Department of Energy, Mines, Industry Regulation & Safety (DEMIRS)

ABANDONED MINE FEATURES ASSESSMENT

NORTHAMPTON – COMMONAGE & WANERENOOKA REHABILITATION OPTIONS STUDY

April 2025

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WML

Consulting Engineers

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WML Consultants Pty Ltd

Ivana Golijanin

Geotechnical Engineer

Author

Simon Maris

Principal Geotechnical Engineer

Reviewer

For and on behalf of WML Consultants Pty Ltd

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1 INTRODUCTION

The Department of Energy, Mines, Industry Regulation & Safety (DEMIRS) engaged WML Consultants (WML) to undertake a geotechnical assessment and rehabilitation options study to support the rehabilitation of abandoned mine features at the Commonage and Wanerenooka sites surrounding Northampton, Western Australia. These include shafts, open stopes, costeans, and shallow workings. Based on the intrusive and non-intrusive geotechnical investigations undertaken in October and November 2023, 59 features at the Commonage site, and 6 features at the Wanerenooka site have been assessed. This report presents a rehabilitation options study, based on the findings of the accompanying geotechnical report, 11126-G-R-001, for different rehabilitation options. The options have been ranked based on suitability against each of the known features and includes detailed descriptions and discussions of each potential rehabilitation option.

The geotechnical study was authorised by DEMIRS via letter of acceptance DMIRS23011, dated 11th May 2023.

This report and the information presented herein must be read in conjunction with the attached "*Report Limitations*".

1.1 Client supplied information

The following information was made available from the Client for the purpose of this report:

- DMIRS23011 Request – 'Geotechnical Engineering Services for Abandoned Mine Features at Commonage and Wanerenooka, Northampton', prepared by DEMIRS.
- Reference Documents and Mine Plans Part A – C, provided by DEMIRS.
- Photographs of features at Commonage and Wanerenooka, prepared by DEMIRS.
- Spatial files for Commonage and Wanerenooka, prepared by DEMIRS.
- Field notes 'Commonage and Wanerenooka', prepared by DEMIRS.

1.2 Objectives of this report

The objectives of this rehabilitation options study are to provide the following for each option:

- Description and rationale.
- Schematics/drawings showing the process/arrangement/design.
- Plant and equipment required to do the works.
- Material specification where relevant (e.g. material type, sizing, density, moisture content) and volumes.
- Potential or likely sources of material.
- Timing and/or sequencing requirements.
- Potential risks to effective implementation including any impact from groundwater or unfavourable geochemistry where applicable.
- Post rehabilitation monitoring requirements.
- Personnel and specific technical expertise required.
- Suitability of each option against each known feature.

In addition, the rehabilitation options have been assessed against the following criteria:

1. Provide a permanent solution to mitigate safety and geotechnical risks associated with the features, including any lateral workings and subsidence risk zones.
2. Minimise risk to personnel during construction.
3. Require minimal ongoing monitoring or maintenance.
4. Be technically feasible and cost-effective.
5. Minimise disturbance to the existing environment and heritage values.

2 REHABILITATION OPTIONS

The rehabilitation options listed below have been assessed to potentially rehabilitate the 68 features identified at the Commonage and Wanerenooka sites. Some features require two levels of treatment; these are typically located within areas which have been identified as medium to high risk of interconnected lateral and underground workings. The following options will be detailed subsequently and include:

1. Leave as is – no rehabilitation required
2. Blading the area to reduce steepness of slopes and soften the feature
3. Backfilling with soil
4. Reinforced earth backfill
5. Concrete slab cap
6. Steel grate cap
7. Reinforced earth cap
8. Reinforced earth cap across areas at risk of void collapse
9. Fencing the area

The seven (7) feature categories identified in the accompanying geotechnical report, 11126-G-R-001, have been classified in accordance with observations made on site during both the intrusive and non-intrusive ground investigations and in terms of the risk posed to humans, vehicles, livestock, and pets. The recommendations below pertain to these categories.

The following recommendations are based on the results of the non-intrusive and intrusive site investigations undertaken In October and November of 2023. While the ground conditions appeared consistent across the site, the contractor should be aware the ground conditions may vary across the site and the excavatability of the natural strata may also vary due to variable depths to the extremely weathered rock layer. It should also be noted that whilst WML have attempted to identify voids and drives within each feature, the potential for unknown voids, drives and underground lateral workings may exist.

The following advice regarding construction equipment and timing is preliminary only, and the earthwork contractor should assess the site conditions to determine the exact requirements for machinery and construction equipment.

The rehabilitation options may require some modifications during construction pending observations of ground conditions and other variables; WML shall be on site during construction to advise and modify the methodology and rehabilitation specifics as required.

2.1 Leave as is – no rehabilitation required

Rehabilitation for up to 39 features is not considered necessary as they exist as Category 1 or 2 features, typically existing as shallow workings, or minor depressions on the ground surface, generally indiscernible from the natural topography of the site. The risk of void collapse and presence of / proximity to lateral workings is very low. These features also pose low risk of trips and falls to humans, livestock, or pets, and a 4x4 vehicle should be able to traverse these features.

Data obtained from the geophysical investigation indicates there are no lateral workings within the top 20 m and low risk of voids within the vicinity of these features.

The base conditions have been validated during the geotechnical investigation and are considered to be stable.

No ongoing maintenance or monitoring of these features is required.

If DEMIRS believes some rehabilitation is necessary to reduce risk, we recommend options 2 and 3 be considered.

2.2 Blading the area to reduce steepness of slopes and soften the feature

This method is typically suited to Category 1 and 2 and features, should rehabilitation be required, which typically exist as shallow workings, minor depressions, costeans, and trenches on the ground surface, generally indiscernible from the

natural topography of the site. The risk of void collapse and presence of / proximity to lateral workings is very low. These features also pose low risk of trips and falls to humans, livestock, or pets, and a 4x4 vehicle should be able to traverse these features.

Data obtained from the geophysical investigation indicates there are no lateral workings within the top 20 m and low risk of voids within the vicinity of these features.

The base conditions have been validated during the geotechnical investigation and are considered to be stable..

Table 1: Blading rehabilitation options study

Requirements	Description
Plant and equipment	Posi track, small dozer, or 5t excavator.
Material specification	No imported material required. The feature is backfilled and softened using surrounding spoil near the berm.
Quantity / volume of material	See Section 3.
Potential source of material	None required.
Timing	It is anticipated a single feature could be rehabilitated in a space of anywhere between 3 hours to up to 2 days (for the larger costeans) pending the amount of vegetation and debris that needs to be removed from the base and pruning/clearing to gain access to the feature, size of the feature, and machinery chosen for the work.
Potential environmental risk, including groundwater, flora and fauna	This may cause some disturbance to the existing ground surface and surrounding environment. Small trees may need to be removed in areas of dense vegetation to allow for a clear path for the equipment to access the feature locations. It is considered in most cases, small trees within and around the feature can be left in place as part of the rehabilitation process. Rabbit burrows were observed within some of the spoil piles on site; re-using the existing spoil material found on site as fill may impact local fauna (rabbits) within the area, however, rabbits are not a protective or native species, this should not be a significant consideration. DEMIRS may wish to undertake environmental assessments on specific features.
Potential risk to contractors and operators	At these features it has been determined that there is no risk due to underground features / lateral workings / subsidence. Therefore, these features pose no additional risk to a competent earthwork contractor.
Personnel and technical expertise	Any competent and experienced earthwork contractor should be able to undertake this work.
Post rehabilitation maintenance and monitoring	None required.

2.3 Backfill with soil

Backfilling with soil has been selected as the rehabilitation option for Category 3 features, which are typically classified as shallow holes and features. The risk of void collapse and presence of / proximity to lateral workings is low. These features also pose medium risk of trips and falls to humans, livestock, or pets, and a 4x4 vehicle should not attempt to traffic these features.

Data obtained from the geophysical investigation indicates there are no lateral workings within the top 20 m and low risk of voids within the vicinity of these features.

The base conditions have been validated during the geotechnical investigation and are considered to be stable.

Table 2: Soil backfill rehabilitation options study

Requirements	Description
Plant and equipment	12t+ excavator. A small (up to 6t) dump truck to bring imported fill from the temporary stockpile location to the feature. A loader or excavator to load the dump truck. A tipper haul truck to import granular fill material to site.
Material specification for imported fill	Any imported fill material should comprise a clean inert granular material with a fines content < 15% and no particles > 100 mm. See Section 2.10.
Quantity / volume of material	See Section 3.
Potential source of material	The contractor is to provide details of sustainable locally sourced, cost-effective fill material to the designer for approval. The fill needs to be a granular, clean, inert, natural material, however, there are no specific structural requirements of this material as it is simply backfilling an existing void. This can consist of spoil generated from nearby construction projects or be sourced commercially; however, the material must meet the specifications.
Timing	Between 1 – 2 days per feature, excluding any time required for creating haul routes to the feature location.
Potential environmental risk, including groundwater, flora and fauna	This may cause some disturbance to the existing ground surface and surrounding environment. Small trees may need to be removed in areas of dense vegetation to allow for a clear path for the equipment to access the feature locations. It is considered in most cases, small trees within and around the feature can be left in place as part of the rehabilitation process. Rabbit burrows were observed within some of the spoil piles on site; re-using the existing spoil material found on site as fill may impact local fauna (rabbits) within the area, however, rabbits are not a protective or native species, this should not be a significant consideration. DEMIRS may wish to undertake environmental assessments on specific features.
Potential risk to contractors and operators	The contractor needs to ensure the haulage routes for any imported fill materials are safe and suitable. During the initial phases of the rehabilitation, we recommend machinery maintains a minimum setback distance of 3 m from the edge of these features. The contractor should be aware of slips, trips, and falls into these features, however, there is no risk of ground collapse due to lateral workings / subsidence / underground features.
Personnel and technical expertise	Any competent and experienced earthwork contractor should be able to undertake this work.
Post rehabilitation maintenance and monitoring	These features have been identified to have very low risk of lateral / deep workings below a false base, therefore one site visit, two years after the rehabilitation is recommended to assess the performance of the rehabilitation solution. If there have been no changes to the rehabilitated features, then no further monitoring is required.

2.4 Reinforced earth backfill

This rehabilitation method has been selected for Category 4 features, which have generally previously been classified as either shallow holes and shafts, with soft or unknown ground conditions at the base of these features. These features pose medium risk of trips and fallings into shafts to humans, livestock, and pets, and a 4x4 vehicle should not attempt to traverse these features.

The base conditions assessed during the geotechnical investigation indicate instability and potential for a false floor. Potential small adits, burrows, or lateral workings may exist; these potential workings may cause loss of backfill material.

This solution may also be considered suitable for Category 5 features, which typically exist as open cuts and shafts filled to the brim with rubbish/debris with unknown depth and base conditions as a primary rehabilitation treatment option. Secondary treatment may also be required for these features, which may involve reinforcing the surrounding area with geofabric.

Soil backfill is not considered suitable for these features as the base conditions of these features are unknown and have not been investigated. This method is suited for features where there exists concern that the floor may potentially give way and collapse, and where these features may extend deeper than they may appear.

While features S0145093-C, Wn1 and Wn2 have been categorised as Category 6 and 7 which have been classified as typically most suited to capping with concrete; these features are located at the base of steep slopes / cliff features, which would require extensive earthworks to be undertaken to level the surrounding area to enable the pre-cast concrete plank solution to be used. Therefore, the most suitable rehabilitation option in these cases, are to use a reinforced earth backfill to rehabilitate these features.

