Primary Industry and Resources**

Memorandum

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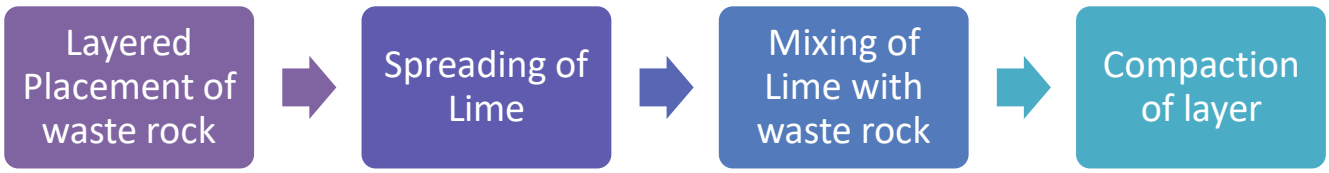
From:	Ben Tarrant	**At:**	SLR Consulting Australia Pty Ltd
Date:	2 October 2019	**Ref:**	680.10421-M01-v0.1 Lime Application.docx
Subject:	Application of Lime in Construction Brief Summary		

The method of blending AMD materials with neutralising agents is not a new concept and has been demonstrated at OK Tedi (PNG), Grasberg (Indonesia) and Savage River (South Australia). At both OK Tedi and Grasberg, a substantial factor of safety (ANC/MPA >2) in the reactive fraction of waste rock and limestone blend was adopted to provide assurance over the long term.

While the application of lime in mine waste treatment operations is typically applied via batch and mixing plants as it is removed from the ore, the Rum Jungle project will differ in that the AMD lime neutralising will occur in the fill operations. The reason for this is the efficiency in application, large nature of the project and prohibitive expense in double handing costs with batch and mixing plants.

1 Methods of Applying Lime

It is envisioned the process of applying lime to the waste rock will follow similar process to that practice in the road construction industry and is outlined below:



1.1 Placement of Waste Rock

The placement of waste rock from the various WRD across the site will typically involve the cutting of the waste rock material from the existing dumps, hauling using large capacity 777 trucks (or similar), dumping in the new waste rock storage facility and spreading using bulldozers and graders. Spreading of the waste rock is currently specified to layer thickness of 500mm ± 50mm. 500mm thickness is chosen as a compromise between achieving a satisfactory compaction, ensuring the layer thickness thin enough to allow for mixing of lime material into the waste rock and efficiency of construction. A 10% allowance in layer thickness variability is a typical geometric constraint within large earthworks projects and can be controlled by on-board GPS units and regular surveying.

Figure 1 Dumping and spreading of material in filling operations

1.2 Spreading of Lime

Self-unloading trucks or tailers can distribute lime pneumatically or mechanically using aggregate-type spreaders. Given the material surface for the waste rock dumps will likely be undulating and subject to boggy/soft zones, equipment capable of negotiating adverse ground conditions will be necessary. Lime can be applied as a dry power, aggregate or slurry with the production of respirable dust decreasing in that order.

Spreaders are typically accompanied by monitoring equipment utilizing GPS tracking and load cells to ensure even application across sites and monitor lime rates and quantities applied. Examples of typical machinery and QA/QC technology currently engaged within civil and agricultural applications is shown in Figure 2 below.

Figure 2 Typical Lime Spread Machinery

Typical Farm Spreader Arrangement for dry lime application. *Image Courtesy of Agri-Spread*

All Terrain Lime Spreader used in Road Construction. *Image Courtesy of Stabilco.*

Spreader Read-Out and Monitoring. *Image Courtesy of Agri-Spread*

Lime Slurry Spreader. *Image Courtesy of Asphalt Driveways*

Videos of Agri-Spreader: https://youtu.be/28lliImCfY0

1.2.1 Mixing of Lime

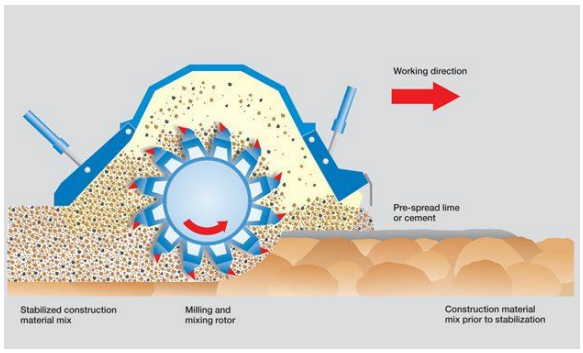
Ensuring homogenous mixing of the lime through the waste rock is paramount to the success of the project. Several methods currently exist within civil and agricultural industry that can be utilized on-site. The final method of mixing will be reviewed following assessment of trial mixing pads prior to full-scale operations. Factors that will be accounted for within selection of mixing methodology will be layer thickness of waste rock, waste rock material (i.e. shale) and particle size distribution. It is important to note, in road construction, mixing of the material is pertinent for overall stability, in the case of PAF waste rock dumps, the objective is to ensure alkalinity within infiltration water to prevent AMD.

