Remediation Options Assessment

Australian Rail Track Corporation

Goulburn Roundhouse
12 Braidwood Road,
Goulburn NSW 2580

September 2022

Ref. 20025.76 R05

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Report Details

Report:

Remediation Options Assessment

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Ref: 20025.76 R05

for

Australian Rail Track Corporation Limited

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Table of Contents

Figures

Appendices

Executive Summary

Cavvanba Consulting Pty Ltd was commissioned by Australian Rail Track Corporation Limited (ARTC) to prepare a remediation options assessment (ROA) and remediation cost estimate for lead and asbestos contaminated soil at the Goulburn Roundhouse, located at 12 Braidwood Road, Goulburn, New South Wales (NSW) 2580 (herein referred to as the site). The site is currently used as a railway museum and actively operated as a Roundhouse by the Goulburn Locomotive Roundhouse Preservation Society Incorporated (GLRPS).

The specific objective of the ROA was to complete a preliminary evaluation of potential on-site remediation options and high-level estimates of associated costs to address the asbestos and lead contaminated soils on-site, and assist ARTC (and Transport for NSW (TfNSW) as the site owner) with an evaluation of management options for the site. Cavvanba understands that ARTC's overarching objective is to ensure the on-site lead and asbestos contamination does not pose an unacceptable risk to human health or the environment under the current commercial/industrial land use scenario and to enable the continued lease of the site to the GLRPS for unrestricted commercial/industrial use.

The purpose of this ROA is to identify, screen and assess technologies that may be suitable for the remediation of lead and asbestos contaminated soil identified at the Goulburn Roundhouse. The ROA provides a recommendation for a preferred remediation approach that may be implemented at the site, with an estimate of the cost associated with its implementation.

The ROA includes a broad screening of remediation options potentially applicable for remediation of lead and asbestos contamination in soil at the site. The broad screen considers the implementability of remediation options which are generally based on a combination of the following criteria:

- *site setting (contaminant characteristics, geology/hydrogeology, depth of impact, existing infrastructure);*
- *potential impacts (health and safety, waste generation, potential for increased risk to off-site receptors);*
- *implementation (timeframe to achieve remediation objectives, complexity/technical considerations, costs, stakeholder acceptance, reputation); and*
- *sustainability (broad consideration of social, economic, and environmental factors including greenhouse gas emissions, dust, noise, traffic, nuisance odours, etc.).*

*Cavvanba considers the preferred option to be **Option 1 – capping and containment** based on the implementability of this option.*

Institutional / administrative controls with response measures must also be implemented as a short-term response for managing contamination due to the presence of co-located lead and asbestos contamination in surface soils at the site which are accessible to site occupants. This approach is not a long-term option and should only be considered for a period of 12-months to reduce as far as practicable, any potential risks to on- and off-site receptors.

The table below presents a summary of costs for each of the assessed remediation options, and also for general comparison purposes. Cavvanba recommends that this report be read in its entirety, including all associated appendices which have been used to develop remediation options and cost estimates.

Technology	*Cost estimate (ex GST)*
Option 1: Capping and containment	*$668,181 (excl. contingency)*
Option 2: Excavation with off-site disposal	*$14,891,538 (excl. contingency)*

1.0 Introduction

Cavvanba Consulting Pty Ltd (Cavvanba) was commissioned by Australian Rail Track Corporation Limited (ARTC) to prepare a remediation options assessment (ROA) and remediation cost estimate for lead and asbestos contaminated soil at the Goulburn Roundhouse, located at 12 Braidwood Road, Goulburn, New South Wales (NSW) 2580 (herein referred to as the site). The site location is presented on Figure 1.

The site is currently used as a railway museum and actively operated as a Roundhouse by the Goulburn Locomotive Roundhouse Preservation Society Incorporated (GLRPS) for storage, restoration and maintenance of locomotives and rolling stock.

An interim environmental management plan was prepared by Cavvanba in 2020, which was updated in July 2022. This plan was prepared to ensure that all practicable steps were taken to minimise the potential risk of exposure to lead and asbestos contaminated surface soils at the site until additional information is obtained which supports more permanent measures, or demonstrates that the site is suitable for its intended land use (i.e. remediation).

The scope of work and methodology was consistent with that detailed within Cavvanba's letter proposal titled '*Contaminated land consulting services – Goulburn Roundhouse, 12 Braidwood Road, Goulburn NSW 2580*' submitted to ARTC on 28 February 2021 (Cavvanba Ref: P20025.76.2). This report should be read in its entirety, with specific reference to Cavvanba's *General Limitations*, included as Section 1.3.

1.1 Purpose of the report

The purpose of this ROA is to identify, screen and assess technologies that may be suitable for the remediation of lead and asbestos contaminated soil identified at the Goulburn Roundhouse. The ROA provides a recommendation for a preferred remediation approach that may be implemented at the site, with an estimate of the cost associated with its implementation.

1.2 Objectives

1.2.1 Site suitability objective

It is understood that ARTC's overarching objective is to ensure the on-site lead and asbestos contamination does not pose an unacceptable risk to human health or the environment under the current commercial/industrial land use scenario and to enable the continued lease of the site to the GLRPS for unrestricted commercial/industrial use.

1.2.2 Remediation options objective

The specific objective of the ROA was to complete a preliminary evaluation of potential on-site remediation options and high-level estimates of associated costs to address the asbestos and lead contaminated soils on-site, and assist ARTC (and Transport for NSW (TfNSW) as the site owner) with an evaluation of management options for the site.

The remediation risk driver, objective and desired end point are summarised below:

- **Primary risk driver:** Human health risk posed by the presence of lead and asbestos contaminated soil. The exposure scenario includes direct contact with contaminated surface soils which also have the potential for inhalation or ingestion via the generation and transport of lead contaminated windborne dust, and asbestos fibres.
- **Remediation objective:** The on-site contamination does not pose an unacceptable risk to human health and/or the environment on- and off-site.

- **Remediation end point:** The exposure to lead and asbestos contaminated soils is mitigated without the requirement for active controls, and the site is suitable for ongoing commercial/industrial landuse with a passive environmental management plan.

The assessment criteria that has been considered to evaluate the effectiveness of remediation options will be driven by regulatory requirements and guidance related to contaminated site assessment and remediation, as follows:

- *Work Health and Safety Regulation 2017* (NSW) (WHS Regulation).
- *National Environment Protection (Assessment of Site Contamination) Measure 1999* (National Environment Protection Council, 2013) (ASC NEPM 2013).
- *Guidelines for the Assessment, Remediation and Management of Asbestos-Contaminated Sites in Western Australia* (Western Australia Department of Health, 2021).
- *Managing Asbestos in or on Soil* (WorkCover NSW, 2014).
- *Code of Practice: How to Safely Remove Asbestos* (Safe Work Australia, 2020).
- *Code of Practice: How to Manage and Control Asbestos in the Workplace* (Safe Work Australia, 2020).
- *Waste Classification Guidelines, Part 1: Classifying Waste* (NSW EPA, 2014).
- *Contaminated Land Guidelines: Consultants Reporting on Contaminated Land* (NSW EPA, 2020).

1.3 Limitations

The findings of this report are based on the objectives and scope of work outlined above. Cavvanba performed the services in a manner consistent with the normal level of care and expertise exercised by members of the environmental assessment profession. No warranties or guarantees, express or implied, are made. Subject to the scope of work, Cavvanba's assessment is limited strictly to identifying typical environmental conditions associated with the subject property, and does not include evaluation of any other issues. This report does not comment on any regulatory obligations based on the findings, for which a legal opinion should be sought. This report relates only to the objectives and scope of work stated, and does not relate to any other works undertaken for the Client.

The report and conclusions are based on the information obtained at the time of the assessment. Changes to the subsurface conditions may occur subsequent to the investigation described herein, through natural processes or through the intentional or accidental addition of contaminants, and these conditions may change with space and time.

The site history, and associated uses, areas of use, and potential contaminants, were determined based on the activities described in the scope of work. Additional site history information held by the Client, regulatory authorities, or in the public domain, which was not provided to Cavvanba or was not sourced by Cavvanba under the scope of work, may identify additional uses, areas of use and/or potential contaminants. The information sources referenced have been used to determine site history and desktop information regarding local subsurface conditions. While Cavvanba has used reasonable care to avoid reliance on data and information that is inaccurate or unsuitable, Cavvanba is not able to verify the accuracy or completeness of all information and data made available.

Further chemicals or categories of chemicals may exist at the site, which were not identified in the site history, and which may not be expected at the site. The absence of any identified hazardous or toxic materials on the subject property, should not be interpreted as a warranty or guarantee that such materials do not exist on the site. If additional certainty is required, additional site history or desktop studies, or environmental sampling and analysis, should be commissioned.

The results of this assessment are based upon site inspection and fieldwork conducted by Cavvanba personnel and information provided by the Client. All conclusions regarding the property area are the professional opinions of the Cavvanba personnel involved with the project, subject to the qualifications made above. While normal assessments of data reliability have been made, Cavvanba assumes no responsibility or liability for errors in any data obtained from regulatory agencies, information from sources outside of Cavvanba, or developments resulting from situations outside the scope of this project.

2.0 Site Setting

For the purposes of this ROA and remediation cost estimates, the site setting and background information has been summarised in the following sub-sections. Additional detail regarding the site history, operational information and site infrastructure are included within *Detailed Site Investigation – Goulburn Roundhouse, 12 Braidwood Road, Goulburn, NSW 2580* (Cavvanba, January 2021) and *Additional Environmental Site Assessment – Goulburn Roundhouse, 12 Braidwood Road, Goulburn, NSW 2580* (Cavvanba, August 2021).

2.1 Site Identification

The site consists of a single lot, identified as Lot 2 in Deposited Plan (DP) 1002813. The total site area is 46,390 m^2 and is located to the south of the Goulburn central business district, and immediately adjacent to the east of the Main South Railway line.

Access to the site is from Braidwood Road via a sealed asphalt access road in the central portion of the site and the remainder is otherwise unsealed gravel access roads, railway lines or fill material comprising coal and ash. Grass cover is present within the southern and eastern portion with sporadic vegetation and larger trees within isolated areas of the site. A chain link fence prevents unrestricted access to the site from Braidwood Road, however there is a portion in the southeast of the site where the fence line intersects, and does not align with the site boundary as presented on Figure 3. As a result, the south-eastern portion is accessible to the public. The site layout has been presented on Figure 2.

The site identification and land use details are provided below.

Site Owner:	TfNSW
Site Manager:	ARTC
Lessee	GLRPS
Site Address:	12 Braidwood Road, Goulburn NSW 2580
Legal Property Description:	Lot 2 in DP 1002813
Property area:	Approximately 46,390 m^2
Co-ordinates:	Latitude: -34.773891 Longitude: 149.710899
Local Government Authority:	Goulburn – Mulwaree Council.
Elevation:	Approximately 638 metres (m) Australian Height Datum (AHD).
Landuse – Proposed:	Commercial / Industrial
Zoning:	IN1 – General Industrial

2.2 Surrounding land use

Land use features surrounding the site are summarised below:

North:	The railway corridor extends to the north of the site. Immediately north is the CFCL Australia Rail Services maintenance facility, located within the railway corridor. It is understood that this facility is used for the overhaul, maintenance, modification and painting of locomotives and rolling stock. A number of commercial properties, including an automotive wreckers and engineering depot are located beyond the CFCL site, followed by residential properties.
East:	Braidwood Road borders the site to the east followed by a rural residential property and agricultural land. The Mulwaree River is located approximately 570 metres from the site boundary.
South:	The Hume Highway is located immediately south of the site followed by rural residential properties and agricultural land.
West:	The Main South Railway line borders the site to the east. A vacant parcel of land within the railway corridor is located directly west of the site followed by a nursery, a livestock sale yard and agricultural land. A Caltex Petroleum Truck Stop and former fuel depot are located to the southwest of the site on Sloane Street.