Fifteen (15) features have been identified within the site where this solution leads itself. Features located in areas that may require secondary treatment beyond the initial rehabilitation have been indicated by an asterisk (*) below:

S0145141, S0145044, S0145124, S0145123, S0145072, S0145177, S0145130, S0145163, S0145137*, S0145145*, S0145143*, S0145171*, S0145093-C, Wn1 & Wn2

Table 3: Reinforced earth backfill rehabilitation options study

Requirements	Description
Plant and equipment	7-22t+ excavator. The contractor should assess the reach of the excavator to ensure it can reach the base of these features. A small (up to 6t) dump truck to bring imported fill from the temporary stockpile location to the feature. A loader or excavator to load the dump truck. A tipper haul truck to import granular fill material to site.
Material specification for imported fill	Any imported fill material should comprise a clean inert granular material with a fines content < 15% and no particles > 100 mm. See Section 2.10.
Quantity / volume of material	See Section 3.
Potential source of material	The contractor is to provide details of sustainable locally sourced, cost-effective fill material to the designer for approval. The fill needs to be a granular, clean, inert, natural material, however, there are no specific structural requirements of this material as it is simply backfilling an existing void. This can consist of spoil generated from nearby construction projects or be sourced commercially; however, the material must meet the specifications.
Timing	The timing is dependent on the contractor's ability, personnel and equipment used. We assume a typical time allowance for each feature, depending on its size, should take approximately 2 days excluding any time required for creating haul routes to the feature location.

Potential environmental risk, including groundwater, flora and fauna	This may cause some disturbance to the existing ground surface and surrounding environment. Small trees may need to be removed in areas of dense vegetation to allow for a clear path for the equipment to access the feature locations. Rabbit burrows were observed within some of the spoil piles on site; re-using the existing spoil material found on site as fill may impact local fauna (rabbits) within the area, however, rabbits are not a protective or native species, this should not be a significant consideration. DEMIRS may wish to undertake environmental assessments on specific features.
Potential risk to contractors and operators	The contractor needs to ensure the haulage routes for any imported fill materials are safe and suitable. During the initial phases of the rehabilitation, we recommend machinery maintains a minimum setback distance of 3 m from the edge of these features. The contractor should be aware of slips, trips, and falls into these features, and the potential risk of ground collapse due to lateral workings / subsidence / underground features. Personnel should maintain a minimum setback distance of 1 m from the edge of these features.
Personnel and technical expertise	Any competent and experienced earthwork contractor should be able to undertake this work.
Post rehabilitation maintenance and monitoring	These features have been identified to have medium risk of lateral / deep workings below a false base, therefore one site visit, to conduct a visual assessment, 6 months after the rehabilitation has been completed, and flown surveys 2 years post rehabilitation and again 10 years post rehabilitation is recommended to assess the performance of the rehabilitation solution. If no deformation is observed 12 years post rehabilitation to the features, no further monitoring is required.

2.5 Concrete slab cap

Category 6 and 7 features exist as deep shafts and the available historical information suggests these shafts once extended to significant depths. These features pose high risk of trips and falling into shafts to humans, livestock, and pets and may result in fatal consequences.

This solution tends itself to rectangular shaped features and have typically been identified as main shafts or within direct vicinity of these. Weathered rock of poor to fair rock mass quality was identified within the walls of these features. WML have undertaken geotechnical assessment of the ground conditions around these features and assessed the stability of the shaft walls. Based on this, concrete slabs are considered a suitable rehabilitation option.

Backfill is not considered suitable for these features as they are deep, potentially comprise a false floor, and may contain significant lateral workings.

Table 4: Concrete slab cap rehabilitation recommendations

Requirements	Description
Plant and equipment	22t+ excavator (with rock pick / breaker). Concrete truck and pump or cement mixer. Crane.
Material specification for imported fill	n/a
Quantity / volume of material	n/a

Requirements	Description
Potential source of material	Concrete and steel reinforcement dimensions and specifications TBD.
Timing	The timing is dependent on the contractor's ability, personnel and equipment used. We assume a typical time allowance for each feature, should take approximately 7 days.
Potential environmental risk, including groundwater, flora and fauna	This may cause some disturbance to the existing ground surface and surrounding environment. Small trees may need to be removed in areas of dense vegetation to allow for a clear path for the equipment to access the feature locations. Rabbit burrows were observed within some of the spoil piles on site; re-using the existing spoil material found on site as fill may impact local fauna (rabbits) within the area, however, rabbits are not a protective or native species, this should not be a significant consideration. DEMIRS may wish to undertake environmental assessments on specific features.
Potential risk to contractors and operators	The contractor needs to ensure the haulage routes for any imported materials are safe and suitable. During the initial phases of the rehabilitation, we recommend machinery maintains a minimum setback distance of 4 m from the edge of these features. The contractor should be aware of slips, trips, and falls into these features, specifically working from heights requirements. Personnel should maintain a minimum setback distance of 1 m from the edge of these features. It is recommended that working at heights gear be utilised by personnel working around these features during the rehabilitation work, even after the void has been backfilled.
Personnel and technical expertise	Any competent and experienced earthwork contractor should be able to undertake this work.
Post rehabilitation maintenance and monitoring	One site visit, to conduct a visual assessment, 1 year after the rehabilitation has been completed, and once every 5 years post rehabilitation is recommended to visually assess the performance of the rehabilitation solution.

2.6 Steel grate cap

A steel grate bridge solution may be suitable for Category 6 and 7 features, which typically exist as deep shafts. These features pose high risk of trips and falling into shafts to humans, livestock, and pets, and a 4x4 vehicle should not attempt to traverse these.

While this is a feasible option, WML recommend the use of concrete slabs in place of a steel grate capping system due to likelihood of corrosion of the steel (resulting in increased maintenance) and the potential viewing platform into the features/down mine shafts this rehabilitation option may form with curious members of the public.

Several galvanized steel grid walkways or one whole steel grate may be used to cap the features.

Table 5: Steel grate cap rehabilitation options study

Requirements	Description
Plant and equipment	22t+ excavator (with rock pick / breaker and chains for handling precast concrete planks). Concrete truck and pump or cement mixer.
Material specification for imported fill	n/a

Quantity / volume of material	n/a
Potential source of material	Galvanized steel grate walkway dimensions and specifications TBD.
Timing	The timing is dependent on the contractor's ability, personnel and equipment used. We assume a typical time allowance for each feature, should take approximately 7 days excluding any time required for creating haul routes to the feature location.
Potential environmental risk, including groundwater, flora and fauna	This may cause some disturbance to the existing ground surface and surrounding environment. Small trees may need to be removed in areas of dense vegetation to allow for a clear path for the equipment to access the feature locations. Rabbit burrows were observed within some of the spoil piles on site; re-using the existing spoil material found on site as fill may impact local fauna (rabbits) within the area, however, rabbits are not a protective or native species, this should not be a significant consideration. DEMIRS may wish to undertake environmental assessments on specific features.
Potential risk to contractors and operators	The contractor needs to ensure the haulage routes for any imported materials are safe and suitable. During the initial phases of the rehabilitation, we recommend machinery maintains a minimum setback distance of 4 m from the edge of these features. The contractor should be aware of slips, trips, and falls into these features, specifically working from heights requirements. Personnel should maintain a minimum setback distance of 1 m from the edge of these features. It is recommended that working at heights gear be utilised by personnel working around these features during the rehabilitation work, even after the void has been backfilled.
Personnel and technical expertise	Any competent and experienced earthwork contractor should be able to undertake this work.
Post rehabilitation maintenance and monitoring	One site visit, to conduct a visual assessment, 6 months after the rehabilitation has been completed, and once every 5 years post rehabilitation is recommended to visually assess the performance of the rehabilitation solution.

2.7 Reinforced earth capping

A reinforced earth solution is recommended for the Category 7 feature with a narrower void opening, which may be a deep shaft. This feature poses high risk of trips and falling into the shaft to humans, livestock, and pets, and a 4x4 vehicle should not attempt to traverse this.

One (1) feature has been identified where this solution should be considered.

S0145126

Table 6: Reinforced earth rehabilitation options study

Requirements	Description
Plant and equipment	22t+ excavator. The contractor should assess the reach of the excavator to ensure it can reach the base of these features. A small (up to 6t) dump truck to bring imported fill from the temporary stockpile location to the feature. A loader or excavator to load the dump truck. A tipper haul truck to import granular fill material to site. Whacker plate compactor. Water cart for moisture conditioning soils.

Material specification for imported fill	Any imported fill material should comprise a clean inert granular material with a fines content < 15% and no particles > 100 mm. See Section 2.10.
Quantity / volume of material	See Section 3.
Potential source of material	The contractor is to provide details of sustainable locally sourced, cost-effective fill material to the designer for approval. The fill needs to be a granular, clean, inert, natural material, however, there are no specific structural requirements of this material as it is simply backfilling an existing void. This can consist of spoil generated from nearby construction projects or be sourced commercially; however, the material must meet the specifications.
Timing	The timing is dependent on the contractor's ability, personnel and equipment used. We assume a typical time allowance for each feature, depending on its size, should take approximately 2 days excluding any time required for creating haul routes to the feature location.
Potential environmental risk, including groundwater, flora and fauna	This may cause some disturbance to the existing ground surface and surrounding environment. Small trees may need to be removed in areas of dense vegetation to allow for a clear path for the equipment to access the feature locations. Rabbit burrows were observed within some of the spoil piles on site; re-using the existing spoil material found on site as fill may impact local fauna (rabbits) within the area, however, rabbits are not a protective or native species, this should not be a significant consideration. DEMIRS may wish to undertake environmental assessments on specific features.
Potential risk to contractors and operators	The contractor needs to ensure the haulage routes for any imported fill materials are safe and suitable. During the initial phases of the rehabilitation, we recommend machinery maintains a minimum setback distance of 3 m from the edge of these features. The contractor should be aware of slips, trips, and falls into these features, and the potential risk of ground collapse due to lateral workings / subsidence / underground features. Personnel should maintain a minimum setback distance of 1 m from the edge of these features.
Personnel and technical expertise	Any competent and experienced earthwork contractor should be able to undertake this work.
Post rehabilitation maintenance and monitoring	These features have been identified to have medium risk of lateral / deep workings below a false base, therefore one site visit, to conduct a visual assessment, 6 months after the rehabilitation has been completed, and flown surveys 2 years post rehabilitation and again 10 years post rehabilitation is recommended to assess the performance of the rehabilitation solution. If no deformation is observed 12 years post rehabilitation to the features, no further monitoring is required.

2.8 Reinforced earth capping areas with void collapse risk

A reinforced earth solution may be used and placed over areas that may contain underground lateral workings between shafts/features and voiding potential of reworked ground are shown in the figures shown below, based on site observations, data obtained from ERT and GPR testing and the available supporting historical information. This solution may be used as a secondary rehabilitation treatment to select features, in conjunction with some of the measures detailed above.

These areas may be prone to subsidence and pose high risk to humans, livestock, pets, and vehicles. In addition to the recommended treatment individual features within these areas may be subject to, it is also recommended that the surrounding ground in these areas be rehabilitated.

Table 7: Reinforced earth capping void risk areas rehabilitation options study

Requirements	Description
Plant and equipment	22t+ excavator. The contractor should assess the reach of the excavator to ensure it can reach the base of these features. A small (up to 6t) dump truck to bring imported fill from the temporary stockpile location to the feature. A loader or excavator to load the dump truck. A tipper haul truck to import granular fill material to site. Plate compactor. Water cart for moisture conditioning soils.
Material specification for imported fill	Any imported fill material should comprise a clean inert granular material with a fines content < 15% and no particles > 100 mm. See Section 2.10.
Quantity / volume of material	See Section 3.
Potential source of material	The contractor is to provide details of sustainable locally sourced, cost-effective fill material to the designer for approval. The fill needs to be a granular, clean, inert, natural material, however, there are no specific structural requirements of this material as it is simply backfilling an existing void. This can consist of spoil generated from nearby construction projects or be sourced commercially; however, the material must meet the specifications.
Timing	The timing is dependent on the contractor's ability, personnel and equipment used. We assume a typical time allowance for each feature, depending on its size, should take approximately 2 days excluding any time required for creating haul routes to the feature location.
Potential environmental risk, including groundwater, flora and fauna	This may cause some disturbance to the existing ground surface and surrounding environment. Small trees may need to be removed in areas of dense vegetation to allow for a clear path for the equipment to access the feature locations. Rabbit burrows were observed within some of the spoil piles on site; re-using the existing spoil material found on site as fill may impact local fauna (rabbits) within the area, however, rabbits are not a protective or native species, this should not be a significant consideration. DEMIRS may wish to undertake environmental assessments on specific features.
Potential risk to contractors and operators	The contractor needs to ensure the haulage routes for any imported fill materials are safe and suitable. During the initial phases of the rehabilitation, we recommend machinery maintains a minimum setback distance of 3 m from the edge of these features. The contractor should be aware of slips, trips, and falls into these features, and the potential risk of ground collapse due to lateral workings / subsidence / underground features. Personnel should maintain a minimum setback distance of 1 m from the edge of these features.
Personnel and technical expertise	Any competent and experienced earthwork contractor should be able to undertake this work.
Post rehabilitation maintenance and monitoring	These features have been identified to have medium risk of lateral / deep workings below a false base, therefore one site visit, to conduct a visual assessment, 6 months after the rehabilitation has been completed, and flown surveys 2 years post rehabilitation and again 10 years post rehabilitation is recommended to assess the performance of the rehabilitation solution. If no deformation is observed 12 years post rehabilitation to the features, no further monitoring is required.

