Douglas Partners
Geotechnics / Environment / Groundwater

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Report on
Geotechnical Investigation

Donnybrook Mine Shaft Remediation Methodology
Lot F27 Goodwood Road, Upper Capel

Prepared for
Department of Mines, Industry Regulation & Safety

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The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

	Signature	Date
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Table of Contents

Page

Report on Geotechnical Investigation
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1. Introduction

This report presents recommendations by Douglas Partners for the remediation of ten mine features investigated as part of the Donnybrook Mine Shaft Remediation Methodology project. The purpose of this report is to detail the recommended methods for remediation and attribute budget cost estimates to carry out the recommended remediation.

The investigation was commissioned in an email dated 14 September 2020 from Kate Hryczyszyn of Department of Mines, Industry Regulation & Safety (DMIRS) and was undertaken in accordance with Douglas Partners' proposal PER200261 dated 7 August 2020.

The ten features were identified by DMIRS as priority for remediation due to the risk to persons within the forest (either for recreational or professional reasons), to make them safe. Based on the results of the investigation undertaken in February and March 2021 (findings detailed in report reference 96721.00.R.002.Rev0), this report provides a recommended remediation methodology for the ten features including comment on:

- detailed description and rationale;
- quality control process for material specifications and backfill methodology;
- plant and equipment requirements;
- personnel and specific technical expertise required;
- timing and/or sequencing requirements;
- remediation schematics;
- disturbance area;
- potential risks to effective implementation including any impact from groundwater or unfavourable geochemistry, where applicable;
- budget costing for the recommended remediation options; and
- post remediation monitoring requirements.

2. Recommended Remediation

Due to the volume of the voids to be filled, the accessibility of the features and the availability of suitable fill, filling the features with soil is considered to form the most suitable solution to remove risk or reduce risk to a suitable level, to personnel or equipment.

Suitable material for use as fill would comprise non-reactive, granular material (e.g. sand and gravel) with not more than 12% fines.

No compaction of the fill is considered necessary (and practical) and therefore, to allow for some consolidation of the material under its own weight following its placement, it is recommended that the fill is placed to 0.5 m above the surface level surrounding the features generally, and 1 m at Feature 8, owing to the depth of this feature. It is anticipated that the surface of the fill will settle (by varying amounts depending on the depth of fill) over time. Further detail on backfill volumes is provided in Section 4.

Consideration was given to re-use the existing mine waste materials from stockpiles surrounding many of the features at site, however in many cases, this material is within mature vegetation and re-using the material would require some clearing of the vegetation, which is anticipated to be undesirable at this site with respect of minimising site impact of the proposed remediation works.

3. Local Fill Sources and Available Equipment

Douglas Partners have met with three contractors from Donnybrook and inspected fill available from their respective borrow pits. Details of the three contractors are listed in the Table 1 below, with some comments on Douglas Partners' appreciation on the level of service each could possibly provide.

Table 1: Local Contractors and Sources of Fill

Contractor	Availability of suitable fill	Comments
Donnybrook Civil Earthmoving Contractors (DBCEC)	Sufficient	Apparently the most established civil contractor in Donnybrook. Have the capability to cart (using 6 wheelers) and place (using a 2.5 tonne excavator) the material. Borrow pit is on Thomson Rd in Beelerup (approximately 6 km to the northeast of the site)
Allen Civil and Rural Contractors	Sufficient	A significantly smaller organisation than DBCEC. Have their own trucks (six wheeler) and a 8t excavator. Borrow pit is on Frontino Rd in Beelerup (approximately 5.5 km to the northeast of the site).
Italia Stone Quarry	Limited	Clayed sand fill available and difficulty in trafficability within the borrow pit during winter. Fill material more difficult to work with and susceptible to excessive long term settlement. Pit is located 1 km south of the site on Upper Capel Road. Source of fill only (no carting).

It is considered that Donnybrook Civil Earthmoving Contractors (DBCEC) and Allen Civil and Rural Contractors both have the required equipment and suitably experienced personnel to carry out the remediation work, however because DBCEC appears a better established company, it is anticipated that they would be more suited to fulfill the quality assurance procedures which would be expected when working for DMIRS.

Italia Stone Quarry was not pursed further for pricing assistance owing to the least favourable fill from a technical consideration and the lack of equipment required to haul and place the fill (carting and placing

would require the services of local earthmoving contractors, possibly DBCEC or Allen Civil and Rural contractor).