2.3 Site operational history

The railway line from Marulan to Goulburn opened on 27 May 1869 and a railway depot was constructed by the NSW Government Railways on the southern outskirts of town at this time. It is understood that this included the construction of the engine shed at the site. The NSW Government Railways opened the Goulburn Roundhouse in 1918, which replaced an earlier locomotive depot and consisted of a 42-road Roundhouse. Both new and old locomotive depots operated simultaneously until 1935. The old depot was demolished in 1941.

The Roundhouse was closed in 1981, and leased to the Goulburn City Council for use by a historical society to restore and maintain heritage locomotives, railway vehicles and railway orientated machinery and equipment. A summary of key current and historical site features has been summarised within *Detailed Site Investigation* (Cavvanba, 2021) and as such, has not been reproduced within this report.

2.4 Environmental setting

2.4.1 Topography and hydrology

The site is situated at approximately 638 m AHD within the Southern Tablelands region of NSW. The site area is relatively flat with the broader area surrounding the site sloping the east and north towards the Mulwaree River. An escarpment is located to the west of the site beyond Sloane Street which is present at an elevation approximately 40 higher than the site.

Surface water on-site is understood to be predominantly uncontrolled and would generally pool on-site and permeate the unsealed ground surface that covers the site, however in moderate – heavy rainfall surface water would follow the local topography and drain towards Braidwood Road away from the rail corridor and eventually into the municipal stormwater system. More broadly, surface water is expected to flow east eventually discharging to the Mulwaree River approximately 570 m from the site boundary. The Wollondilly River is located approximately 3.8 kilometres (km) north of the site.

It is noted that an open drainage line is located immediately adjacent to the south of the site. However, based on the orientation and layout of the site, surface water is not anticipated to drain to this area.

2.4.2 Soils and geology

Soils

Based on a review of the *Atlas of Australian Soils*, soils beneath the site are characterised as Sodosol described as the following:

> *Sodosol: Undulating to hilly country: chief soils are hard neutral and acid yellow mottled soils (Dy3.42 and Dy3.41) in a general pattern as follows: (i) undulating to hilly slopes of various (Dy) and (Dr) soils, including (Dy3.41), (Dy3.42), (Dy3.2), (Dr2.2), (Dr2.4); (ii) (Dy3.42) and sometimes (Dr3.42) soils in basins which merge with unit Va21 and lower-lying sites generally; and (iii) less frequently (Gn2. 15) and (Gn2.25) soils on gently undulating areas, usually situated between (i) and (ii).*

The soil profile observed during previous investigation was reported to consist of fill material which was reported to extend to depths of up to 2.5 m on-site, comprising spent coal ash and/or coal fragments, asbestos containing material (ACM) and other buried waste material. Natural sandy clays and clays were reported to underlay fill material at the site to the maximum depth of investigation, being 10.0 m.

Geology

According to the *Goulburn 1:250,000 Geological Series Sheet 55-12* (Second Edition, 2013), the site is underlain by Cainozoic Aged alluvium consisting of gravels and sands overlying Palaeozoic Aged Gundary beds consisting of sandstone, siltstone volcanic mudstone and lithic-quartz sandstone.

2.4.3 Hydrogeology

According to the most recent *Groundwater Monitoring Event* (Cavvanba, 2022), groundwater beneath the site was observed to be present within an unconfined water bearing zone in natural clays and sandy clays at depths of between approximately 3.4 m to 6.7 m below ground level. Groundwater was shallowest in the north-eastern portion of the site.

Groundwater elevations indicated that groundwater flow was predominantly in a north-easterly direction, generally aligning with the general topographic slope of the site and towards the Wollondilly River.

It is important to note that groundwater flow direction can be influenced locally and regionally by not only surface topography, but recharge and discharge areas, horizontal and vertical inconsistencies in the types, location and orientation of subsurface soils or bedrock, and proximity to water extraction / pumping bores.

Groundwater Bore Search

A total of five registered groundwater bores were located within a 1,000 m radius of the site (Cavvanba, 2021). Groundwater bore information from these bores has been provided within Table 2.1, below.

Table 2.1: Licensed bore summary

Bore ID	Registered use	Distance from site (m)	Geology	Depth (m)	Standing water level (m)
GW105739	Stock / Domestic Purposes	~195m (South)	Sand / Gravel / Clay	78.00	2.00
GW110381	Recreation (groundwater)	~689m (Northeast)	Gravel / Clay / Siltstone	54.00	5.00
GW064585	Stock / Domestic Purposes	~765m (North)	Clay / Gravel / Shale	15.80	-
GW071524	Monitoring	~887m (North)	Silty Sand / Silty Clay	6.50	5.30
GW102093	Domestic	~907m (Northeast)	Sandy Clay / Gravel / Shale	27.40	0.60

3.0 Contamination Summary

A number of environmental investigations have been completed at the site since 1996. The following have been made available to Cavvanba for review:

- *Phase 1 Environmental Contamination Assessment* (CMPS&F Pty Ltd, 1996);
- *Environmental Investigation – Goulburn Fuelling Facility at Braidwood Rd (*Jeffrey and Katauskas Pty Ltd, 1997);
- *Preliminary Contamination Investigation – Goulburn Roundhouse Railway Track* (DM McMahon Pty Ltd, 2014);
- *Interim Management Plan – Goulburn Roundhouse, 12 Braidwood Road, Goulburn, NSW 2580* (Cavvanba, September 2020);
- *Detailed Site Investigation – Goulburn Roundhouse, 12 Braidwood Road, Goulburn, NSW 2580* (Cavvanba, January 2021);
- *Interim Management Plan – Goulburn Roundhouse, 12 Braidwood Road, Goulburn, NSW 2580* (Cavvanba, April 2021); and
- *Additional Environmental Site Assessment – Goulburn Roundhouse, 12 Braidwood Road, Goulburn, NSW 2580* (Cavvanba, August 2021).

Adequate site characterisation has been achieved and a suitably robust conceptual site model has been developed for informed remediation decision making. The site has been divided into four separate areas based on spatial distribution and contamination type. These areas are presented on Figure 3, and are further discussed in the following sub-sections.

Groundwater at the site is currently being managed through a program of routine groundwater monitoring. Therefore, has not been considered further in this ROA.

3.1 Area A – North of Roundhouse

This area is located to the north of the roundhouse building, amongst buildings that currently or historically contain ACM. The area comprises approximately 1,200 m^2.

Co-located asbestos and lead contamination

Non-friable ACM fragments were identified across the surface of this area, and lead was reported to exceed the adopted assessment criteria at the surface and within fill material with a maximum reported concentration of 1,800 mg/kg. Fill material was reported to comprise black sandy gravel, with evidence of intermixed ash material to a maximum depth of 1.8 m (BH03) and minimum depth of 1.2 m (MW03).

3.2 Area B – Southwest of Roundhouse

This area is located to the southwest of the roundhouse building, adjacent to the western fenced boundary, and comprises an active railway siding which ceases at the roundhouse building. This area comprises approximately 2,200 m^2.

Asbestos contamination only

Non-friable ACM fragments were identified across the surface of this area. Fill material was reported to comprise black sandy gravel comprising spent coal ash to a maximum depth of 0.6 m (TP44), and minimum depth of 0.3 m (TP15). Test pit location TP13, was advanced within the buffer stop / small stockpile that was present at the end of the railway line.

Lead was reported below the adopted assessment criteria within samples collected from the fill material (including ash) within this area.

3.3 Area C – South of Roundhouse

This area is located to the south of the roundhouse building, and encompasses the area surrounding the former Wellington Building and Plumber's Shed. This area is bound to the east by the existing fence line and Fitter's Amenities Building, and comprises approximately 8,100 m^2.

Co-located asbestos and lead contamination

Non-friable ACM fragments were identified on the ground surface of this area. Fill material was reported to predominantly comprise black sandy gravel with spent coal ash to a maximum depth of 2.2 m (TP08), and minimum depth of 0.3 m (TP37 and TP38) in the southern portion of the site. Significant quantities of buried and layered ACM sheeting was identified at test pit locations, TP06, TP07 and TP08, present to depths of 2.2 m.

Lead was reported to exceed the adopted assessment criteria at the surface and within fill material with a maximum reported concentration of 9,550 mg/kg.

3.4 Area D – East of Existing Fence Line

This area is located to the east of the existing fenceline, and comprises the filled / raised area, encompassing the area immediately to the east of the Fitter's Amenities Building. This area comprises approximately 3,000 m^2.

Co-located asbestos and lead contamination

Non-friable ACM fragments were identified on the ground surface within areas of exposed bare soils. Fill material was reported to consist of a black sandy gravel with spent coal ash to a maximum depth of 2.2 m (TP30), and minimum depth of 1.2 m (TP21). Buried waste materials included bricks, glass, concrete, plastic, rags and steel were identified within a number of test pit locations. ACM sheeting was observed within test pit location TP30, from approximately 1.7 m to 2.2 m in depth.

Lead was reported to exceed the adopted assessment criteria within fill material at test pit location TP23, at a depth of 0.9 – 1.0 m and reported concentration of 1,540 mg/kg.

3.5 Area E – Between Existing Railway Siding Roads

This area is located between the existing railway siding roads which were inaccessible during the completion of the previous investigations. This area is to be assessed as part of the remediation investigation and prior to the preparation of a remediation action plan.

4.0 Conceptual Site Model

Fundamental to the risk assessment process is the development of a conceptual site model (CSM), which is the qualitative description of plausible mechanisms where receptors may be exposed to site contamination. For exposure to be considered possible, a mechanism / pathway must exist by which contamination from a given source can reach a given receptor. A complete source-pathway-receptor (SPR) exposure mechanism is referred to as a SPR linkage throughout this report.

The potential SPR linkages are evaluated for completeness based on the existence of:
- a source of contamination;
- a mechanism for release of contaminants from identified sources (i.e. dispersion through windborne dust);
- a contaminant retention or transport medium (i.e. soil, air, groundwater, etc);
- potential receptors of contamination; and
- a mechanism for chemical intake by the receptors at the point of exposure (ingestion, dermal contact or inhalation, or a combination of).

4.1 Source of contamination

A discussion of the contamination sources at the site based on reported historical operations / actions is presented in Section 3.0. This ROA is focussed towards the remediation of lead and asbestos contaminated soil identified at the Goulburn Roundhouse, which is predominantly related to historical site infilling and waste disposal.

According to anecdotal information provided by GLRPS, the southern portion of the site was historically used as a scrapping / burning area for redundant timber railway carriages. The source of ACM in and on soils was considered likely associated with the inappropriate removal of ACM from on-site buildings and structures.