Figure 1: Reinforced earth area Commonage (Area 1)

Figure 2: Reinforced earth area Commonage (Area 2)

Figure 3: Reinforced earth area Wanerenooka

2.9 Fence the area

Fencing may be considered as secondary or tertiary rehabilitation options for areas containing Category 5, 6 and 7 features to provide additional risk control by limiting the public's interaction with these easily accessible and/or poorly lit areas. Fencing is already in place in the Wanerenooka area, and it is recommended that this fencing be re-instated upon completion of remedial works and ensure it is maintained.

2.10 Fill suitability

2.10.1 In-situ material quality

Material won from excavation work carried out on site within the majority of the site for the top 0.5 m – 1.0 m is expected to comprise fine to coarse-grained gravelly SAND (subject to depth of excavation) which are considered geotechnically suitable for re-use as fill material for rehabilitation works.

Beyond this depth, extremely weathered rock can be expected. It should be noted that an excavator equipped with a rock pick will be required within this material.

The existing spoil piles surrounding the features typically comprises of fine to coarse-grained gravelly SAND / sandy GRAVEL, which are also considered geotechnically suitable for re-use as fill material for rehabilitation works (subject to DPLH / DEMIRS approval).

Where WML have stated these materials are subject to DPLH / DEMIRS approval, this is only if this material has a contaminated sites issue or is deemed to have heritage value.

It should be noted that the spoil pile to the north of feature S0145137 may comprise of lead tailings and should not be re-used in the rehabilitation works.

Site won CLAY materials should not be used as fill material if encountered, however, WML did not encountered any CLAYS during the site investigations. In-situ fill material should be free from organics and deleterious material and be approved by the WML site engineer.

2.10.2 Imported fill

All imported fill material to be used should meet the following requirements:

- Clean inert, well-graded, granular fill material.
- With fines content < 15%.
- No particles > 100 mm.
- Less than 2% organics.
- No deleterious material.

Imported fill material is to be approved by the WML site engineer prior to use.

3 FEASIBILITY

The seven (7) feature categories identified in the accompanying geotechnical report, 11126-G-R-001, have been classified in accordance with observations made on site during both the intrusive and non-intrusive ground investigations and in terms of the risk posed to humans, vehicles, livestock, and pets. The rehabilitation options presented in Section 2 have, therefore, been ranked based on feasibility and suitability of design and implementation against each feature. The approximate volumes of each feature have been provided within the subsequent tables to assist with determination of amount of required soil fill material. Features marked with an asterisk may require secondary treatment beyond the primary rehabilitation solution due to potential for underground lateral workings within the vicinity of these features. The option to proceed with this secondary treatment solution will need to be assessed on site by the WML geotechnical engineer during the earthworks stage.

The feasibility of each solution has been assessed in terms of long-term suitability, ongoing maintenance and monitoring, cost, risk to construction personnel, constructability, and environmental risk.

No rehabilitation / leave as is:

Features	Estimated Fill Volume (m^3)	Risk Rating	Ranked Rehabilitation Options
Category 1: Shallow workings & minor / imperceptible depressions			
S0145073	1-2	Low	**WML Preferred Option – Leave as is.** Rehabilitation of these features is not considered necessary as these features are typically indiscernible from the surrounding environment and pose low risk to humans/pets/vehicles. Leave as is. Do not rehabilitate. **Alternative Option 1 – Blade the area.** If DEMIRS believes some rehabilitation is necessary, the surrounding spoil piles can be bladed back into the depression and the area can be bladed with a dozer to reduce steepness of slopes and soften the feature. **Alternative Option 2 – Backfill with imported fill.** If DEMIRS believes some rehabilitation is necessary the features may be backfilled with imported fill material. Note that the volume of the existing spoil material surrounding these features is likely insufficient or difficult to locate (likely grass has grown over and covered this material).
S0145102	40		
S0145106	5-7		
S0145076	75		
S0145131	5-7		
S0145083	40		
S0145100	1-2		
S0145121	2.5		
S0145129	1-2		
S0145127	1-2		
S0145142	50		
S0145109	20		
S0145146	1-2		
S0145144	1-2		
S0145108	2.5		
S0145149	1-2		
S0145151	1-2		
S0145135	3-5		
S0145128	25-30		
S0145132	1-2		
S0145045	1-2		
S0145154	1-2		

S0145098	1-2		
S0145138	1-2		
S0145133	12-15		
S0145046	1-2		
S0145049	1-2		
WML01	1-2		
WML02	1-2		
Category 2: Small depressions / shallow workings / costeans / trenches			
S0145101	25	Low to Medium	**WML Preferred Option – Leave as is.** Rehabilitation of these features is not considered necessary as these features are typically indiscernible from the surrounding environment and pose low risk to humans/pets/vehicles. Leave as is. Do not rehabilitate. **Alternative Option 1 – Blade the area.** If DEMIRS believes some rehabilitation is necessary, the surrounding spoil piles can be bladed back into the depression and the area can be bladed with a dozer to reduce steepness of slopes and soften the feature. **Alternative Option 2 – Backfill with surrounding spoil.** If DEMIRS believes some rehabilitation is necessary, the features may be backfilled with existing surrounding spoil material. For the entirety of the project, the contractor should allow for 50% of the volume of the voids to be backfilled using imported fill material as an overall fill shortage of spoil may exist. **Alternative Option 3 – Backfill with imported fill.** If DEMIRS believes some rehabilitation is necessary, the features may be backfilled with imported fill material if the existing spoil material is deemed unsuitable for re-use.
S0145110	75-80		
S0145107	5-7		
S0145099	1-2		
S0145094	20-25		
S0145078	3-5		
S0145139	1-2		
S0145153	5-7		
S0145150	10		
S0145075	5-7		

Backfill:

Features	Estimated Fill Volume (m^3)	Risk Rating	Ranked Rehabilitation Options
Category 3: Shallow holes and shafts			
S0145174	5-7	Low to Medium	**WML Preferred Option – Backfill with surrounding spoil.** These features pose low risk of void collapse/lateral workings and medium risk of trips and falls to humans. The feature can be backfilled with existing surrounding spoil material. For the entirety of the project, the contractor should allow for 50% of the volume of the voids to be backfilled using imported fill material as an overall fill shortage of spoil may exist.
S0145120	17-20		
S01145082	15		
S0145122[1)]	18-20		
S0145111	3-5		
S0145093-D	7-10		

			Alternative Option 1 – Backfill with imported fill. If the existing spoil material is deemed unsuitable for re-use, backfill with imported fill material.
Category 7: Deep shafts			
S0145165*	110-115	High	**WML Preferred Option – Backfill with surrounding spoil.** The northern drive of this feature should first be collapsed to determine the extent of the drive and the void should be backfilled with the surrounding spoil. The contractor should allow for 50% of the volume of the void to be backfilled using imported fill material as an overall fill shortage of spoil may exist. **Alternative Option 1 – Backfill with imported fill.** Additional fill material may be required to completely backfill the void. Alternatively, if the existing spoil material is deemed unsuitable for re-use, backfill with imported fill material.

Note: [1)] The southern wall to base corner of this feature should be reinforced prior to backfill.
**This area may be reinforced.*

Reinforced earth backfill:

Features	Estimated Fill Volume (m^3)	Risk Rating	Ranked Rehabilitation Options
Category 4: Shallow holes and shafts – soft / unknown base conditions			
S0145141	25.0	Medium	**WML Preferred Option – Reinforced earth backfill** These features pose medium risk of void collapse as base conditions are typically unknown and medium risk of trips and falls to humans. These features should be backfilled with geofabric reinforcement. Soil backfill alone is not considered suitable as the base conditions have not been investigated. For the entirety of the project, the contractor should allow for 50% of the volume of the voids to be backfilled using imported fill material as an overall fill shortage of spoil may exist. **Alternative Option 1 – Concrete cap.** Alternatively, a concrete capping solution may be implemented, however, the brim of these features will need to be cut and levelled. **Alternative Option 2 – Steel cap.** Alternatively, a steel grate capping solution may be implemented, however, the brim of these features will need to be cut and levelled. A concrete cap is preferred to this method due to corrosion potential of steel.
S0145072	75		
S0145124	40		
S0145044	20		
S0145163	2-3		
S0145130	55		
S0145177	17-20		
S0145171*	20		
Category 5: Open cuts / shafts filled with rubbish and debris – unknown base and wall conditions			
S0145137*	80	Medium to High	**WML Preferred Option – Reinforced earth backfill** These features pose medium to high risk of void collapse as base conditions are typically unknown and medium risk of trips and falls to humans. These features can be rehabilitated with a reinforced earth backfill. Soil backfill alone is not considered suitable as the base conditions have not been investigated. Secondary rehabilitation of these feature is required within the general
S0145143*	200		
S0145145*	220		

			defined area. The contractor should allow for 100% of the volume of the voids to be backfilled using imported fill material. **Alternative Option 1 – Concrete cap.** Alternatively, a concrete capping solution may be implemented, however, these features have large opening areas that would need to be bridged. **Alternative Option 2 – Steel cap.** Alternatively, a steel grate capping solution may be implemented, however, these features have large opening areas that would need to be bridged. A concrete cap is preferred to this method due to corrosion potential of steel.
Category 6 & 7: Deep shafts			
S0145093-C	25-30	High	**WML Preferred Option – Reinforced earth backfill** These features are located at the base of steep slopes / cliff features, which would require extensive earthworks to be undertaken to level the surrounding area to enable a concrete capping solution to be used. Therefore, the most suitable rehabilitation option in these cases, are to use a reinforced earth backfill. Soil backfill alone is not considered suitable as the base conditions have not been investigated. The contractor should allow for 100% of the volume of the voids to be backfilled using imported fill material. **Alternative Option 1 – Concrete cap.** Alternatively, a concrete capping solution may be implemented, however, extensive earthworks would be required to enable a flat level area around the features to place the concrete cap. **Alternative Option 2 – Steel cap.** Alternatively, a steel grate capping solution may be implemented, however, these features have large opening areas that would need to be bridged. There also exists the potential for steel to corrode. **Alternative Option 3 – Fence.** Fencing the area may also be considered, however, this solution may be more suited to a secondary rehabilitation treatment method rather than a primary solution. Should personnel make their way past the fence, the risk of falls/trips remains high.
Wn1	40		
Wn2	105		
S0145123	50		

*Note: *This area may be reinforced with geofabric to span any potential underground lateral workings.*
Category 5 volumes have been approximated as the depth of the features is unknown (assumed 5 m deep). These estimated volumes should be allowed for.

Concrete cap:

Features	Estimated Fill Volume (m^3)	Risk Rating	Ranked Rehabilitation Options
Category 6 & 7: Deep shafts			
S0145093-A	n/a	High	**WML Preferred Option – Concrete cap.**
S0145093-B*	n/a		
S0145140	n/a		

		These features pose high risk of void collapse/lateral workings as suggested by the available historical information. A concrete cap solution should be used to bridge these features. **Alternative Option 1 – Steel cap.** Alternatively, a steel grate capping solution may be implemented. A concrete cap is preferred to this method due to corrosion potential of steel. **Alternative Option 2 – Fence.** Fencing the area may also be considered, however, this solution may be more suited to a secondary rehabilitation treatment method rather than a primary solution. Should personnel make their way past the fence, the risk of falls/trips remains high.