It is emphasised that Douglas Partners has not worked with any of the above listed contractors and the comments above are based on our observations made when visiting their borrow pits and our professional judgement.

4. Recommended Plant and Process

4.1 Recommendations Common to All Features

Remediation via backfill of the features is anticipated to require:

- Six-wheeler trucks to cart material to the site in stockpiles on site. Relatively small trucks are required owing to the narrow site access provided by the existing track;
- Small to medium sized excavator (say, 5 or 7 tonne) with a suitably sized bucket to place and move the fill from the stockpile into the features. It is considered important that the proposed backfilling methodology and equipment allows a safe clearance between the mine feature and both the operator and equipment used to backfill the feature. This requirement precludes in particular the use of bobcat or similar to push fill into the features.
- Water cart or similar, with pump and hose, regarding the suggested remediation at Feature 5, as further discussed in a section below;
- Plate compactor to undertake some limited compaction across the surface of the fill.

Other typical site works plant such as a loader and bobcat may be utilised by a contractor to assist in transport of fill across the site, movement of equipment or material and shaping the access track.

Following liaison with the contractors from Donnybrook, there is concern that the access track may not be trafficable for six-wheeler trucks further south than the section of track near Feature 5. As such, it is anticipated that the likely remediation sequencing could be summarised as such:

1. Undertake minor clearing, shaping and realignment (eg realignment at existing tight bends of the access track) and sheeting with gravel where required between Goodwood Road and Feature 2, to allow six-wheeler trucks to access the area.
2. Deliver a load of fill material to an area adjacent to Feature 1.
3. Place entire load of fill into Feature 1.
4. Repeat Steps 2 and 3 until the feature has been filled to 0.5 m above the surrounding surface level, battering edges of the mounded fill at an angle of 1V:1.5H (therefore, 0.75 m beyond the edge of the feature).
5. Undertake surface compaction across the finished surface of the fill at Feature 1 using a plate compactor.
6. Relocate operations further south along the track and continue in same fashion: delivering loads of fill and placing the fill into the mine features. To facilitate efficient vehicle movements, it is suggested

that fill could be unloaded at a point near the 'Y-intersection' of the track between Features 1 and 2 and the Y-intersection should remain free to be used for vehicles and plant to turn around. Consideration could also be given to forming one or two areas immediately adjacent to the track where plant could be stop and park to allow plant to pass each other on the track.

7. Where stockpiles of disturbed soils, free of significant vegetation are adjacent to features (i.e. material disturbed during the February 2021 field work), this material could be spread across the surface of the imported fill.
8. Following completion of filling each feature, nominal compaction of the surface of the fill using a plate compactor is recommended.

The above procedure is anticipated to take 10 to 15 working days.

It is emphasised that the described procedure does not make any allowance for handling the potentially asbestos containing materials (PACM) identified in Feature 6.

Table 2: Estimated Fill Volumes

Feature	Volume of Feature (m^3)[1]	Fill Required to Surface (m^3)	Volume to Mound Above Feature (m^3) (to 0.5 m above surface)[3]	TOTAL (m^3)
1	51	51	14	65
2	12	12	2	14
3	<5	5	1	6
4	13	13	3	16
5	18	15[2]	2	17
6	<5	5	2	7
7	72	72	14	86
8	84	72[2]	4[3]	76
9	<5	5	2	7
10	25	25	6	31
TOTAL	**~290**	**275**	50	**325**