4.2 Exposure and migration pathways

The pathways for potential contaminant migration and potential exposure for receptors at the site include the following:
- incidental ingestion;
- incidental direct contact;
- inhalation of windborne dust / asbestos fibres;
- exposure to contaminated soil via plant root update / organisms that may inhabit / contact soils.

4.3 Receptors

The following potential receptors at the site include the following:
- on-site commercial / industrial and intrusive maintenance workers; and
- on-site soil processes, plant species and organisms that may inhabit or contact soils.

4.4 Source-pathway-receptor linkages

The potentially complete SPR linkages identified for the site include the following:
- direct contact, incidental ingestion and inhalation of windborne dust / asbestos fibres by on-site receptors; and
- direct contact with impacted soil by terrestrial ecological receptors.

Contaminated soils – human health

The uncovered lead contaminated surface soil provides a direct exposure pathway to site occupants and intrusive maintenance workers via dermal contact, dust inhalation or ingestion of contaminated soil. Elevated concentrations of lead were reported to be

widespread in fill material across the southern and north-western portion of the site which represents a potential risk to human health.

Non-friable ACM in and on soil provides a direct exposure pathway to on-site occupants and intrusive maintenance workers via airborne fibre inhalation if not appropriately managed. At depth the risk is reduced, however the area where highly concentrated ACM is buried at depth poses a high risk if the material is disturbed and should be treated as friable asbestos.

5.0 Remediation options assessment

5.1 Contamination policy framework

In completing a review of remediation options with consideration to the above criteria, this assessment also considered the current policy framework such as the National Environment Protection Council (NEPC) *National Environment Protection (Assessment of Site Contamination) Measure 1999 (ASC NEPM (2013))*. More specifically, the ASC NEPM (2013) remediation hierarchy within the Contamination Policy Framework which is defined as follows:

> *(16) Attainment of environmental outcome*
>
> *In general, to achieve the desired environmental outcome, the process of the assessment of site contamination should be placed within the context of the broader site assessment and management process. In particular, in assessing the contamination, the site assessor and others should take into account the preferred hierarchy of options for site clean-up and/or management which is outlined as follows:*
>
> - *on-site treatment of the contamination so that it is destroyed, or the associated risk is reduced to an acceptable level; and*
> - *off-site treatment of excavated soil, so that the contamination is destroyed or the associated risk is reduced to an acceptable level, after which soil is returned to the site; or*
>
> *If the above are not practicable,*
> - *consolidation and isolation of the soil on site by containment with a properly designed barrier; and*
> - *removal of contaminated material to an approved site or facility, followed, where necessary, by replacement with appropriate material;*
>
> *or,*
> - *Where the assessment indicates remediation would have no net environmental benefit or would have a net adverse environmental effect, implementation of an appropriate management strategy.*
>
> *When deciding which option to choose, the sustainability (environmental economic and social) of each option should be considered, in terms of achieving an appropriate balance between the benefits and effects of undertaking the option.*
>
> *In cases where no readily available or economically feasible method is available for remediation, it may be possible to adopt appropriate regulatory controls or develop other forms of remediation.*
>
> *It should be emphasised that the appropriateness of any particular option will vary depending on a range of local factors. Acceptance of any specific option or mix of options in any particular set of circumstances is therefore a matter for the responsible participating jurisdiction.*

5.2 Technology screening criteria

The remediation technology selection process included a general screening of available technologies against site specific conditions such as the site setting, current and proposed land use activities, lithology, the nature and extent of contaminants of concern. The selection process also includes consideration of key stakeholders including ARTC, TfNSW, Goulburn – Mulwaree Council and the NSW EPA, and the policy outlined in Section 5.1.

A review of remediation options considered potentially implementable at the site are described below. Remediation technologies were identified and screened for implementability at the site, with key consideration given to the abovementioned remediation objectives, and includes a combination of the following criteria:

Technical feasibility

- Overall protection of human health and the environment.
- Ability of the technology to meet applicable regulations, guidelines and/or permitting requirements.
- Effectiveness, performance and reliability of the technology to eliminate or reduce the concentration, mobility, mass, or volume of contaminants.

Logistical feasibility

- Assessment of logistical considerations, including space limitations, equipment and resource availability, stakeholder input, utility requirements, monitoring concerns, operation and maintenance.
- Time required to achieve the project end points.
- Assessment of negative attributes of implementing the technology and how they might affect the remediation effort at the site.

Economic feasibility

- Cost effectiveness of the remediation technology.

Additional criteria that is to be considered as part of the technology evaluation includes the following:

Regulatory acceptance

- Compliance with regulatory and stakeholder expectations.

Timeframe

- Duration required to deliver remediation goals.

Sustainability

- The overall net benefit of the project with respect to intergenerational equity considerations, greenhouse gases, energy consumption, waste generation, safety of workers, and effects on neighbours.

5.2.1 Environmental management plans

The Guidelines for the NSW Site Auditor Scheme (3rd edition) (NSW EPA, 2017) defines the purpose of an environmental management plan as a plan which addresses the integration of environmental mitigation and monitoring measures for soils (or groundwater and/or hazardous ground gases) throughout an existing or proposed land use. An EMP can be an effective means of ensuring the environment is protected, users of the site are not exposed to contamination remaining on site and the site remains suitable for the proposed use when:

- complete remediation of contamination is not practicable (i.e. below building footprints or beneath railways lines);
- contaminants are being capped or contained on-site; and/or
- remediation is likely to cause greater adverse impact than would occur if the site were left undisturbed.

Systems to manage contaminated detailed within an environmental management plan (EMP) may be passive or active. Passive management systems usually require minimal management and maintenance and do not usually incorporate mechanical components (i.e. ongoing maintenance of a durable capping layer). Active management systems usually incorporate mechanical components and/or require monitoring and regular maintenance and inspections are necessary. Most active management systems are applied at sites, if the systems are not implemented, an unacceptable risk may occur. Active management systems must only be considered for properties where effective long-term management is feasible.

5.3 Applicable remediation technologies

The following technologies and alternatives were considered for implementation. These technologies have been considered with respect to site-specific conditions and overall implementability at the site.

Table 5.1: Remediation technologies

Category	Technology
No Action	• N/A.
Management	• Active institutional controls. • Active institutional / administrative controls with response measures.
Removal	• Excavation with off-site disposal. • Excavation with on-site treatment and on-site re-use.
Containment	• Excavation, movement, regrading and leveling followed by cap and contain, and passive management. • Cap and contain in-situ and passive management

5.4 Technology evaluation

As discussed in Section 5.2, each potential remediation option was assessed with respect to technical, logistical and economic feasibility and with consideration given to the stated objectives.

If the technology was deemed feasible under each of the three criterion, the technology was considered implementable and was retained for further consideration and comparison with other retained technologies. If a technology was deemed not feasible for one or more of the criteria, the technology was not considered implementable and was eliminated from further evaluation and/or consideration.

The following Table 5.2 summarises the technologies reviewed, and the results of the assessment (retained or eliminated from further consideration). A complete review of the technologies evaluated is presented as Appendix A.

Table 5.2: Remediation technologies evaluation results

Technology	Retained	Eliminated	Summary
No action	-	×	Not acceptable
Institutional / administrative controls	-	×	Active management required, and too active to enforce. Not acceptable
Institutional / administrative controls with response measures	✓ (short-term*)	× (long-term)	Active management required, and too active to enforce. Not acceptable
Excavation and off-site disposal	-	×	Very high capital costs
Excavation with on-site treatment and on-site reuse	-	×	Co-located lead and asbestos contaminated soils cannot be treated
Excavation, movement, regrading and leveling followed by cap and contain and passive management	✓	-	Acceptable and minimal maintenance through passive management
Cap and contain in-situ and passive management	-	×	Requirement to raise the current site surface resulting in aesthetic issues. Not acceptable.

Notes: *Short-term refers to a duration of approximately 12 months.

5.5 Recommended remediation options

The following remediation technologies are considered technically, logistically and economically feasible based on the technology screening included as Appendix A:

- **Option 1 – Cap and contain**. This technology involves excavation, movement, regrading and levelling followed by cap and contain to ensure the final site level will be consistent with the surrounding area. This enables ongoing use of the site under a commercial/industrial land use scenario, satisfying all stakeholders. A passive long-term EMP (LTEMP) will be required and enforced. A conceptual design has been included as Figures 4a to 4c.

- **Option 2 – Excavation and off-site disposal.** Excavation with off-site disposal is a viable option for removing contamination. However, this option has been provided for cost comparison purposes only, and is presented in Section 6.3.

5.6 Recommended interim management measures

- **Institutional / administrative controls with response measures**. This is a short-term response for a period of 12 – months. This is not a long-term option. However, this is considered to be an acceptable approach to manage contamination in the short – term, provided that any potential risks to on- and off-site receptors are low and acceptable. This option involves restricting access to the known contamination areas and the implementation of active administrative controls to manage any future activities and use, and minimising exposure to on-site contamination.

6.0 Preliminary cost estimate

This section presents the methodology and results of the preliminary costs, primarily for implementing the recommended remediation alternatives, however for comparative purposes, Cavvanba have presented cost estimates for the following remediation options:

- Option 1 – Capping and containment;
- Option 2 – Excavation with off-site disposal which has been provided for cost comparison purposes.

Cavvanba has also presented a cost estimate for the short-term management of Institutional / administrative controls with response measures which is considered to be a short – term (approximately 12-months) approach to managing on-site contamination.

6.1 Option 1 - Capping and containment

This technology involves capping and containing a total area of approximately 14,500 m^2, comprising Areas A to Area D as presented on Figure 3. The final site level for Area A and B, and Area C surrounding existing infrastructure will be consistent with the current elevation, enabling continued commercial/industrial use of the site and satisfying key stakeholders. The rear, southern and lower portion of Area C will be used for the placement of excavated contaminated soils from Areas A and B, and surrounding existing infrastructure within the northern portion of Area C to raise and level this area prior to the placement of the capping layer. Area D will be reshaped and regraded to ensure longevity of the area to prevent potential future erosion and sediment control issues.

The capping layer will be keyed into existing railway and heritage infrastructure, with an assumption that approximately 1 m outside of existing railway lines will suffice and the management of potentially contaminated sub-soils below and within the immediate vicinity of railway lines will be managed through the implementation of a passive LTEMP. The LTEMP must include a procedure for the appropriate management and removal / capping of material below railway infrastructure during future maintenance activities to ensure the appropriate protection of human health and the environment. A conceptual design has been provided as Figures 4a to 4c.

To enable the generation of the cost estimate, the following scope summary has been prepared:

Preliminaries

- *Project management* – General project management and coordination, contract administration, procurement and stakeholder engagement.

- *Remediation investigation* – Completion of a follow-up investigation to further understand the nature and extent of contamination within Area E, being areas previously inaccessible due to the presence of railway related infrastructure.

- *Remediation Action Plan* (RAP) – Preparation of a RAP which sets remediation objectives and documents the process to be followed on how to remediate the site. Whilst considered unlikely, Area E may be required to be added to the remediation area.

- *Engineering design* – Obtaining a detailed engineering design for the proposed works, incorporating survey plans, cut and fill designs, and affiliated plans and specifications.