Note:
**This area may be reinforced with geofabric to span any potential underground lateral workings.*

Reinforced earth cap:

Features	Estimated Fill Volume (m^3)	Risk Rating	Ranked Rehabilitation Options
Category 7: Deep shafts			
S0145126	n/a	High	**WML Preferred Option – Reinforced earth cap.** This feature poses high risk of void collapse/lateral workings as suggested by the available historical information. Due to the relatively small void opening area, a reinforced earth cap is preferred to a concrete cap, as this method is more cost-effective, quicker and simpler to construct. **Alternative Option 1 – Concrete cap.** A concrete cap solution using may be used to bridge this feature. **Alternative Option 2 – Steel cap.** Alternatively, a steel grate capping solution may be implemented. A concrete cap is preferred to this method due to corrosion potential of steel. **Alternative Option 3 – Fence.** Fencing the area may also be considered, however, this solution may be more suited to a secondary rehabilitation treatment method rather than a primary solution. Should personnel make their way past the fence, the risk of falls/trips remains high.

Areas at risk of void collapse:

Area	Estimated Fill Volume (m^3)	Risk Rating	Ranked Rehabilitation Options
Commonage (Area 1)	250	High	**WML Preferred Option – Reinforced earth cap to span voids.** This treatment options depends on the WML geotechnical engineer's site observations during the earthworks stage. The WML engineer may deem the primary treatment on its own is suitable for
Commonage (Area 2)	610		

Wanerenooka	265		Area 1 and Area 2 depending on the level of risk mitigated during the earthworks. WML recommend secondary treatment be utilised at Wanerenooka. Geofabric may be placed over the following areas to span the voids in one direction. Suitable site won or imported fill material should be used. **Alternative Option 1 – Fence the area.** Alternatively, the area can be fenced off to restrict access to the public. This can also be done as a tertiary level treatment, and it is recommended the fencing at Wanerenooka be reinstated upon completion of remedial works.

Note: Cut will balance to the fill.

4 CLOSURE

This report is intended for distribution to the public.

We trust that the information provided within this report satisfies your present requirements and meets with your approval. Should you have any queries, please do not hesitate to contact the author of this report.

We draw your attention to the attached "*Report Limitations*" included with this report. This information sheet is intended to provide additional information about this report and information included within it. This information is provided not to reduce the level of responsibility accepted by WML but to ensure that all parties that rely on this report, and the information contained herein, are aware of the responsibilities that each assumes in so doing.

5 REFERENCES

1. Geological Series Map 1:250,000 Scale ‘Geraldton’.
2. Standards Australia. 2017. *Geotechnical Site Investigations*. AS 1726:2017. SAI Global.

LIMITATIONS

REPORT LIMITATIONS

This geotechnical report is provided for the sole use by the Client. This report must not be applied for any other purpose or project except the one originally contemplated without written authorisation from WML. WML accepts no responsibility for the use of this report / document, in whole or in part, in other contexts or for any other purpose.

WML have undertaken investigations, performed consulting services, and prepared this report based on the Client's specific requirements, documents and information supplied, and previous experience. If changes occur in the nature or design of the project, however minor, it is recommended WML review this report to assess their impacts and provide additional recommendations, if any. WML does not assume any responsibility or liability for problems that arise due to developments on site of which we were not informed.

This report utilises data and information provided by third parties, including, but not limited to sub-consultants, published data, and the Client. This information has been assumed to be correct unless otherwise stated. WML assumes no responsibility for assessments made partly or entirely based on information provided by third parties or for the adequacy, incompleteness, inaccuracies, or reliability of any data provided by third parties.

It is the responsibility of the Client to transmit the information, recommendations, and limitations of this report to the appropriate organisations or people involved in design of the project, including, but not limited to developers, builders, owners, buyers, architects, engineers, and designers.

WML's opinions are based on upon information that existed at the time of the production of this report and ground conditions encountered at the time the site study was performed. This geotechnical report should not be relied upon if its adequacy has been affected by: the passage of time, by man-made events, such as construction on or adjacent to the site, or by natural events, such as floods, earthquakes, or groundwater fluctuations. In the event of the above changes, WML should be contacted to determine if this report is still reliable or whether additional testing is required.

The subsurface conditions identified within this report are based only upon investigation locations where subsurface tests have been conducted and / or samples obtained, which are explicitly representative of the specific sample or test location. Interpretation of conditions between such points cannot be assumed to represent actual subsurface information and unknowns or variations in ground conditions between test locations that cannot be inferred or predicted. Actual subsurface conditions may differ significantly from those indicated in this report. Specific warning is also given that many factors, either natural or artificial, may render ground conditions different from those which pertained at the time of the investigation. WML does not accept any responsibility for any variance in the ground conditions that may exist across the site. If unexpected subsurface conditions are encountered, WML shall be notified immediately to review those conditions and provide additional and/or modified recommendations, as necessary.

This geotechnical assessment is based upon judgment of the investigation data, visual observations of the site and materials encountered, along with the proposed land use and project specifications. The findings and recommendations presented within this report represent professional opinions and estimates and should not be taken as fact unless explicitally stated. In general, statements of fact are are limited to what was done and / or what was observed on site.

The recommendations provided in this report are preliminary only; final recommendations can only be given after observing the actual subsurface conditions revealed during construction. WML does not assume responsibility or liability for the recommendations in this report if construction observation has not been performed by a WML geotechnical engineer.

Our services did not include any contamination or environmental assessment of the site or adjacent sites. The equipment and techniques used to perform a geoenvironmental study differ from those used to perform a geotechnical investigation. If you require any geoenvironmental information for your project, WML can advise on further steps to be undertaken.

WML have performed our professional services in accordance with generally accepted geotechnical engineering principles and practices currently employed in the area; no warranty, expressed or implied, is made as to the professional advice included in this report.

APPENDIX A

GEOTECHNICAL REPORT

Department of Energy Mines, Industry Regulation & Safety (DEMIRS)

ABANDONED MINE FEATURES ASSESSMENT

NORTHAMPTON – COMMONAGE & WANERENOOKA GEOTECHNICAL REPORT

April 2025

11126-G-R-001 Public Document

WML

Consulting Engineers

Document History and Status				
Revision	**Prepared By**	**Reviewed By**	**Purpose of Issue**	**Date**
-	IG	SM	Public Issue	15/04/2025

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WML Consultants Pty Ltd

Ivana Golijanin

Geotechnical Engineer

Author

Simon Maris

Principal Geotechnical Engineer

Reviewer

For and on behalf of WML Consultants Pty Ltd

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1 INTRODUCTION

The Department of Energy, Mines, Industry Regulation & Safety (DEMIRS) engaged WML Consultants (WML) to undertake a geotechnical assessment and rehabilitation options study to support the rehabilitation of abandoned mine features at the Commonage and Wanerenooka sites surrounding Northampton, Western Australia. These include shafts, open stopes, costeans, and shallow workings. 59 abandoned mine features at the Commonage site and 6 at the Wanerenooka site are to be assessed. This report presents the results of the non-intrusive and intrusive geotechnical investigation and details the findings of the different types of features identified on site.

The geotechnical study was authorised by DEMIRS via letter of acceptance DMIRS23011, dated 11th May 2023.

This report and the information presented herein must be read in conjunction with the attached "*Report Limitations*".

1.1 Desktop study

Mining for lead and copper in Northampton started in the 1850's and is the oldest mining area in Western Australia. Mining in the region began after lead (galena) ore was discovered in the dry Murchison riverbed at Ajana, located to the north of Northampton. In 1855 copper was found at Wanerenooka Hill at present day Northampton, and by 1890 there were approximately 80 lead and copper mines in the region, of which, approximately 25% dealt with copper.

Between the years 1910 – 1930, and again between 1948 – 1960, there was a revival of mining practices within Northampton driven by the fluctuating prices of lead and copper. Sporadic mining continued until 1973, when the field was permanently abandoned. As these sites have not been subjected to modern mining techniques which entail destructive open pit operations, many of the sites retain items of historic interest which are covered by heritage laws.

The region contains the Northampton Complex, a fault bounded complex of Proterozoic aged metasediments surrounded by Mesozoic to Cenozoic aged unmetamorphosed sediments. The pelitic metamorphic rocks are composed of migmatitic gneisses and schists, and a foliated quartz-microcline-plagioclase-biotite granite in the south eastern area. The pegmatites of the Northampton Complex were formed from temperatures ranging between 600 – 800 °C, and pressures of 560 – 700 kPa, and may have formed from the partial melting of the country rock. Lead and copper mineralisation fills open fissures and fault breccias formed by faults striking north to north-east which cut the garnet granulite and gneiss. The lodes typically follow contacts with dolerite dykes which have intruded and follow the same strike direction.

1.2 Site description

The sites are located at the abandoned mines (Commonage and Wanerernooka) in Northampton, Western Australia. The Commonage site is located approximately 1.8 km north west of the town, and the Wanerenooka site is situated approximately 1.3 km directly to the north and within the townsite. Both sites are surrounded by relatively dense vegetation comprising long grass, trees, and shrubbery.

The western portion of the Commonage site predominantly consists of grass fields, while the eastern side is covered by denser vegetation. Unsealed access tracks for vehicles are located throughout and around the site and majority of the features are located directly alongside the western and eastern access tracks in a relatively straight line. There are four features located within the top north western corner of the site, situated within the active firing range. Based on available topographical information, the existing ground surface appears to slope upwards from south east to north west with RLs ranging between 145 m AHD to 184 m AHD.

The features identified at the Wanerenooka site are located inside of a fenced area; there exists two smaller sheds along the western side of the site, and the ground surface comprises red sandy clayey gravels with scattered small to medium trees and shrubs situated within the fenced zone. The northern and southern portions of the site, however, are relatively clear of any vegetation. The existing ground surface appears to slope downwards from north to south with RLs ranging between 175 m AHD to 181 m AHD, based on the available published topographical information.

Location of the 57 Commonage and 3 Wanerenooka features are shown on the site maps, 11126-G-D-001 to -007, and are shown in the image below.

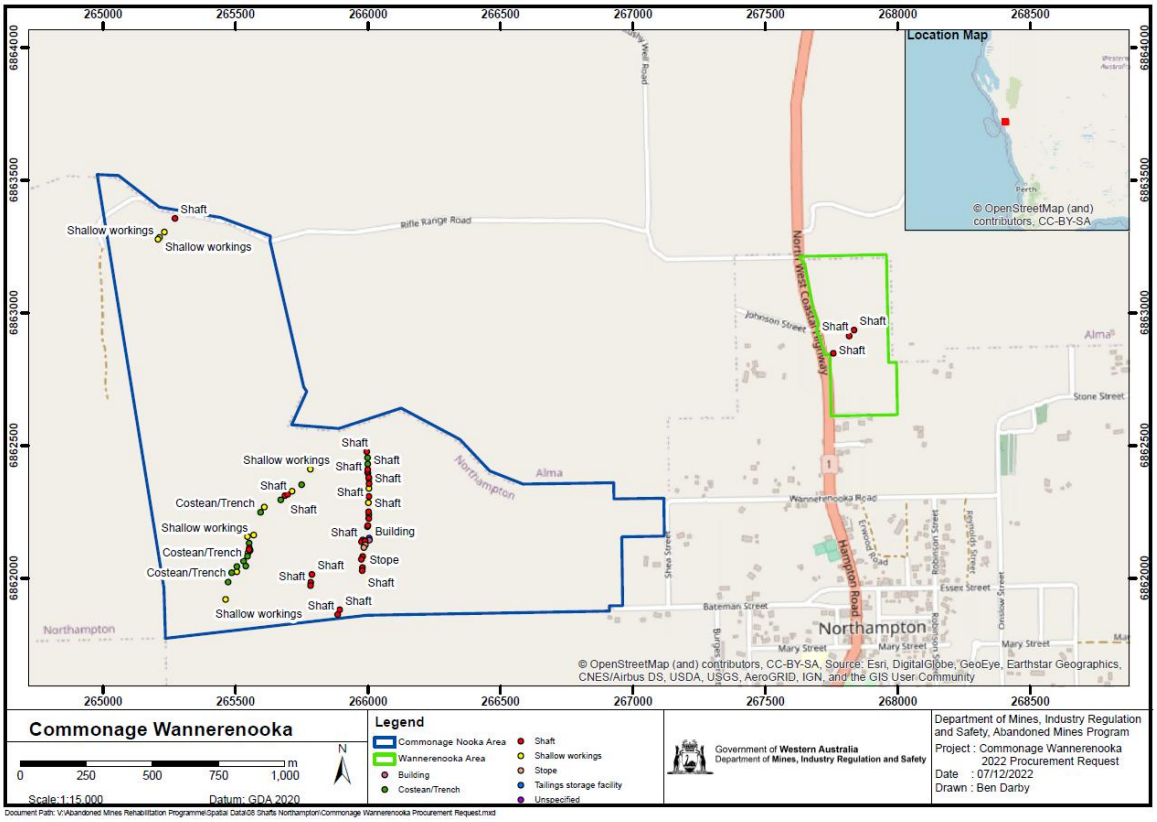

Figure 1: Commonage and Wanerenooka plan, prepared by DEMIRS

1.3 Client supplied information

The following information was made available the Client for the purpose of this report:

- DMIRS23011 Request – 'Geotechnical Engineering Services for Abandoned Mine Features at Commonage and Wanerenooka, Northampton', prepared by DEMIRS.
- Reference Documents and Mine Plans Part A – C, provided by DEMIRS.
- Photographs of features at Commonage and Wanerenooka, prepared by DEMIRS.
- Spatial files for Commonage and Wanerenooka, prepared by DEMIRS.
- Field notes 'Commonage and Wanerenooka', prepared by DEMIRS.