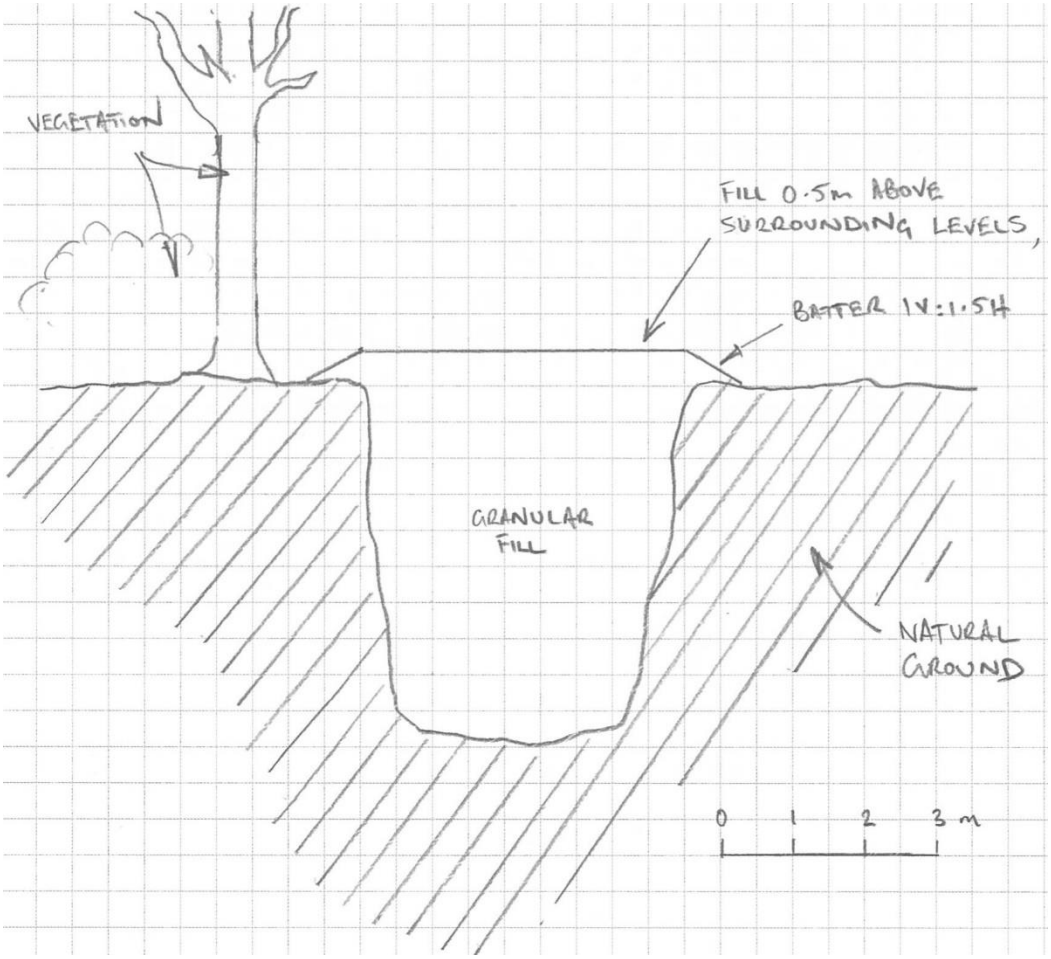
Notes: [1]: Derived from LiDAR data scans of the features undertaken in February 2021.
[2]: Fill volume less than feature volume due to removal of areas within lateral workings which will not be filled when placing fill in the features from the surface.
[3]: 1 m thick mounding (rather than 0.5 m) at Feature 8.

Dieback management will need to be considered and will possibly impact the scope and cost of the remediation at this site owing to specific constraints to access the features by the earthmoving plants. Dieback management is outside the area of expertise of a geotechnical consultant, such as Douglas Partners, however it is generally understood that management requirements are derived on a case by case basis. It is suggested that the fill could be delivered to the access track no further south than the section of track adjacent to Feature 4 to avoid trucks moving into an area of dieback affected forest. Ensuring this should simplify dieback management to the excavator or front hand loader (if used to transport soils within the site) travelling between the stockpiles of fill and the features.

It is recommended that work is undertaken in dry weather to aid dieback management and the placement of fill.

Consideration was given to the placement of a geogrid within upper part of the fill at Feature 6 and 7, however such provision was considered redundant provided regular monitoring similar to that suggested in Section 6 is undertaken. If additional provision (over the backfilling of the features and post remediation monitoring) is further considered, fencing (as discussed in Section 8) of selected features is suggested owing to its simplicity of implementation and relative cost effectiveness.

Figure 1: Mine Feature Remediation Schematic



4.2 Additional Preparation Measures for Features 5 and 6

Variation to the general process suggested above in Section 4 is recommended for Features 5 and 6 as per the following comments.

4.2.1 Feature 5

To assist the migration of fill within Feature 5, that includes a relatively narrow opening at its base followed by an inclined gallery, it is recommended that during the placement of fill, provision be made to add water to assist the placement of the fill through the opening at the base of the vertical shaft, into the inclined gallery. Fill should be placed from the surface, as close as practicable to the lateral opening at the base of the feature. It is suggested that water is directed into the feature (for instance using a pump

and hose), from the surface and with sufficient pressure to flush the fill through the opening. It is recommended that this process is undertaken under the supervision of a geotechnical engineer. All personnel should keep a safe distance (2 m suggested) from the features.