- *Pre-field and planning* – Preparation of health and safety documentation, asbestos removal control plans, construction environmental management plans, obtaining any required licences, permits and/or approvals, and notification of regulatory authorities of the intention to complete the remediation project.

Remediation

- *Mobilisation / Demobilisation* – Mobilisation all required plant and equipment to site, erection of on-site office and amenities, security fencing and associated signage.

- Remediation oversight, supervision and record keeping by a suitably qualified contaminated land consultant, including daily asbestos control air monitoring throughout the duration of the works.

- ***Area A*** – Excavation of the upper 0.3 m from Area A, comprising an approximate volume of 360 m^3 for relocation and placement within Area C. Capping layer to be keyed into surrounding buildings and infrastructure.

  Application of a geofabric marker layer across 1,200 m^2 followed by importation of 360 m^3 of virgin excavated natural material (VENM), roadbase or similar as capping material.

- ***Area B*** – Excavation of the upper 0.3 m from Area B, comprising an approximate volume of 660 m^3 for relocation and placement within Area C. Excavation to within approximately 1 m of existing railway infrastructure, and capping layer keyed into railway infrastructure and surrounding buildings and infrastructure.

  Application of a geofabric marker layer across 2,200 m^2 followed by importation of 660 m^3 of VENM, roadbase or similar as capping material. Cavvanba acknowledges that the contamination within this area is limited to asbestos only and fill material was identified at a maximum thickness of 0.6 m. The requirement for complete remediation within this area without the requirement for capping and passive management is to be assessed during the course of the remediation program.

- ***Area C*** – Excavation of the upper 0.3 m within and around existing buildings and infrastructure in the northern portion of Area C for relocation and placement within the southern portion. Area C is to be prepared for the placement of contaminated soils from Area A and Area B, to ensure a level and workable site surface. Excavation to within approximately 1 m of existing railway infrastructure, and capping layer keyed into railway infrastructure and surrounding buildings and infrastructure.

  Application of a geofabric marker layer across 8,100 m^2 followed by the importation of 2,430 m^3 of VENM, roadbase or similar as capping material.

- ***Area D*** – Clearing and grubbing of tree and vegetation within Area D followed by reshaping of the embankment area. Pending the results of the cut and fill design, there is the potential for material to be added to Area D, should this be required. Area D is to be reshaped and regraded to ensure the future stability of the area, and to prevent erosion and sediment control issues.

  Application of a geofabric marker layer across 3,000 m^2 followed by importation of 500 m^3 of VENM, roadbase or similar as capping material. An allowance has been made for hydroseeding and placement of erosion and sediment controls.

- ***Area E*** – Not included within the cost estimate, and will be subject to additional investigation. If required, excavation of the upper 0.3 m from Area E, comprising an approximate volume of 450 m^3 for relocation and placement within Area C or Area D (pending cut and fill balances). Capping layer to be keyed into surrounding buildings and infrastructure.

  Application of a geofabric marker layer across 1,500 m^2 followed by importation of 450 m^3 of VENM, roadbase or similar as capping material.

Validation and reporting

- Validation of the completion of remediation works will be achieved through a visual appraisal, materials tracking and survey plans and is to be thoroughly documented by a suitably qualified contaminated land consultant throughout the duration of the works.

- Preparation of all required final project documentation including validation report and passive LTEMP.

A preliminary cost estimate has been provided for this remediation option below. For comparative purposes, all other options have been presented as shaded text within Table 6.1, below. A complete breakdown of costs is provided as Table 1 of Appendix B.

Table 6.1: Preliminary cost estimate summary

Technology	Cost estimate (ex GST)
Option 1: Capping and containment	$668,181 (excl. contingency & Area E)
Option 2: Excavation with off-site disposal	$14,891,538 (excl. contingency)

The cost estimate excludes any requirements that may be associated with the preparation of a development application, and there has been no allowance made for the installation of on-site stormwater drainage systems, as given the unsealed nature of the proposed surface covering, is not considered required. This remediation option assumes that the works can be completed within the timeframe specified, without hinderance beyond reasonable control. As such, no allowance has been made for unforeseen delays in the program.

6.2 Option 2 – Excavation with off-site disposal

A cost estimate for the excavation and off-site disposal of contaminated soils assumes the technology can be completed without variability in the extent of remediation required. The key uncertainty in the preparation of this cost estimate includes the potential variability of the volume of waste streams across the site, such as general solid waste, restricted solid waste, special waste (asbestos) and hazardous waste, in accordance with the NSW EPA (2014) *Waste Classification Guidelines*. In some circumstance, there are limited disposal options for specific waste streams with large capital cost variations. As such, this technology requires additional site investigation to better determine the extent of soil contamination, and therefore volume of waste proposed for off-site disposal.

This technology has been presented for cost comparative purposes, and assumes a reasonable worst-case scenario, whereby all material proposed to be excavated is in accordance with the results of previous environmental investigations completed by Cavvanba in 2020 and 2021. This assumes all material to be excavated from Area A, B and D will be classified as General Solid Waste – Special Waste (asbestos) in accordance with the NSW EPA (2014) *Waste Classification Guidelines*, and approximately 75 % of the total material to be excavated from Area C will be classified as Restricted Solid Waste – Special Waste (asbestos) and the remaining 25 % will be General Solid Waste – Special Waste (asbestos).

A preliminary cost estimate has been provided for this remediation option below. For comparative purposes, all other options have been presented as shaded text within Table

6.2, below. A complete breakdown of costs is provided as Tables 3 of Appendix B, detailing the reasonable worst-case scenario.

Table 6.2: Preliminary cost estimate summary

Technology	Cost estimate (ex GST)
Option 1: Capping and containment	$668,181 (excl. contingency & Area E)
Option 2: Excavation with off-site disposal	$14,891,538 (excl. contingency)

The cost estimate excludes any requirements that may be associated with the preparation of a development application. In some circumstances, complete remediation may not be practicable including beneath building footprints and beneath active railway lines. Therefore, passive management will likely be required following the completion of this remediation option. It assumes that following additional site investigation, no unexpected finds are uncovered. It is noted that this technology assumes appropriately licensed waste receiving facilities have the capacity to receive the quantities of waste proposed as part of this remediation option.

6.3 Interim management – Institutional / administrative controls with response measures

This is a short-term response for a period of 12 – months and is currently being implemented. This is not a long-term option. It is considered to be an acceptable approach to manage contamination in the short – term, provided that any potential risks to on- and off-site receptors are low and acceptable. This option involves restricting access to the known contamination areas and the implementation of administrative and active controls to manage any future activities and use, and minimising exposure to on-site contamination. Active controls will include routine hand-picking of ACM to ensure accumulation and disturbance of ACM is minimised, and managing dust during plant or vehicular movements. Restricting access via fencing and trafficking of unsealed areas will promote grass growth to minimise dust generation during dry and dusty conditions.

Asbestos hand-picking will be undertaken in accordance with ASC NEPM (2013) and *Guidelines for the Assessment, Remediation and Management of Asbestos-Contaminated Sites in Western Australia* (Western Australia Department of Health, 2021) and generally include the following:

- hand-picking and manual collection of ACM across Areas A to D through the use of four personnel, including a SafeWork NSW Class B licensed asbestos removal contractor;
- at least two passes of hand-picking made with a 90° direction change between each, and using a grid pattern; and
- disposal of ACM to a suitably licensed waste receiving facility.

A preliminary cost estimate has been provided for this response measures below. A complete breakdown of costs is provided as Table 3 of Appendix B.

Table 6.3: Preliminary cost estimate summary

Technology	Cost estimate (ex GST)
Institutional / administrative controls with response measures	$101,800 (Annually)

It is noted that this approach will not achieve the site or remediation objective, however is considered to an acceptable approach to managing contamination in the short – term, provided that any potential risks to on- and off-site receptors are low and acceptable.

6.3.1 Key assumptions, limitations and variations

It is acknowledged that cost estimating is defined by the assumptions made, and relies solely on the data used in the development of such estimates.

The preliminary costs estimates prepared as part of this ROA have been produced for comparative purposes only. All costs have generally been provided as an overestimate and exclude GST. Should Cavvanba be afforded the opportunity, Cavvanba reserve the right to further refine the costs associated with the preferred technology.

Certain aspects of the cost estimating (i.e, labour and subcontractor costs) were based on Cavvanba's past industry and professional experience in cost estimating for remediation of contaminated sites together with costs provided by a suitably qualified and experienced remediation contractor. Actual costs at the time of future remediation may vary particularly if new and/or revised regulatory guidelines are introduced.

7.0 Closing

This remediation options assessment was completed to enable the selection of the most appropriate remediation option that can be implemented to reduce potential risks associated with lead and asbestos contaminated soils on-site.

The ROA includes a broad screening of remediation options potentially applicable for remediation of lead and asbestos contamination in soil at the site. The broad screen considers the implementability of remediation options which are generally based on a combination of the following criteria:

- site setting (contaminant characteristics, geology/hydrogeology, depth of impact, existing infrastructure);
- potential impacts (health and safety, waste generation, potential for increased risk to off-site receptors);
- implementation (timeframe to achieve remediation objectives, complexity/technical considerations, costs, stakeholder acceptance, reputation); and
- sustainability (broad consideration of social, economic, and environmental factors including greenhouse gas emissions, dust, noise, traffic, nuisance odours, etc.).

Cavvanba considers the preferred option to be **Option 1 – capping and containment** based on the implementability of this option.

Institutional / administrative controls with response measures must also be implemented as a short-term response for managing contamination due to the presence of co-located lead and asbestos contamination in surface soils at the site which are accessible to site occupants. This approach is not a long-term option and should only be considered for a period of 12-months to reduce as far as practicable, any potential risks to on- and off-site receptors.

Thank you for the opportunity to assist ARTC and TfNSW with this evaluation. We trust that the information proves useful in your business decision making process.

8.0 References

Previous Environmental Investigations

Cavvanba (August, 2021) *Additional Environmental Site Assessment – Goulburn Roundhouse, 12 Braidwood Road, Goulburn, NSW 2580.*

Cavvanba (January, 2021) *Detailed Site Investigation – Goulburn Roundhouse, 12 Braidwood Road, Goulburn, NSW 2580.*

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Cavvanba (April, 2021) *Interim Management Plan – Goulburn Roundhouse, 12 Braidwood Road, Goulburn NSW 2580*.

Cavvanba (July, 2022) *Interim Management Plan – Goulburn Roundhouse, 12 Braidwood Road, Goulburn NSW 2580*.

Cavvanba (April, 2022) *Groundwater Monitoring Event - Goulburn Roundhouse, 12 Braidwood Road, Goulburn NSW 2580.*

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EPA (1999) *Contaminated Sites: Guidelines on Significant Risk of Harm from Contaminated Land and the Duty to Report*. NSW EPA, Sydney.

EPA (2000) *Environmental Guidelines: Use and Disposal of biosolids products*. NSW EPA, Sydney.

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EPA (2015) *Guidelines on the Duty to Report Contamination under the Contaminated Land Management Act 1997*. NSW DECC, Sydney.

EPA (November 2014) *Waste Classification Guidelines – Part 1: Classifying Waste*. NSW EPA, Sydney, NSW.