1.4 Objectives of this report

The objectives of the intrusive and non-intrusive geotechnical investigation were to assess the following characteristics:

- Geometric characteristics of the features, including any lateral workings (e.g. dimensions, volume, shape).
- Base conditions and presence of material or obstructions of the features.
- Structural stability and subsidence potential or risk zones.
- Underground connectivity between features.
- Presence of groundwater or hydrogeological features which may have an impact on rehabilitation.
- Surface hydrology flow which may impact upon features.
- The presence of flora and fauna within the features.
- Potential for noxious or flammable gases.

2 FIELD PROGRAMME

2.1 Non-intrusive fieldwork (Phase 1)

Fieldwork for the non-intrusive investigation was carried out between the 1st and 9th of October 2023, by qualified WML geotechnical engineers and comprised:

- Desktop study to review Client supplied data, as well as undertake a comprehensive search and study of publicly available records, data and reports, including historical photography (e.g. aerial photography).
- Field mapping to observe each of the existing mine features (e.g. measuring the geometry) and to take record photographs and videos.
- 3D LIDAR scanning of the features.
- Dynamic Cone Penetrometer (DCP) tests.
- Ground probing and prodding using a metal rod.
- Testing for presence of noxious and flammable gasses, at each feature location.
- Detection of groundwater at each feature location.

2.1.1 Field mapping, down hole scanning

Each feature was field mapped by geotechnical engineers from WML to target evidence of voids and geotechnical deformation. Each feature was 3D scanned using a LiDAR camera. The data gathered from the 3D scanning has been combined with existing data sets and the results of the geophysical investigations, to support the void risk assessments and rehabilitation recommendations. The field mapping was undertaken in accordance with WML's Safety Management Plan.

2.1.2 LiDAR survey

HTD surveyors undertook a LiDAR survey of the Commonage and Wanerenooka sites. This information has been combined with the 3D LIDAR scanning data carried out by WML. The survey is shown in Appendix B.

2.1.3 Hand tools

Each feature, where safe to do so, was investigated using hand tools to measure the voids and determine the ground conditions at both the base of the feature and of the surrounding area. The dimensions of the features were measured using a laser pointer device and/or dipping tape / tape measure. A dip meter was also lowered down the features where water was visually observed (S0145093-A, S0145093-B) or in instances where the base of the feature or any obstructions were not visible (S0145140, S0145165, S0145129) to determine the presence and depth of water from the top of the surrounding ground level. Where the base conditions of features were observed to be dry, a dip meter was not lowered.

Each feature was tested for presence of noxious and flammable gasses. Readings were taken to measure levels of CH_4, CO_2, H_2S, O_2, CO, and lower explosive limit (LEL). It should be noted that no noxious / flammable gasses were detected during the investigation.

2.1.4 Dynamic Cone Penetrometer (DCP) testing

The Dynamic Cone Penetrometer (DCP) test is an in-situ, manual penetration test that measures the penetration resistance of the soil and provides an indication of the relative density. The test is conducted by driving a cone-tipped rod into the ground surface using a 9 kg weight dropped from a standard height. The number of drops (called blows) is recorded for each 150 mm depth, and the process continues till the target depth is achieved. The number of blows is also correlated to a relative density and is used to describe the condition of the in-situ material. DCP testing was undertaken in accordance with AS 1289.6.3.2.

DCPs were undertaken within and surrounding the feature to determine the ground conditions. DCP testing typically encountered shallow refusal on a weathered rock profile, overlain by a thin layer of sandy clayey gravels.

2.1.5 Geophysical survey

GBG undertook a geophysical survey, between the 13th and 20th of October 2023, to provide detailed spatial data pertaining to the voids and the surrounding ground profile, including lateral extent of voids directly below the survey lines.

Electrical Resistivity Tomography (ERT) was undertaken along 21 transects totalling to approximately 4,095 m at Commonage and 5 transects totalling 795 m at Wanerenooka to obtain subsurface electrical resistivity models to a target depth of 20 m below ground level (bgl) to map potential underground mine workings around the identified shafts. The ERT transects were positioned to run parallel to the strikes of mineral deposits to assess whether mine tunnels extend laterally from the major strike. Additional ERT transects were positioned perpendicular to the strikes of mineral deposits to confirm the validity of the ERT method over areas most likely to feature horizontal tunnel workings. ERT data was acquired using ZZ Universal 64 (ZZ Resistivity Imaging) which utilises a 64-electrode array with maximum 2,500 mA current output. Data acquisition was acquired using a 3 m electrode spacing for a maximum single transect length of 189 m, with a 32 electrode (64 m) 'roll-along' for longer lines. Resistivity measurements were made using a customised array type for high vertical resolution and sensitivity to lateral variations. Spatial positioning of the acquired ERT transects were obtained using a Differential GNSS receiver with horizontal accuracy of better than +/-0.25 m for both the vertical and horizontal components.

Ground Penetrating Radar (GPR) testing, to a depth of 5 m bgl, was undertaken within the four critical zones identified on site during the field mapping stage; these areas are shown via the blue boxes in Figure 2 and Figure 3 below, alongside the geophysical transects (ERT) shown by the red lines.

Anomalous subsurface features discovered via ERT testing have been labelled as targets and GPR testing indicated worked ground with voiding potential of subsurface material have been mapped. It should be noted that these detected abnormalities can be interpreted as either rocky material or void space (i.e. air), as both substances display high electrical resistivity properties. The larger targets may likely be interpreted as rocky material; WML have undertaken test pitting, borehole drilling, and ground prodding at selected target locations to confirm the presence of rock.

These identified targets were cross-referenced with the available historical maps of the mining area and overlayed onto the direction of the seam where mining activity was known to have occurred. Areas of low conductivity typically represented high strength rock around the known strike of the ore as evidenced by borehole drilling and test pitting. The targeted areas as shown by the geophysical testing could either be interpreted as a void within rock where ore was mined, or these targets may be indicative of high strength rock with no voids within them.

Where large targets have been identified outside of the main mining areas, as indicated by the available historical information, these are likely to be high strength rock; in many cases these have been investigated by test pitting or borehole drilling, which confirmed there exists no risk of voids at these targeted locations.

The geophysical survey report has been attached in Appendix C.