Consideration was given to the use of a pumped fill product (e.g. slurry) to fill the lateral working of Feature 5, however this is considered likely beyond the capability of the local contractors and would require specialised equipment, likely to be mobilised from Perth. The aforementioned approach using water is anticipated to form a cost effective solution to achieve the objective of the remediation.

4.2.2 Feature 6

From a geotechnical perspective, the remediation suggested in Section 4 is considered suitable for Feature 6, whether the PACM is removed or not (from an environmental perspective). However, under a scenario where the rubbish of unknown thickness observed in the feature is left in place prior to backfilling using the proposed clean fill, it is recommended that the surface of the rubbish be tamped with the bucket of the excavator prior to filling, and that filling be placed above the rubbish in approximately 400 mm thick layers or less, with the surface of each lift being tamped with the excavator bucket prior to placing the next lift. This operation would require a relatively small bucket or similar attachment to tamp the fill. Some geotechnical supervision is recommended at this feature if the rubbish is left in place prior to backfilling.

5. Quality Control

Quality control of the fill material need not be onerous given the primary focus is to backfill the features in such a way so that there is minimal movement of the fill following its placement. Provided the material is free of organics and oversized material, and contains not less than about 12% fines, supervision by a geotechnical engineer during site works is generally not considered necessary for the majority of the work. As detailed in Section 4.1 however it is considered prudent to allow for supervision of remediation of Feature 5 and possibly Feature 6.

Laboratory testing of representative samples of fill proposed to be imported to site would be prudent. Based on the fill observed in DBCEC's pit during a site inspection undertaken by Douglas Partners for the preparation of this report, a laboratory testing programme that comprises the assessment of the soil particle size distribution and Atterberg limits (liquid limit, plastic limit and plasticity index) on representative samples is recommended. Three samples collected from the source pit are suggested to be tested prior to import to site.

It is recommended that results of this testing be assessed by a geotechnical engineer prior to importing to site. Douglas Partners would be pleased to assist with the sampling within the pit, scheduling the laboratory testing programme at a NATA accredited laboratory, and interpretating the test results.

Some laboratory testing on samples of fill delivered to site is recommended to ensure consistency of the material delivered. The assessment of at least the soil particle size distribution is recommended. The assessment of the soil Atterberg limits can be requested either by default or at the discretion of the geotechnical engineer (who would indicate its requirement depending on previous information available about the delivered fill). Review of the laboratory results by a geotechnical engineer is recommended. Considering the anticipated volume of fill, it is suggested that not less than six soil samples of fill

delivered to site be tested, ensuring at least one sample is collected from the fill proposed for Features 1, 7 and 8.

If fill from other sources is considered, the following fill specification is suggested:

- the fill should comprise a granular material (i.e. either sand or gravel);
- organic content should be less than 5% (when assessed in accordance with ASTM D2974-14 - Test Method C);
- fines content (i.e. passing 75 mm sieve size) should be less than 12% (when assessed in accordance with AS1289.3.6.1);
- no particle greater than 75 mm in size (when tested in accordance with AS 1289.3.6.1;
- liquid limit of less than 15% (when tested in accordance with AS 1289.3.1.1).

Other materials that do not meet the above specification could possibly be suitable provided they are assessed and approved by a geotechnical engineer.

6. Post Remediation Monitoring

Monitoring of the remediated features is recommended to assess the stability of the fill.

It is considered that monitoring could be undertaken by either a geotechnical engineer, a civil engineer, or other competent professional familiar with site conditions (for instance a representative from Department of Biodiversity, Conservation and Attractions). Monitoring by the same person between successive monitoring event would be preferred, if possible, in order to assist in identifying any evolution in site conditions.

Monitoring should comprise visual assessment as a minimum, with photographic records and written records of any notable observations. Consideration should be given to also include measurement of the fill surface levels (such as by a surveyor), at least within the first year, and for the deepest features (proven or possible) such as Feature 7 and 9, and for Feature 6 if the rubbish is left in place prior to backfilling.

Following completion of the remediation, monitoring should be undertaken at regular intervals, such as:

- Fortnightly for a period of one month (2 events);
- Once every two months for the first 6 months; then
- Annually thereafter.