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Figures

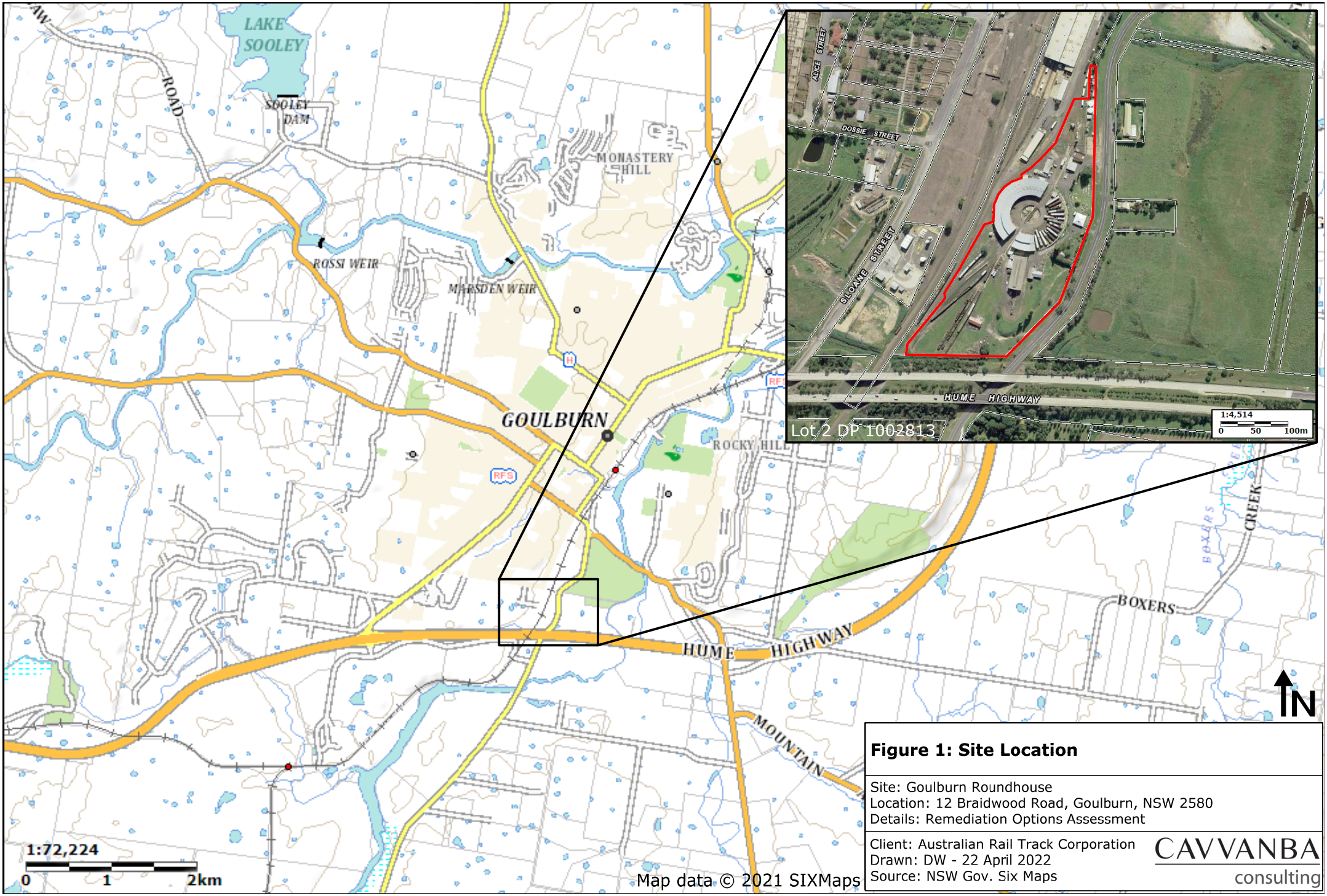

Figure 1: Site Location

Site: Goulburn Roundhouse
Location: 12 Braidwood Road, Goulburn, NSW 2580
Details: Remediation Options Assessment

Client: Australian Rail Track Corporation
Drawn: DW - 22 April 2022
Source: NSW Gov. Six Maps

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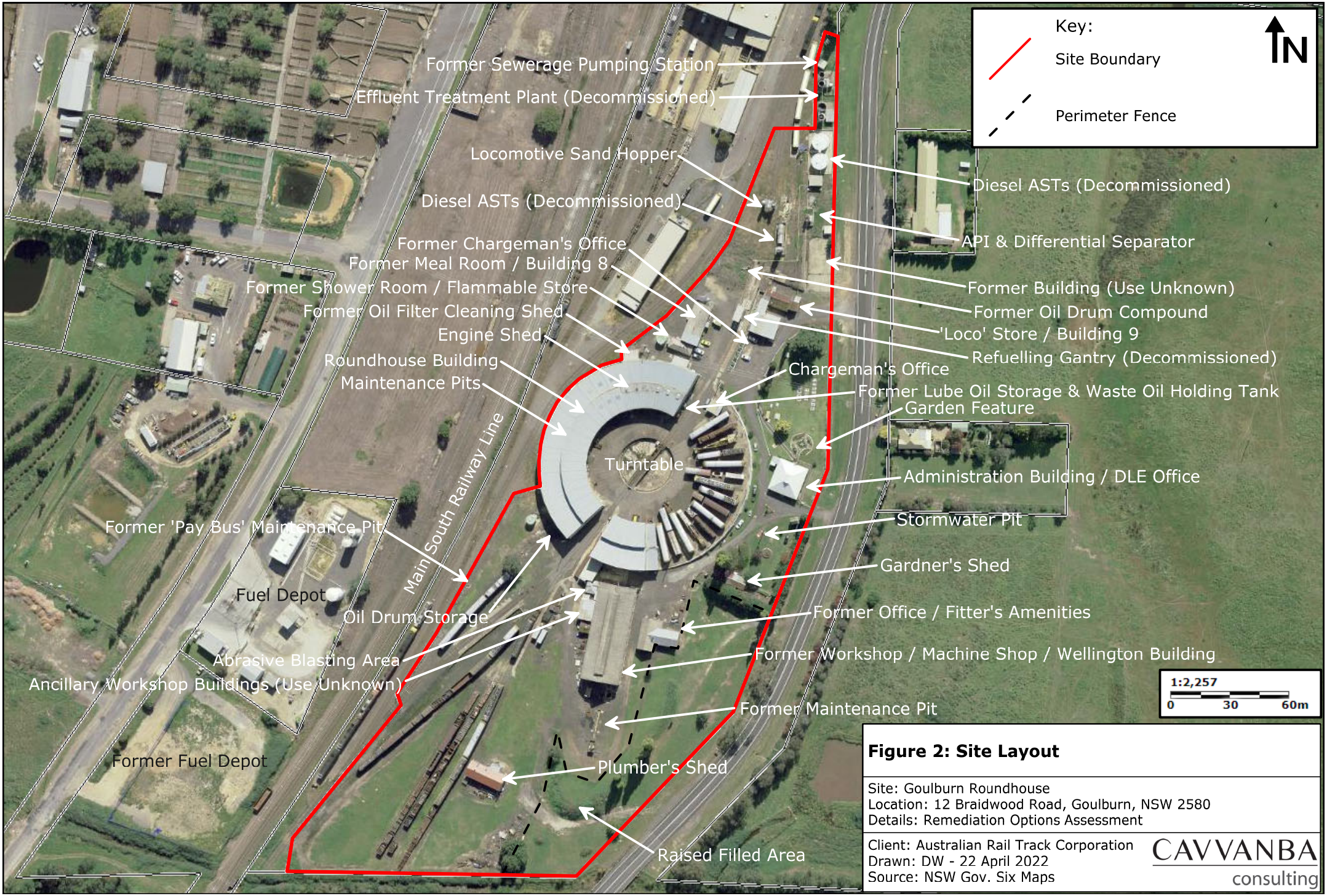

Figure 2: Site Layout

Site: Goulburn Roundhouse
Location: 12 Braidwood Road, Goulburn, NSW 2580
Details: Remediation Options Assessment

Client: Australian Rail Track Corporation
Drawn: DW - 22 April 2022
Source: NSW Gov. Six Maps

CAVVANBA consulting

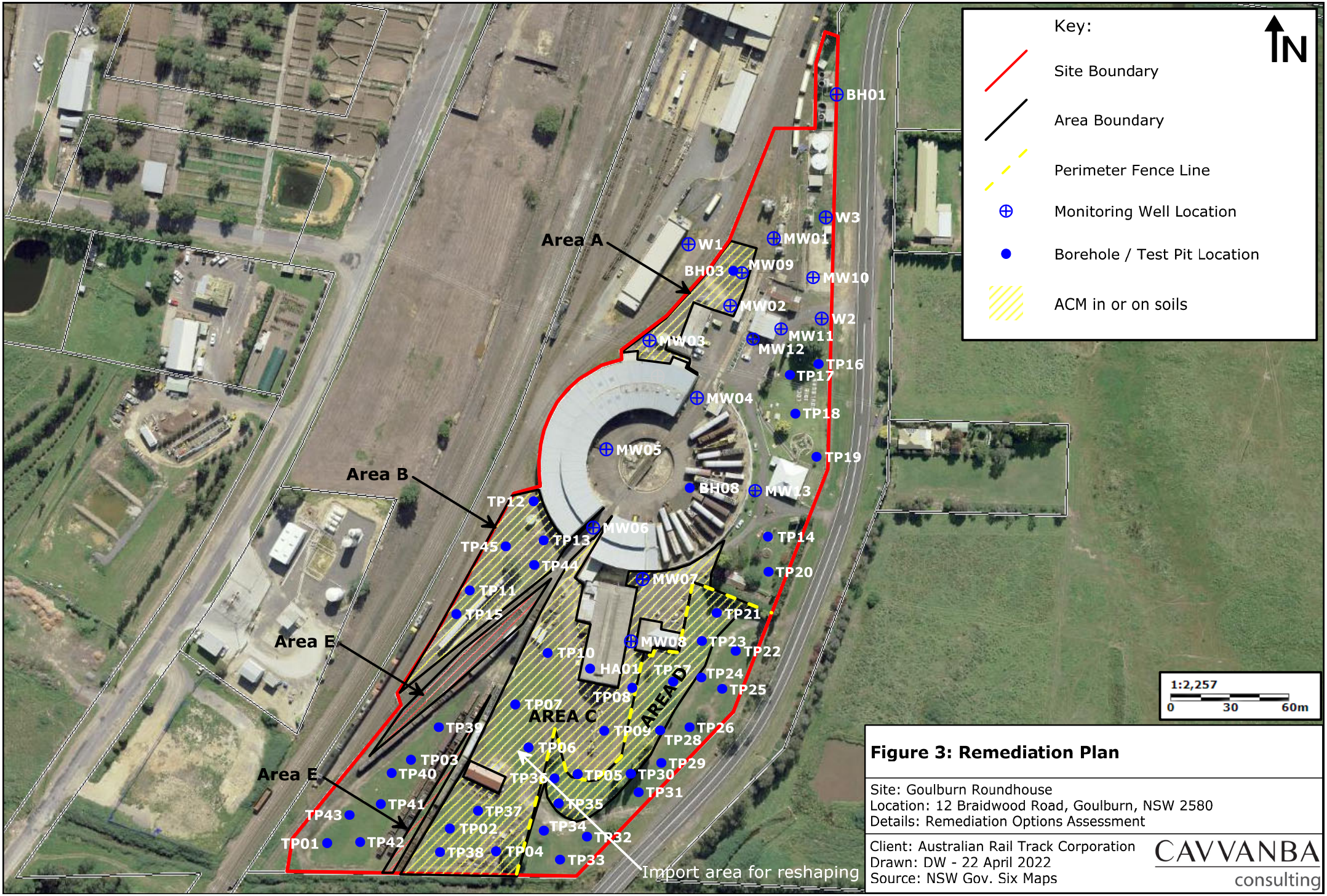

Figure 3: Remediation Plan

Site: Goulburn Roundhouse
Location: 12 Braidwood Road, Goulburn, NSW 2580
Details: Remediation Options Assessment