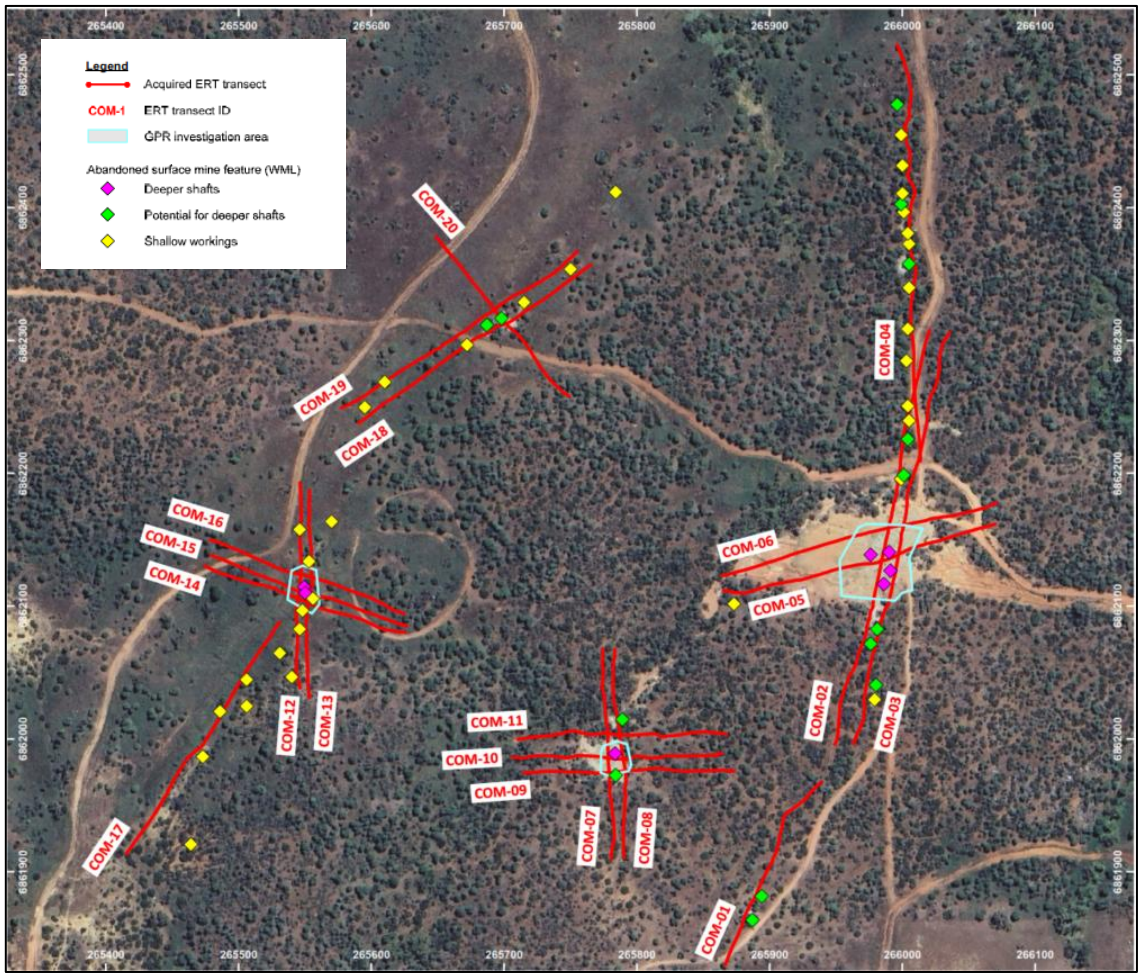

Figure 2: Geophysical test locations – Commonage

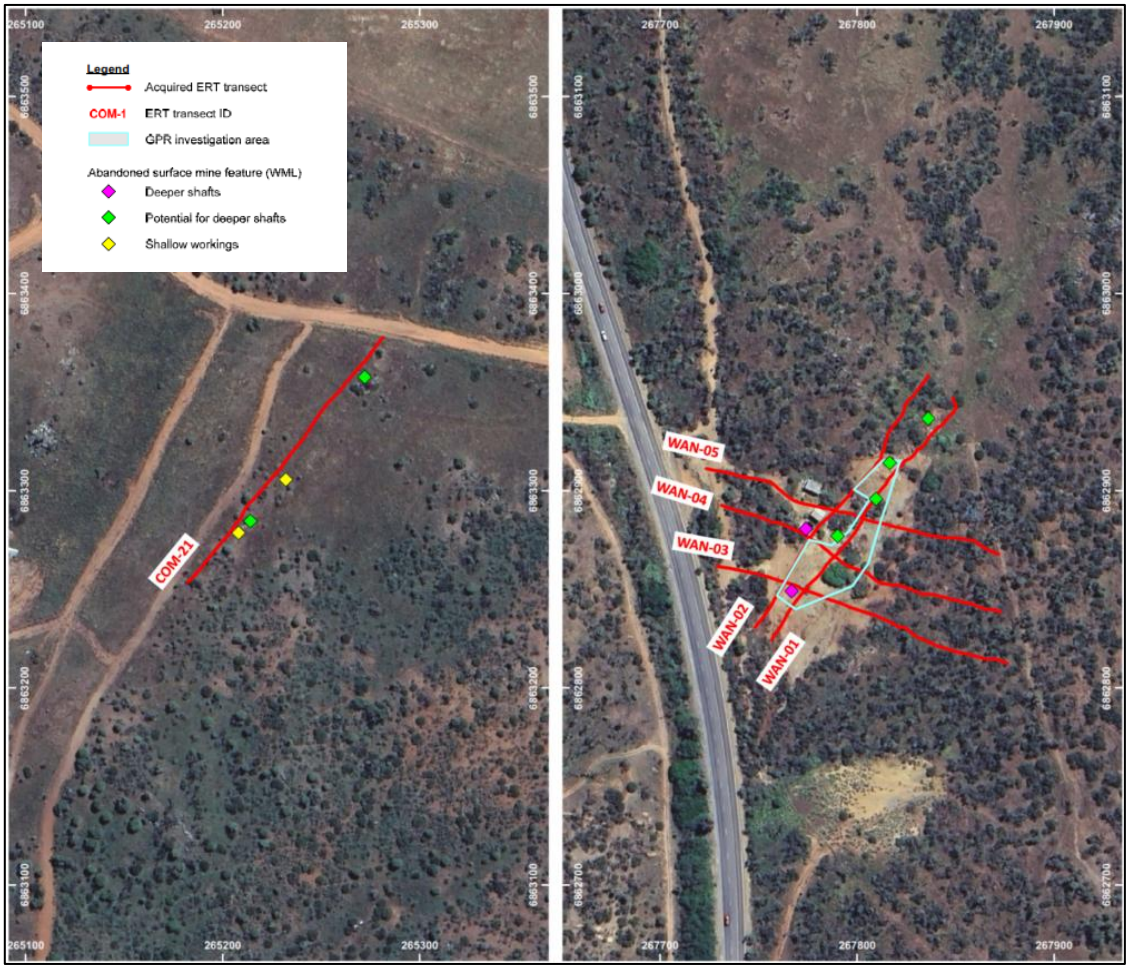

Figure 3: Geophysical test locations – Left Commonage (NW); Right Wannerenooka

2.2 Intrusive fieldwork (Phase 2)

Fieldwork for the intrusive investigation was carried out between the 13th and 16th of November 2023, by qualified WML geotechnical engineers and comprised:

- Shallow test pits, excavated with 6t backhoe with a 300 mm wide tooth bucket.
- Borhole drilling.

Due to site access constraints, pending heritage approvals at the Wanerenooka area, only the Commonage site was investigated during the intrusive works.

Each location for intrusive and non-intrusive ground investigation was checked for underground services against Dial-Before-You-Dig plans, prior to any excavations works.

The approximate test locations are presented on the site maps, 11126-G-D-008 to -012.

2.2.1 Machine excavated test pits

Test pitting works were undertaken utilising a 6t backhoe with a 300 mm wide, toothed bucket. The test pits undertaken terminated due to hard digging at depths between 0.5 m – 1.2 m bgl on strong highly weathered rock.

Each test pit was supervised by a WML geotechnical engineer and logged in accordance with AS 1726:2017 and approximate test pit locations are shown on the site map 11126-G-D-008 to -012. No test pit was entered by any personnel once the excavation was deeper than 1 m. The test pits were immediately backfilled following excavation and compacted with the bucket.

2.2.2 Borehole drilling

The results from the borehole drilling indicated that the subsurface soil conditions across the site were found to be relatively consistent and comprised a strong and extremely weathered rock profile.

This intrusive investigation method was selected due to the low dust generation (low risk of potential lead contamination). Due to the dense vegetation and topography of the site, auger drilling was only undertaken in areas accessible with the drill rig. Borehole drilling was undertaken wherever possible, as opposed to test pitting, as minimal disturbance was caused by this method. The boreholes were logged in accordance with AS 1726:2017 and approximate borehole test locations are shown on the site map 11126-G-D-008 to -012.

3 HISTORICAL INFORMATION & DESKTOP STUDY

3.1 Wanerenooka

3.1.1 Published geology

The 1:250,000 scale Geological Map 'Geraldton' indicates that the site is underlain by **Pgm**: Migmatite in association of the following geological units:

- **Pg**: Porphyritic granite – including contaminated facies (largely marginal).
- **Pm**: Granulite – including cordierite gneisses, predominantly metasedimentary.
- **Pq**: Feldspathic quartize.

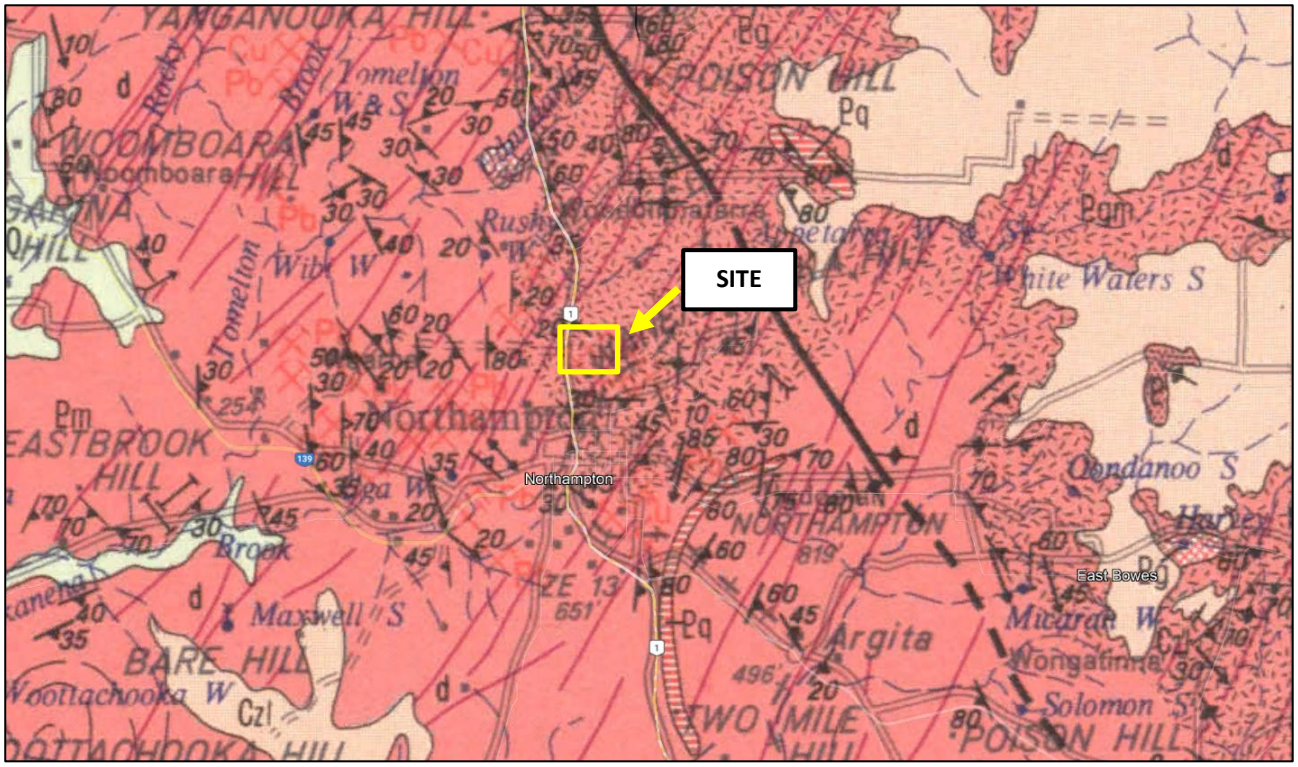

Figure 4: Extract from the 1:250,000 scale Geological Map "Geraldton"

3.1.2 Wanerenooka copper and lead mine site

Wannerenooka was the first mine in Northampton, located on the northern margin of the Northampton townsite, and is the second oldest copper mine in Western Australia; copper was founded here in 1855. Lead was also mined in this area. The mine site has remained relatively undisturbed, and remaining mining evidence consists of shafts, foundations of buildings, early winding and pumping gear.

Review of available historical information indicates the extent of mine workings within the Wanerenooka copper mine site, as shown in Figure 5 and Figure 6. WML have labelled the shafts as we believe them to be indicated on the plans below based on the relative distances between the features mapped and observed within the Wanerenooka site. Figure 5 shows the plan of the levels of lateral workings / drives; there appears to be three levels of workings, linked by internal shafts, which are located at 24 m, 43 m, 55 m, and 73 m below the existing ground level. The plan indicates the main shafts extends to a depth of 73 m; however, this could potentially be much deeper as the plans do not suggest a termination point. Based on Figure 6, the remaining shafts (S0145093-B, S0145093-C, Wn1, and Wn2) appear to be shallower than the main shaft, however, the actual depth remains unknown.

As shown in Figure 5, the main shaft (S0154093-A) is 3.9 m x 1.5 m and is shown to stope on a copper lode, dipping approximately 75° to the north east. The copper lode strikes north east, crossing the main highway at the lode's northern extremity. The vein is directly north east of Wanerenooka Hill, on the northern outskirts of Northampton. An inspection of the mine was undertaken in 1906 and the copper was described as varying from taint marks to ore a few

inches thick, in a lode 30 inches wide, which increases in thickness with depth of levels (from 8 m to 12 m wide). In the hanging wall were large veins and small pockets of copper ore, the veins pinching out and replaced with galena (lead). The copper veins were up to 15 cm wide, in siliceous breccia with fine grained disseminated pyrite, with 1 – 5 mm diameter galena fragments, copper-stained aplite and quartzose pegmatite, granulite, and vuggy quartz, coarse galena, and fine grained pyrite-chalcopyrite. Lead mineralization was only found on the hanging wall side, 11.8 m wide, while copper veins, 300 m wide, were found in both the hanging wall and footwall.

Based on the available historical information, it is unclear whether the underground mine workings have been backfilled or left as is.