The recommended frequency of surface level measurements should be assessed and adjusted following each survey event, depending on the measured rate of settlement.

As the fill will be placed with no compaction (albeit for some light compaction at the surface), some settlement at the fill surface, estimated to be likely less than 0.5 m, is anticipated due to densification of the backfill. If either:

- total settlement is in excess of 0.5 m; or

- an accelerating settlement rate is recorded;
- any other abnormal feature is observed,

then further geotechnical assessment should be promptly undertaken, and it would be recommended to contact Douglas Partners office for further assistance.

7. Opinion of Probable Costs

Donnybrook Civil Earthmoving Contractors (DBCEC) and Allen's Civil and Rural Contractors were requested to provide input to assist with the preparation of an opinion of probable costs (OPC) for the remediation works.

Both contractors provided information to assist to derive an OPC for the site works. Although each contractor adopted a slightly different way to move the sand fill, their estimates were within about $1,000 of each other. Based on the experience of Douglas Partners and our subconsultant, the consulting engineer, The Civil Group we then reviewed the estimates provided by each contractor and concluded that each appears reasonable and within current market rates.

The estimates provided by each contractor are estimates and not a tender sum. Each was based on a detailed description of the proposed works, their experience in undertaking earthworks, and an interpretation of what is required.

The total OPC is derived as per the following schedule:

• Prepare Tender Document and Contract Administration	$5,000 - $7,000
• Preliminaries and Project Set-up	$2,000
• Dieback - management of activities	TBA
• Water Supply, clearing, shaping track	$10,000
• Supply Fill to Site	$10,500
• Earthworking Plant (incl. mobilisation)	$16,500
• Geotechnical Engineer Supervision and Review	$6,000 - $8,000
• Contingency (allow about 15%)	$7,500 - $8.000
TOTAL OPC	$57,500 to $62,000 + 10% GST

The OPC covers the suggested rehabilitation works detailed in Section 4 and the quality control detailed in Section 5, but excludes costs for the monitoring indicated in Section 6. Also, possible specific requirements relating to dieback management during construction might result in additional costs to be considered once such requirements are known. Allen's recognised that dieback was a matter for management and their approach to the works took an assumed acceptable practice into account. A dieback management plan will need to be approved by the DBCA.

8. Optional Feature Remediation

Considering that the features and shafts have been remaining stable over the past 120 years, it is considered that the suitability of simply fencing the features (rather than backfilling them) be considered as a risk mitigation measure. The objective of such fencing would include to mainly signal the presence of the features, to deter their voluntary visit and to decrease the risk of involuntary fall into the features, but would not physically entirely preclude any voluntary or involuntary entry into the features by persons or equipment (for instance under a worst-case scenario of an emergency service vehicle during a bush fire). However, this solution is discussed in this report mostly for its cost benefit.

With a set-back of 1.5 m between the edges of the features and the fenceline, it is estimated that approximately 260 m of fencing would be required. Based on a preliminary estimate of $50/m for fence installation, it is suggested that a budget estimate approximately $15,000 + GST would be required to fence the features.

An example where this solution was implemented is shown in Figure 2 below.

If this approach was considered further, it would be prudent to place fill in:

- Feature 3 – due to the small volume required and the proximity to the track; and
- Feature 6 – if the PACM is left in place, to 'cap' the contaminated material.

Figure 2: Example of fencing around an abandoned mine shaft (coal mine shafts in Coalseam Conservation Park, Mingenew, WA)

9. Limitations

Douglas Partners (DP) has prepared this report for this project at Lot F27 Goodwood Road, Upper Capel in accordance with DP's proposal dated 7 August 2020 and acceptance received from the Department of Mines, Industry Regulation and Safety (DMIRS) dated 14 September 2020. The work was carried out under DMIRS General Conditions of Contract dated August 2019.This report is provided for the exclusive use of Department of Mines, Industry Regulation & Safety for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions on the site only at the specific sampling and/or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be affected by undetected variations in ground conditions across the site between and beyond the sampling and/or testing locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

The assessment of atypical safety hazards arising from this advice is restricted to the (geotechnical / environmental / groundwater) components set out in this report and based on known project conditions and stated design advice and assumptions. While some recommendations for safe controls may be provided, detailed 'safety in design' assessment is outside the current scope of this report and requires additional project data and assessment.

This report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

Douglas Partners Pty Ltd