Client: Australian Rail Track Corporation
Drawn: DW - 22 April 2022
Source: NSW Gov. Six Maps

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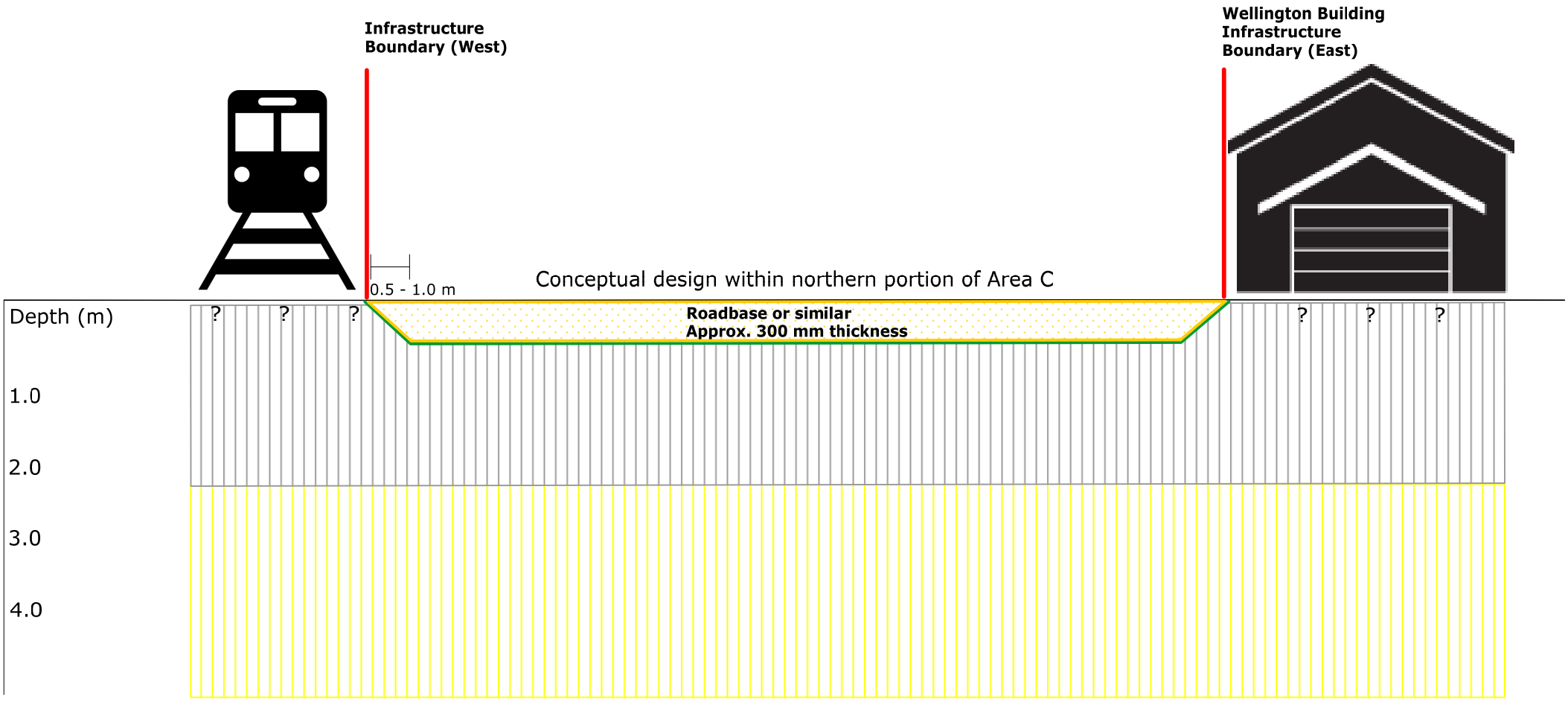

Note: Drawing for conceptual purposes only, not to scale

Legend

- Approx. capping layer
- Geofabric / marking layer
- Existing contamination (soils)
- Natural clay

Figure 4a: Conceptual Capping Design

Site: Goulburn Roundhouse
Location: 12 Braidwood Road, Goulburn, NSW 2580
Details: Remediation Options Assessment

Client: Australian Rail Track Corporation
Drawn: DW - 22 April 2022
Source: NSW Gov. Six Maps

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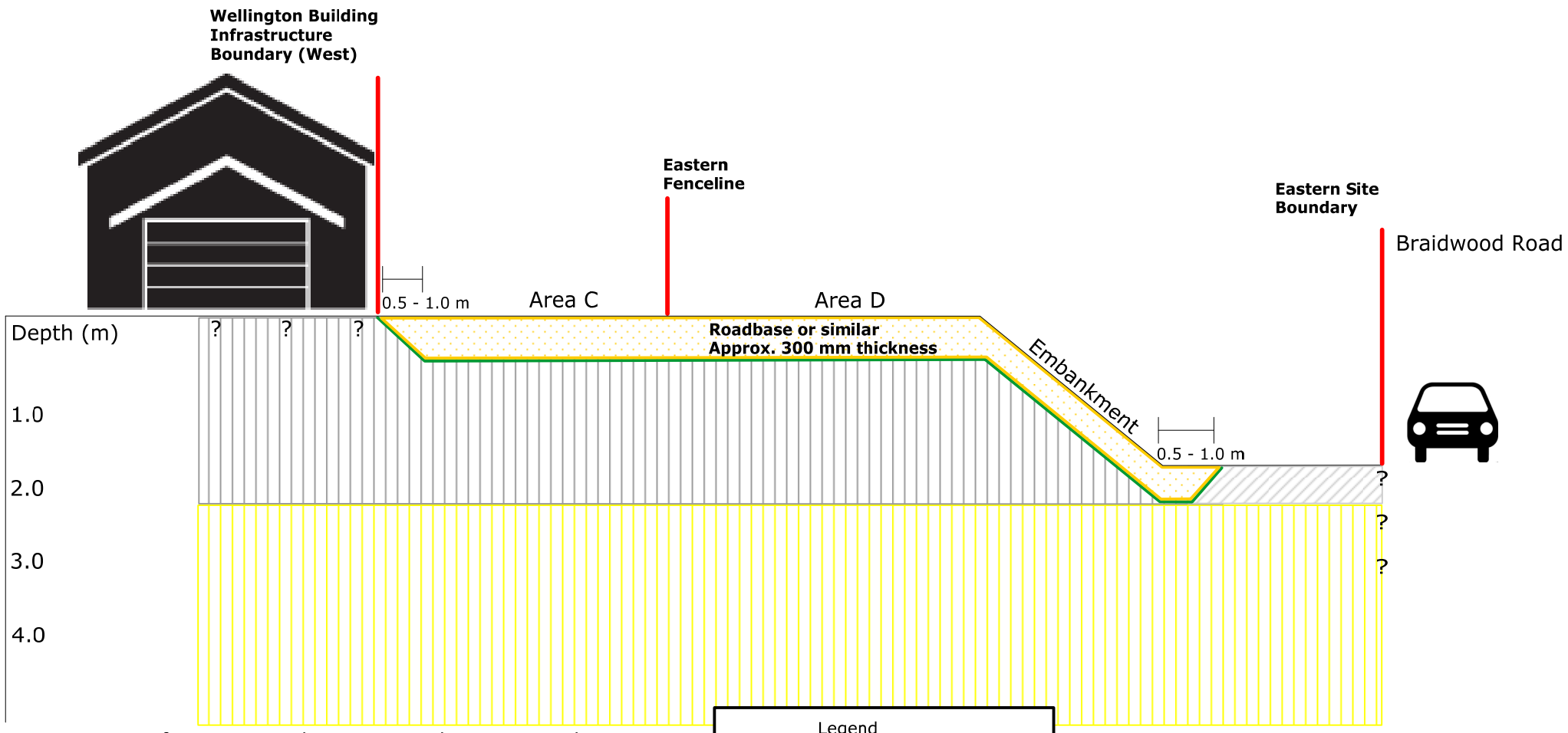


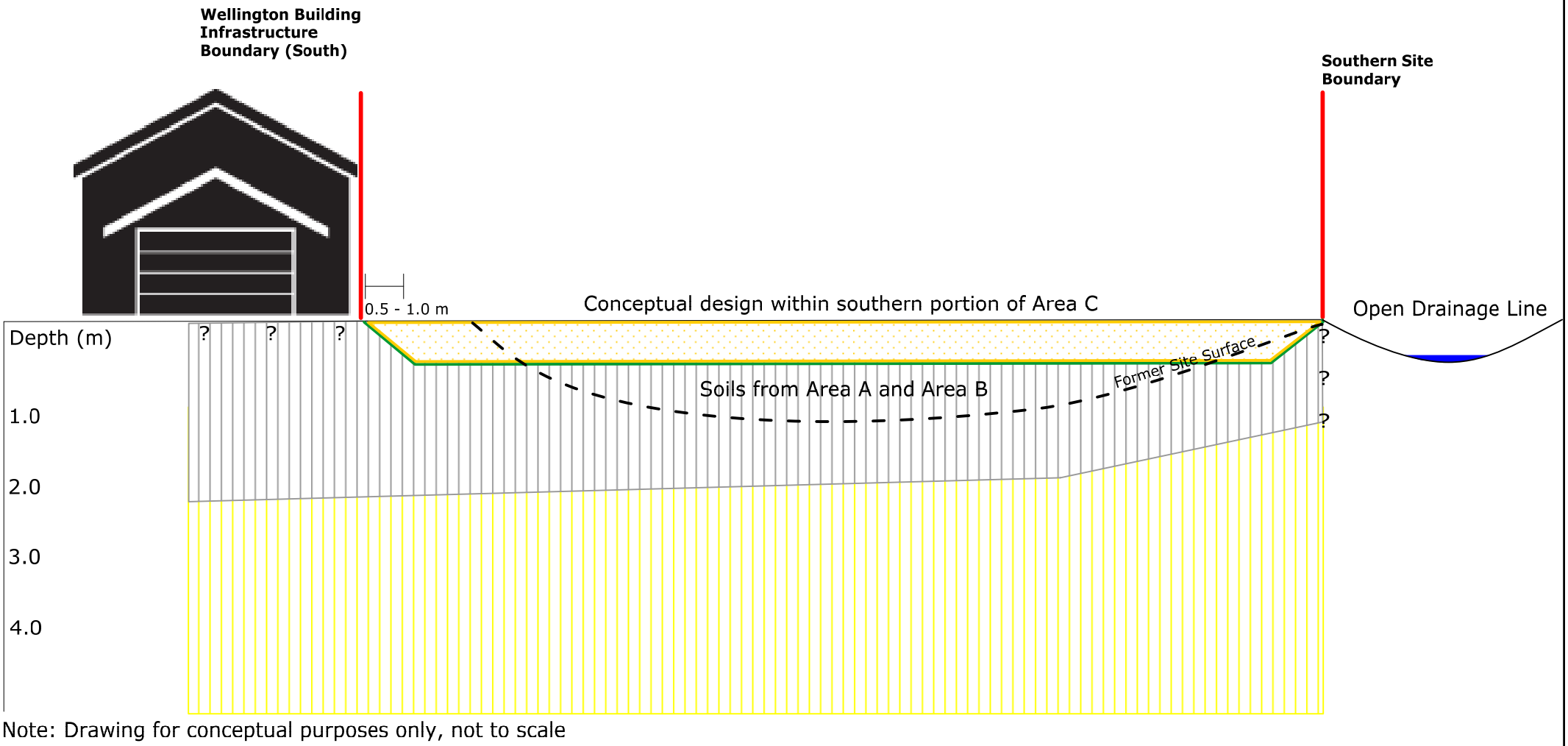
Note: Drawing for conceptual purposes only, not to scale