It is anticipated larger cobbles/boulders will be present within the waste rock materials (>1.0m diameter) as encountered within previous investigations. Such boulders are occasional within the dumps but are likely to pose a jamming and breakage risk to typical road soil mixers (top left and bottom left images in Figure 3). It is envisioned mixing of the lime will occur using either a grader pulled or tractor pulled ripper/tyne/harrow (top right and bottom right images in Figure 3) that will be able to manage the expected undulating terrain and occasional larger pieces within the waste rock.

Figure 3 Various Mixing Machinery for Lime Application

Typical Soil Mixer/Stabalizer Machine for dry lime application. *Courtesy of Writen Group*

Tyning Lime into Soil. *Image Courtesy of National Lime Association.*



Mixer/Stabalizer Process. *Courtesy of Stablico*

Large Disc Harrow. Image Courtesy of *O-Connors*

1.3 Compaction of Layer

Compaction of the waste rock layer will further ensure homogenisation of the lime as well as reducing the permeability of the material to oxygen intake and water infiltration. Given the granular particle size distribution of the material, a 90% standard compaction is anticipated to occur through day to day traffic and operations on the rock mass without the requirement for specialised compaction equipment. Compaction density testing will be used as a QA/QC measure and is standard practice within civil industry to insure bulk earthworks fill operations are carried out correctly and achieving project specification. QA/QC is carried out using a nuclear density test and can provide results in a short time, informing site operators if further work is required on the layer within the same day of testing.

2 Quality Assurance and Quality Control

A program of laboratory testing applicable to the neutralisation of the PAF materials will be formulated by geochemists and geotechnical engineers with measurable parameters that can be tested and used as hold points/acceptance criteria. As is the case in civil industry bulk earthworks, contractors must allow for a program of laboratory and field testing, typically performed by 3rd parties to ensure the work is up to specifications and must accept any costs required to rework materials should they not pass the QA/QC process. As part of the QA/QC process, typically Contractors will have a record of each lift, geometrics, its location and location of testing, allowing for the calculation of volumes (both lime and waste rock) placed, conforming material and location of non-conforming material requiring re-work. The QA/QC process is typically part of a feedback loop process of continuous improvement, where it is envisioned volumes/mass of lime applied will be correlated against geochemical testing which can be correlated to application rates and densities, allowing for increased efficiency and confidence in construction. Critical elements of the Rum Jungle waste rock treatment are envisioned to be volume of lime applied to volume of waste rock, such controls will be assessed prior to construction commencement and confirmed by specialists as to the appropriateness of the control methods.
While there does not exist a general standard for geochemical testing frequency within waste rock neutralisation, it is envisioned a testing program frequency based off typical earthworks specifications (per volume placed or per linear meter treated for example), would be sufficient. It is important to note, testing frequencies can be made stringent in the early stages of a project and relaxed following proof that construction methodologies are fit for purpose.

As part of QA/QC, given the scale of the project and testing likely involved, on site laboratories would be required and justified given the anticipated volume of testing. Such laboratories are not uncommon within large scale projects and as part of the project specification will require NATA accreditation and be operated by qualified personnel.

Below is some publicly available documentation relevant to the application of lime within construction.

3 Existing Specification and Documentation on Application of Lime in Construction

AustRoads Guide to Pavement Stabilisation Part 4D
Stabilised Materials
2019

AustRoads is the peak organisation of Australasian roads and traffic and is the main body from which Australian States and Territories base their road specifications.

Stabilisation of road subgrade soils using lime has long been a road construction methodology used to improve low bearing, reactive (high shrink/swell) soils, with large investment in research and development backed by

project experience. While the purpose of liming in road construction is typically targeted at subsoil mechanical strength improvement, the methodologies used in application are concordant to application of lime for chemical neutralisation, with machinery used in road construction appropriate to that in waste rock.

Transport and Main Roads Specification
MRTS07B In-situ Stabilised Pavements using Cement of Cementitious Blends
July 2019

Developed by the Queensland Government Department of Transport and Main Roads, this document details the construction requirements, QA/QC requirements and required documentation relevant to stabilisation of soils for road construction. Building from the AustRoads guide, the QLD Main Roads document further details procedures and construction requirements for liming including work rate, construction material requirement and acceptance criteria. It is envisioned this document can be used as a guidance and template in the development of specifications and construction methodology procedures for the proposed Rum Jungle Waste Rock Storage Facility liming works. Similar specifications exist for NSW (RMS) and Victoria (VicRoads).

National Lime Association
Lime-Treated Soil Construction Manual - Lime Stabilization & Modification
January 2004

This document, created by the National Lime Association (USA) provides high level guidance on the typical construction methodologies used in the application of lime to soils. The focus of the document is around the application of lime to clay soils. While the application is not relevant to the neutralisation of PAF waste rock it is envisioned similar processes of application will be applied to the Rum Jungle Waste Rock Storage Facility.

4 YouTube Videos

To help visualise the use of lime in construction, please feel free to view the following videos.

Various machinery used in the application of lime:
https://www.youtube.com/watch?v=D_ncFvBljvk
https://www.youtube.com/watch?v=_2hLw8ho47k
https://www.youtube.com/watch?v=nbNMsYd6fOo

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