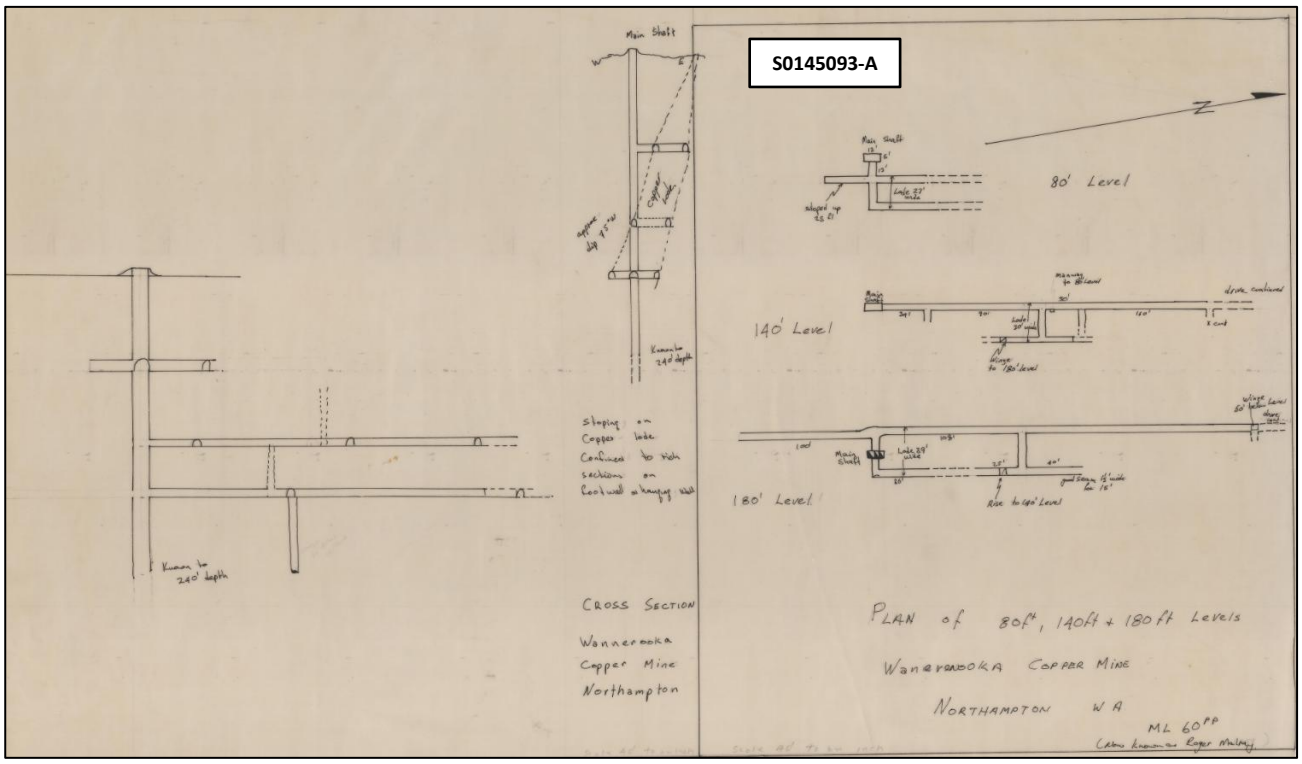

Figure 5: 984 Wanerenooka copper mine plan of levels (1957)

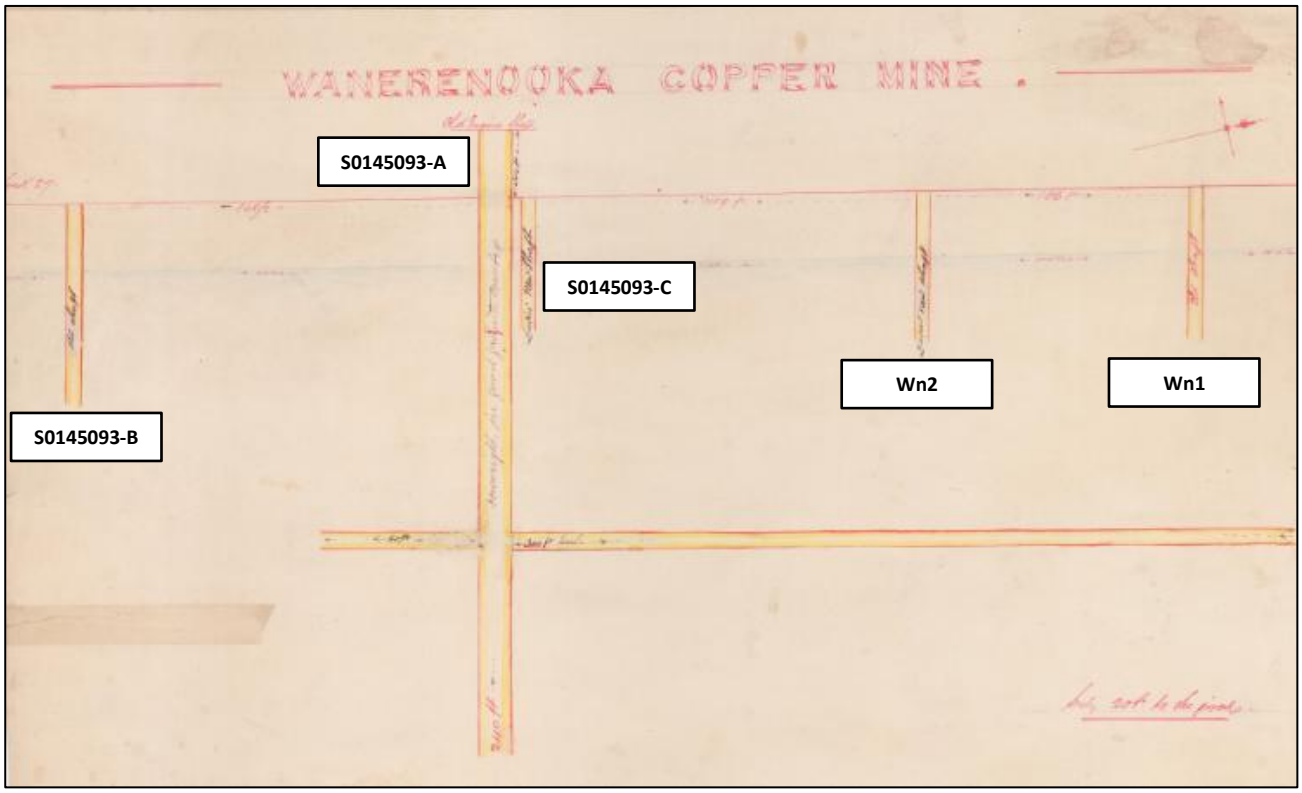

Figure 6: 7497 New Find Unaring Wanerenooka Section (1898)

3.2 Commonage

3.2.1 Published geology

The 1:250,000 scale Geological Map 'Geraldton' indicates that the site is underlain by the following geological unit:

- **Pm**: Granulite – including cordierite gneisses, predominantly metasedimentary.

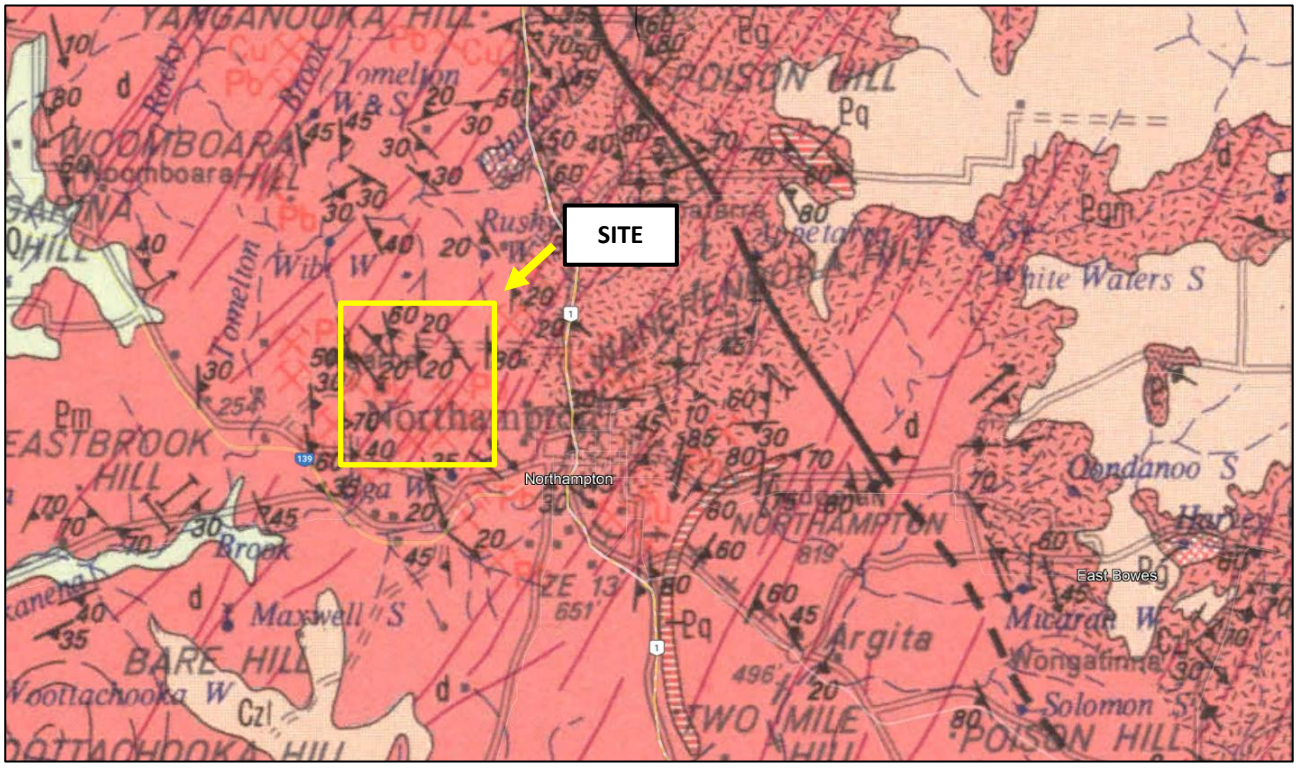

Figure 7: Extract from the 1:250,000 scale Geological Map "Geraldton"

3.2.2 Chiverton & Nooka mine sites

The Nooka mine is located approximately 2 km west of Northampton townsite, on land easily accessible to the public. In recent times, the area has been subject to increasing activity of dumping of generic household waste within shafts, holes, and small depressions in the ground surface. The site comprises partially collapsed shafts, open cuts and trenches filled with rubbish, foundations of buildings, and small mullock piles.

Review of available historical information indicates the extent of mine working within the Nooka mine site, as shown in Figure 8. Figure 9 shows the location of the features observed and identified on site during the field investigation in relation to the historical maps of the mine. The 1968 plans show levels of lateral workings / drives; there are three levels of workings, some of which have been filled or partly filled, other areas exist as stopes, however, there is no indication in what condition these areas currently exist. These areas are likely as wide as necessary for one person to fit through as the lodes are shown to be between 8 cm – 22 cm wide. The plans indicate that the mine had been worked to a depth of 85 m, and the upper levels are located at 39 m and 58 m below ground level.

The Nooka mine is located in the curve of a shear, which strikes north, and dips 70° west. The shear at the mine site cuts a quartzite band in granulite and siliceous breccia. As shown in Figure 8, the lode is stoped north-south. There appears to be two shallower shafts, trenches and open cuts, one 85 m deep main shaft, and two shafts (one of which exists as a sand-pass) of unknown depths.

An inspection of the mine was undertaken in 1906 to determine the extent of workings; extensive but shallow workings following a distinct fissure vein were noted, with much of the lode altered dyke rock. The area had second class ore of quartz, galena, sphalerite, copper pyrites and carbonates of lead plentiful in weathered material. Sphalerite and copper staining was also common.

The available published data suggests 1,000 tonnes of ore had been mined at Nooka.