Figure 4b: Conceptual Capping Design

Site: Goulburn Roundhouse
Location: 12 Braidwood Road, Goulburn, NSW 2580
Details: Remediation Options Assessment

Client: Australian Rail Track Corporation
Drawn: DW - 22 April 2022
Source: NSW Gov. Six Maps

CAVVANBA consulting



Note: Drawing for conceptual purposes only, not to scale

Legend

- Approx. capping layer
- Geofabric / marking layer
- Existing contamination (soils)
- Natural clay

Figure 4c: Conceptual Capping Design

Site: Goulburn Roundhouse
Location: 12 Braidwood Road, Goulburn, NSW 2580
Details: Remediation Options Assessment

Client: Australian Rail Track Corporation
Drawn: DW - 22 April 2022
Source: NSW Gov. Six Maps

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Appendix A

Remediation Options Assessment Review Table

Table 1: Remediation Options Assessment

General Remediation Options and Technologies	Screening Criteria				Relative Cost	Conclusion
	Technical Feasibility - Can the remedial option achieve the remediation objectives? - Will the remedial option succeed? - Will the remedial option be effective in the long-term?		**Logistical Feasibility** - Can the remedial option be implemented in a reasonable timeframe? - Is the option acceptable to stakeholders? - Can effects on noise / traffic / etc be adequately managed?			Retain for further consideration -or- Eliminate from further consideration
	Pros	Cons	Pros	Cons		
No action	Can be implemented.	Not effective in reducing / removing contaminant toxicity, mobility or mass. Contaminant mass remains and would continue to potentially pose an unacceptable risk to human health through generation and transport of windborne dust / asbestos fibre(s). Will not satisfy regulator and/or stakeholders.	Can be implemented.	Will not satisfy stakeholders, particularly given the use of the site as a railway heritage museum. Land use restrictions, and consequentual loss of income relating to sub-leasing of land, and dilapidation of buildings and structures due to no ongoing maintenance.	No capital cost. However, likely to be future additional costs associated with regulatory involvement / enforcement. Land use restrictions, and consequentual loss of income relating to sub-leasing of land, and dilapidation of buildings and structures due to no ongoing maintenance.	**Eliminate** Will not satisfy regulator and/or stakeholders. Will not prevent exposure to contamination and enable use of the site under the current commercial/industrial land use scenario.
Institutional controls Implementation of active administrative controls to minimise exposure to on-site contamination, and manage any future development and use.	Can be implemented on-site only. Applicable as a minimal effort required to eliminate, minimise or control exposure to asbestos and lead contamination identified.	Not effective in reducing / removing contaminant toxicity, mobility or mass. Contaminant mass remains and would continue to potentially pose an unacceptable risk to human health through generation and transport of windborne dust / asbestos fibre(s). Site maintenance activities such as lawn mowing will require strict procedures, monitoring and management. Will not satisfy regulator and/or stakeholders.	Can be implemented on-site only.	Difficult to enforce given current lease arrangement. Will not satisfy stakeholders, particularly given the use of the site as a railway heritage museum. Land use restrictions, and consequentual loss of income relating to sub-leasing of land, and dilapidation of buildings and structures due to no ongoing maintenance.	Low capital costs associated with implementing institutional controls (< $20,000). However, likely to be future additional costs associated with regulatory involvement / enforcement. Land use restrictions, and consequentual loss of income relating to sub-leasing of land, and dilapidation of buildings and structures due to no ongoing maintenance.	**Eliminate** Will not satisfy regulator and/or stakeholders. Difficult to enforce given the current lease arrangement, and will not prevent exposure to contamination and enable continued use of the site under the current commercial/industrial land use scenario.
Institutional controls with fencing and monitoring Restrict access and implementation of active administrative controls to manage any future development and use, and to minimise exposure to on-site contamination. Control immediate potential ACM risk through hand-picking.	Can be implemented on-site only. Applicable as a minimal effort required to eliminate, minimise or control exposure to asbestos and lead contamination identified on-site.	Not effective in reducing / removing contaminant toxicity, mobility or mass. Contaminant mass remains and may continue to pose an unacceptable risk to human health through generation and transport of windborne dust / asbestos fibre(s). Site maintenance activities such as lawn mowing will require strict procedures, monitoring and management. Will not satisfy regulator and/or stakeholders in long-term.	Can be implemented on-site only. Relatively low effort required to manage potential risk in the short-term.	Will not satisfy stakeholders, particularly given the use of the site as a railway heritage museum. Land use restrictions, and consequentual loss of income relating to sub-leasing of land, and dilapidation of buildings and structures due to no ongoing maintenance.	Low capital costs associated with fencing and implementing institutional controls. Additional monitoring, maintenance and management costs associated with ensuring potential risk to receptors is acceptable. However, given potential for generation of windborne dust / asbestos fibre(s), potential for additional costs associated with regulatory involvement / enforcement. Land use restrictions, and consequentual loss of income relating to sub-leasing of land, and dilapidation of buildings and structures due	**Eliminate** This is not a long-term option and must be considered for short-term application to reduce potential risks to human health and the environment. Acceptable for a period of 12-months. Will not satisfy regulator and/or stakeholders. Difficult to enforce given the current lease arrangement. Potential for migration of contaminants through windborne dust and exposure due to seasonal variations (dry, summer conditions) and through site
Excavation with off-site disposal Excavation of known contaminated soils. Excludes beneath building footprints and railway lines which will likely require ongoing passive management regardless.	Can be implemented at the site. Suitable landfill disposal sites are available, and excavation equipment readily available. The contaminated soil is present within approximately 2.2 m of the ground surface, and can be safely excavated, stockpiled, loaded and transported off-site. Effective in the long-term, with contaminated soil / waste contained in an approved disposal facility.	Excavation with off-site disposal is technically feasible at the site. Appropriately licensed waste receiving facilities may not have capacity to receive the quantities proposed to be excavated. May increase disposal costs. There is the potential for contamination to remain beneath the Wellington Building, and existing railway sidings. Therefore, complete removal of contamination may not be technically feasible without infrastructure removal.	The majority of contaminated soils will be removed from site and site will be suitable for commercial/industrial use. Acceptable to NSW EPA. Equipment is available. This option will meet the requirements of the site objectives and remediation objectives.	Disturbing soil enhances occupational and public risk due to: - Large quantities of asbestos contamination. - Has potential to generate dust, which requires management and monitoring. Given the nature of contamination and potential for numerous waste streams (GSW, GSW with asbestos, RSW and hazardous waste), additional investigation will be required to further refine extent of contamination to facilitate remediation. Large volume (mass) of soil to be excavated. Uncertainty regarding capacity of disposal facilities, and whether they can accept volumes proposed. Backfill with VENM required.	<u>Capital</u> Very large capital costs associated with this option, therefore not considered further. Refer to costs associated with excavation with off-site disposal for an indication of costs. <u>O&M</u> Once excavation is backfilled, additional remediation costs are not required.	**Eliminate** Not considered further due to very large capital costs associated with this option. Refer to costs associated with excavation with off-site disposal for an indication of costs.

Table 1: Remediation Options Assessment

General Remediation Options and Technologies	Screening Criteria				Relative Cost	Conclusion
	Technical Feasibility - Can the remedial option achieve the remediation objectives? - Will the remedial option succeed? - Will the remedial option be effective in the long-term?		**Logistical Feasibility** - Can the remedial option be implemented in a reasonable timeframe? - Is the option acceptable to stakeholders? - Can effects on noise / traffic / etc be adequately managed?			Retain for further consideration -or- Eliminate from further consideration
	Pros	Cons	Pros	Cons		
Excavation with on-site treatment and on-site reuse	No contaminated soil needs to be moved off-site for disposal. Risk is removed, and negates requirement for future management.	Generally not suitable for high levels of contamination, where asbestos is present and additional debris / anthropogenic inclusions within fill material.	Accepted industry approach, however not logistically feasible.	Implementing treatment enhances occupational and public risk due to: - Large quantities of asbestos contamination. - Has potential to generate dust, which requires management and monitoring. - Technique has potential to generate considerable dust, which requires management and monitoring.	High capital costs. Not considered further due to not technically or logistically feasible.	**Eliminate** Not considered further due to not technically or logistically feasible.
Cap and contain in-situ Cap and contain in-situ involving raising the site surface by 0.3 m	Can be implemented at the site. Applicable as the most efficient and cost effective approach to eliminate / control exposure to asbestos and lead contamination at the site. Minimal disturbance, and therefore minimal dust generation. Minimise amount of sampling required.	Capping layer will need to be durable to ensure longevity, which will require ongoing maintenance to ensure suitable surface covering. Due to the current uneven site surface / topography, this will remain unchanged however will be at an elevation approximately 0.3 m higher than the current elevation to allow for durable capping layer. Ongoing / long - term management of the site under passive EMP.	The site land use will remain consistent with the current use, and will enable to the use of the entire site area by the lessee. Lower costs, time delays and greater confidence of outcome. Acceptable to NSW EPA. Equipment is available. This option will meet the requirements of the site objectives and remediation objectives.	Disturbing soil enhances occupational and public risk due to: - Large quantities of asbestos contamination. - Has potential to generate dust, which requires management and monitoring. Contamination remains on-site and will need to be managed. The site will require long-term management / passive EMP. The final site level will be raised, and unlikely to be acceptable to stakeholders due to the heritage significance of the site. Additionally, this will result in mounding within areas not previously identified to ensure that the capping layer is appropriately keyed into surrounding infrastructure.	<u>Capital</u> Low capital costs in comparison to off-site disposal and less than the cap and contain options with movement of contaminated soils. <u>O&M</u> Additional maintenance costs associated with ensuring durability of cap / vegetation control / etc. However, passive management is required which is expected to be minimal.	**Eliminate** Feasible for contaminated soil, however not considered further due to the requirement to raise the current site surface and will result in mounding within areas to ensure that the capping layer is appropriately keyed into surrounding infrastructure. Not acceptable to stakeholders, particularly due to the heritage significance of the site.
Cap and contain Excavation, movement, regrading and leveling to ensure final site level will be consistent with surrounding area, followed by cap and contain.	Can be implemented at the site. Applicable as the most efficient and cost effective approach to eliminate / control exposure to asbestos and lead contamination at the site. Minimal disturbance, and therefore minimal dust generation. Minimise amount of sampling required.	Capping layer will need to be durable to ensure longevity, which will require ongoing maintenance to ensure suitable surface covering. Ongoing / long - term management of the site under passive EMP.	The site land use will remain consistent with the current use, and will enable to the use of the entire site area by the lessee. Lower costs, time delays and greater confidence of outcome. Acceptable to NSW EPA. Equipment is available. This option will meet the requirements of the site objectives and remediation objectives.	Disturbing soil enhances occupational and public risk due to: - Large quantities of asbestos contamination. - Has potential to generate dust, which requires management and monitoring. Contamination remains on-site and will need to be managed. The site will require long-term management / EMP.	<u>Capital</u> A summary of cost estimates are provided in Section 6. <u>O&M</u> Additional maintenance costs associated with ensuring durability of cap / vegetation control / etc. However, passive management is required which is expected to be minimal.	**Retain** Feasible for contaminated soil, however limitations due to ongoing long-term maintenance under a apssive EMP.

Appendix B

Scenario Cost Estimates

Table 1: Option 1 - Capping and containment

Item	Description	Task Subtotal (Approx.)	Comments
1	**Project management** - Contract administration - Regulatory liaison - Coordination	$22,000	Total project duration - approx. 8 weeks Contracting, procurement, invoicing Liaise with NSW EPA Stakeholder, site and contractor coordination
2	**Remediation Investigation and Remediation Action Plan** - Remediation investigation, targeted towards Area E - Remediation Action Plan	$35,000	To further understand the nature and extent of contamination within Area E, being inaccessible at the time of previous investigations. Preparation of Remediation Action Plan
3	**Engineering design** - Site survey - Plans and specifications - Construction scheduling and tracking	$35,000	Detailed survey prior to remediation Detailed survey post remediation Schedule development and tracking.
4	**Pre-field and planning** - Health and safety plan - Air monitoring plan - Stormwater pollution prevention plan - Permitting	$15,000	Planning Asbestos Removal Control Plan Asbestos air monitoring plan Stormwater management during works Resource consent for remediation Remediation oversight by a suitably qualified contaminated land consultant, and asbestos control air monitoring throughout the duration of the works.
5	**Mobilisation / demobilisation** - Construction equipment - Amenities - Security, fencing and signs - Decontamination facilities	$25,000	Delivery to, and remove from site Office, storage, amenities, etc Work site protection, occupation and public safety Personnel and equipment decontamination
6	**Remediation: Cap and contain (Area A - Approx. 1,200 m²)** - Excavation of the upper 0.3 m from Area A for placement within Area C - Geofabric marker layer - Cap and contain	$55,752	Excavation of the upper 0.3 m to ensure a finish surface level consistent with the current site surface to retain the heritage amenity of the site. Excavate 648 tonne to be placed within Area C for reapplication. Geofabric marker layer, supply and install across 1,200 m² Supply and placement of 648 tonne of VENM Approximately 5 days
7	**Remediation: Cap and contain (Area B - Approx. 2,200 m²)** - Excavation of the upper 0.3 m from Area B for placement within Area C - Geofabric marker layer - Cap and contain	$90,479	Excavation of the upper 0.3 m to ensure a finish surface level consistent with the current site surface to retain the heritage amenity of the site. Excavate to within approximately 1 m outside of existing railway infrastructure, with capping layer to be appropriately keyed in. Excavate 1,188 tonne to be placed within Area C for reapplication. Geofabric marker layer, supply and install across 2,200 m² Supply and placement of 1,188 tonne of VENM Approximately 8 days
8	**Remediation: Cap and contain (Area C - Approx. 8,100 m²)** - Application of 648 tonne from Area A - Application of 1,188 tonne from Area B - Geofabric marker layer - Cap and contain	$268,254	Excavate to within approximately 1 m outside of existing railway infrastructure, with capping layer to be appropriately keyed in. Preparation of Area C for placement, including keying into existing infrastructure. Spread and placement of excavated material from Area A and Area B. Geofabric marker layer, supply and install across 8,100 m² Supply and placement of 4,374 tonne of VENM Approximately 18 days
9	**Remediation: Cap and contain (Area D - Approx. 3,000 m²)** - Clearing and grubbing of trees and vegetation - Reshaping and grading of embankment. - Geofabric marker layer - Cap and contain	$101,695	Clearing and grubbing of trees and vegetation, following by reshaping of embankment. Geofabric marker layer, supply and install across 3,000 m² Supply and placement of 900 tonne of VENM Provision for hydroseeding and placement of erosion and sediment controls Approximately 5 days
12	**Reporting** - Site Validation Report - Long-Term Passive Environmental Management Plan	$20,000	Final project documentation
	Project Subtotal	**$668,181**	
	Contingency (10%)	$66,818	
	Project Total	$734,999	
13	**Remediation: Cap and contain (Area E - Approx. 1,500 m²)** - Excavation of the upper 0.3 m from Area E for placement within Area C or Area D - Geofabric marker layer - Cap and contain	$78,216	Excavation of the upper 0.3 m to ensure a finish surface level consistent with the current site surface to retain the heritage amenity of the site. Excavate to within approximately 1 m outside of existing railway infrastructure, with capping layer to be appropriately keyed in. Excavate 810 tonne to be placed within Area C or Area D for reapplication. Geofabric marker layer, supply and install across 1,500 m² Supply and placement of 1,188 tonne of VENM Approximately 8 days

Table 2: Option 2 - Excavation with off-site disposal

Item	Description	Task Subtotal (Approx.)	Comments
1	**Project management** - Contract administration - Regulatory liaison - Coordination	$22,000	Total project duration - approx. 30 weeks Contracting, procurement, invoicing Liaise with NSW EPA Stakeholder, site and contractor coordination
2	**Remediation Investigation and Remediation Action Plan** - Remediation Investigation - Waste Classification - Remediation Action Plan	$100,000	To further refine waste streams and conduct in-situ waste classification assessments. Preparation of Remediation Action Plan Preparation of Waste Classification Letters
3	**Engineering design** - Site survey - Plans and specifications - Construction scheduling and tracking	$35,000	Detailed survey prior to remediation Detailed survey post remediation Schedule development and tracking.
4	**Pre-field and planning** - Health and safety plan - Air monitoring plan - Stormwater pollution prevention plan - Permitting	$15,000	Planning Asbestos Removal Control Plan Asbestos air monitoring plan Stormwater management during works Resource consent for remediation
5	**Mobilisation / demobilisation** - Construction equipment - Amenities - Security, fencing and signs - Decontamination facilities	$25,000	Delivery to, and remove from site Office, storage, amenities, etc Work site protection, occupation and public safety Personnel and equipment decontamination
6	**Remediation: Excavation and off-site disposal (Area A - Approx. 1,200 m²)** - General Solid Waste with asbestos	$806,872	Subject to Cavvanba additional investigation. Assumes average depth of 1.5 m of 1,200 m² to be removed from site - 1,800 m³. Includes excavation of approximately 3,240 tonne. Assume 3,240 tonnes - GSW with asbestos Approximately 8 days
7	**Remediation: Excavation and off-site disposal (Area B - Approx. 2,200 m²)** - General Solid Waste with asbestos	$494,494	Subject to Cavvanba additional investigation. Assumes average depth of 0.5 m of 2,200 m² to be removed from site - 1,100 m³. Includes excavation of approximately 1,980 tonne. Assume 1,960 tonnes - GSW with asbestos Approximately 5 days
8	**Remediation: Excavation and off-site disposal (Area C - Approx. 8,100 m²)** - General Solid Waste with asbestos - Restricted Soil Waste with asbestos	$8,974,213	Subject to Cavvanba additional investigation. Assumes average depth of 1.5 m of 8.100 m² to be removed from site - 12,150 m³. Includes excavation of approximately 21,870 tonne. Assume 5,400 tonnes - GSW with asbestos Assume 16,470 tonnes RSW with asbestos Approximately 40 days
9	**Remediation: Excavation and off-site disposal (Area D - Approx. 3,000 m²)** - General Solid Waste with asbestos	$2,647,040	Subject to Cavvanba additional investigation. Assumes average depth of 2.0 m of 3,000 m² to be removed from site - 6,000 m³. Includes excavation of approximately 10,800 tonne. Assume 10,800 tonnes - GSW with asbestos Assume clearing and grubbing Approximately 22 days
10	**Validation Sampling**	$10,000	Visual clearance for asbestos containing material, analytical sampling for lead only at a rate of 2 samples per 5 m for walls (1 sample for < 0.5 m in depth), and base of excavation in accordance with NSW EPA (1995) Sampling Design Guidelines. Area A - 113 samples (Approximate perimeter of 264 m) Area B - 104 samples (Approximate perimeter of 472 m) Area C - 344 samples (Approximate permitter of 809 m) Area D - 169 samples (Approximate perimeter of 400 m) * Potential to remove approximately 160 samples due to common boundary between Area C and Area D.
11	**Site reinstatement** - VENM to reinstate excavations - Backfill and track roll	$1,746,920	VENM quantities like for like. Area A - 3,240 tonne (Approximately 8 days) Area B - 1,980 tonne (Approximately 5 days) Area C - 21,870 tonne Approximately 40 days) Area D - 10,800 tonne (Approximately 22 days)
12	**Reporting** - Site Validation Report	$15,000	Final project documentation
	Project Subtotal	**$14,891,538**	
	Contingency (10%)	$1,489,154	
	Project Total	$16,380,692	

Table 3: Institutional / administrative controls with response measures

Item	Description	Task Subtotal (Approx.)	Comments
1	**Project management** - Stakeholder liaison - Coordination	$1,800	Stakeholder, site and contractor coordination
2	**Interim response measures** - Hand-picking of surface ACM fragments to reduce the load - Asbestos disposal	$13,000	SafeWork NSW notification One full day of hand-picking with four personnel, including a SafeWork NSW Class B asbestos removal contractor Disposal at a suitably licensed waste receiving facility.
5	**Reporting** - Interim Environmental Management Plan	$5,000	Interim Environmental Management Plan has already been prepared for the site within *Interim Management Plan - Goulburn Roundhouse, 12 Braidwood Road, Goulburn NSW 2580* (Cavvanba, April 2021). Ensure adequate to meet the current requirements.
	Project Subtotal	**$19,800**	
	Security Fencing - Sub-surface utility clearance - Fencing	$33,000	Clearance of potential underground services prior to fence install. Provided as additional item to replace / expand fencing that is currently present at the site and will depend on heritage requirements. 1.8 m high chainlink fence.
	Routine response measures (quarterly) - Hand-picking ACM - Asbestos disposal	$39,000	Routine hand-picking of ACM Frequency to depend on climatic condictions, and volume of asbestos removed and condition of the site from previous event Disposal at a suitably licensed waste receiving facility. Three additional events @ $13,000 / event.
	General maintenance - Fence maintenance - Signage	$10,000	
	Project Total	$101,800	Assume 12 month duration.