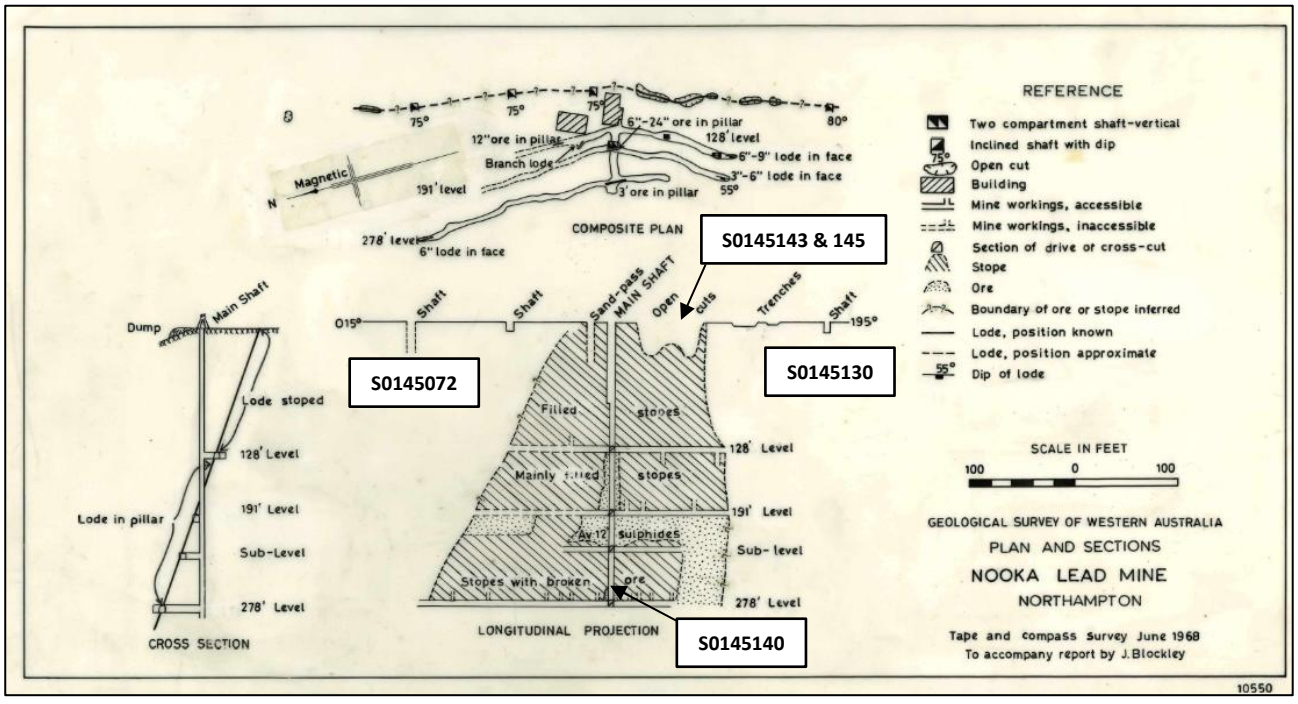

Figure 8: 10550 Nooka Lead Mine (1968)

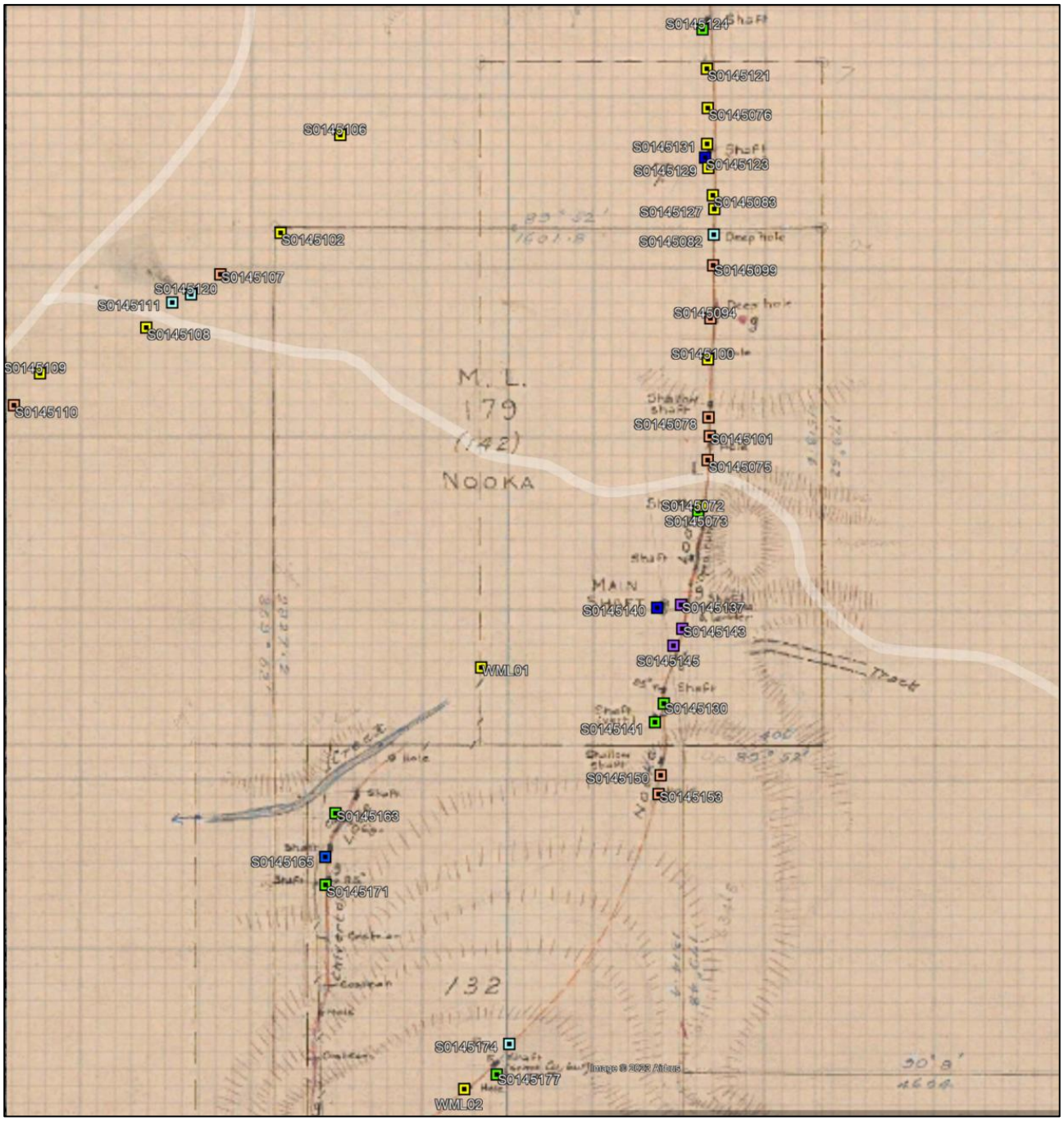

Figure 9: 5742 Chiverton and Nooka Plan showing lodes

4 FINDINGS

4.1 Summary of features

59 features at Commonage and 6 features at Wannerenooka were observed and mapped during field investigations in October and November of 2023.

3D LiDAR scanning was undertaken within the shafts to investigate the potential for near surface underground lateral workings which may cause subsidence and ground collapse. The available historical data, summarised in Section 3 above, indicates there exist no stopes or underground lateral workings within the top 20 m of the ground surface; this has been confirmed via geophysical testing (GPR/ERT) which has assessed the top 20 m of ground for voiding potential. Based on the geophysical survey, no significant targets were identified within the historical mine working areas, and where significant targets were identified outside of these main areas, test pitting, borehole drilling suggested these to be hard rock as opposed to voids.

Based on the good quality rock mass identified on site, and the available historical information which suggests there are relatively narrow lodes, and thus, voids, at Commonage, we have determined that the collapse of any voids below 10 m depth to be of very low risk to humans as minimal surface deformation would be experienced. Therefore, the risk of ground movement from collapse of stopes is deemed to be very low. Furthermore, these mine workings are more than 150 years old and are still stable. The flown LiDAR drone survey also did not identify any surface deformation, which yields no reason to believe instability of these old mine workings should occur in these areas in the near future.

Based on the 65 features observed on site, we have grouped the features into 7 distinct categories on a risk-rating basis as surmised in Table 1 below.

Table 1: Summary classification of abandoned mine features

Category	Description	Features		Risk Rating (see Section 4.2)
1	Shallow workings and trenches/costeans that appear to be minor depressions within the ground surface, or imperceptible impressions. The investigation methods confirmed the stability of base conditions of the features.	S0145073 S0145102 S0145106 S0145076 S0145131 S0145083 S0145100 S0145121 S0145129 S0145127 S0145142 S0145109 S0145146 S0145144	S0145108 S0145149 S0145151 S0145135 S0145128 S0145132 S0145045 S0145154 S0145098 S0145138 S0145133 S0145046 S0145049 WML01 WML02	Low to Negligible (risk of voids) Low (risk of trips and falls)
2	Shallow workings and trenches/costeans that exist as depressions within the ground surface. These features may have steeper wall slopes that may require rehabilitation to soften these areas. The investigation methods confirmed the stability of base conditions of the features.	S0145107 S0145099 S0145094 S0145078 S0145101 S0145110 S0145139 S0145153 S0145150 S0145075		Low to Negligible (risk of voids) Medium (risk of trips and falls)

3	Shallow holes and shafts. The investigation methods confirmed the stability of base conditions of the features. Data obtained from the geophysical investigation indicates there are no lateral workings within the top 20 m and low risk of voids within the vicinity of these features.	S0145120 S0145082 S0145174 S0145122 S0145111 S0145093-D		Low to Negligible (risk of voids) Medium (risk of trips and falls into holes, causing injury)
4	Shallow holes and shafts with soft / unknown base conditions. The investigation methods suggest the base conditions of these features are potentially unstable. Data obtained from the geophysical investigation indicates there are no lateral workings within the top 20 m and low to medium risk of voids within the vicinity of these features.	S0145141 S0145171 S0145177 S0145130 S0145163 S0145044 S0145124 S0145072		Medium (risk of failure of rehabilitation method, significant injury due to falling into a feature)
5	Open cuts and shafts filled to the brim with debris and rubbish. The depths of these features are typically unknown and limited assessment of rock mass quality on the side walls has been made. Data obtained from the geophysical investigation indicates there are no lateral workings within the top 20 m and low risk of voids within the vicinity of these features. However, the available historical information indicate these features are located around the main shafts and are potentially located on top of significant underground mine workings (drives / lateral workings / stopes).	S0145137 S0145143 S0145145		Medium (risk of lateral workings and ground collapse) High (risk of major injury due to falling into a feature, diseases, cuts)
6	Wanerenooka:	S0145093-A S0145093-B S0145093-C		Medium (risk of lateral workings)

	Deep shafts typically situated within a fenced / gated area. The available historical information suggests these are typically main shafts and extend to significant depths beneath the ground surface and comprise of several lateral workings / drives. Data obtained from the geophysical investigation indicates there are no lateral workings within the top 20 m and low risk of voids within the vicinity of these features.	Wn2		High (risk of major injury due to falling into a feature)
7	Deep shafts. The available historical information suggests S0145140 is a main shaft and extends to a significant depth beneath the ground surface and comprises of several lateral workings / drives. The remaining features may extend to significant depths; however, the depth and base conditions are unknown. Data obtained from the geophysical investigation indicates there are no lateral workings within the top 20 m and low risk of voids within the vicinity of these features.	S0145140 S0145165 S0145126 S0145123 Wn1		High (risk of major injury due to falling into a feature) Low to Medium (risk of lateral workings)

4.2 Risk assessment

A risk assessment has been undertaken of each of the features identified on site, as they exist in their current conditions (i.e. some features are fenced off/gated), and have been grouped via the 7 feature classifications as detailed in Table 1 and the risk assessment matrix is shown in Table 2.

Category 1: Minor depressions / shallow workings

- The base conditions of these features have been validated during the geotechnical investigation and are stable. **1E = Low 1.**
- The features have been either identified as minor depressions within the ground surface and are typically indiscernible amongst the topography of the surrounding area. These features pose low risk to humans, livestock, and pets, as the likelihood of trips and falls are unlikely to occur but could happen which presents a minor consequence. **2D = Low 5.**
- These features pose no risk to vehicles as a 4x4 could traverse these. **1E = Low 1.**
- No noxious or flammable gasses were detected within these features. **1E = Low 1.**

Category 2: Small depressions / shallow workings / costeans / trenches

- The base conditions of these features have been validated during the geotechnical investigation and are stable. **1E = Low 1.**
- The features have been either identified as small depressions and shallow workings within the ground surface and typically comprise of steeper wall slopes. These features pose risk of trips and falls (minor consequence) as the likelihood of this occurring is possibly and likely to occur at some time and can be considered medium risk to humans, and low risk to livestock and pets. **2C = Medium 9.**
- These features pose low risk to vehicles as a 4x4 could traverse these in the majority of cases. **1E = Low 1.**
- No noxious or flammable gasses were detected within these features. **1E = Low 1.**

Category 3: Shallow holes and shafts

- The base conditions of these features have been validated during the geotechnical investigation and are stable. **1E = Low 1.**
- The features are typically shallow holes and shafts. These features, in their current state, may pose medium risk of injury to humans, livestock, and pets due to trips, falls, falling into the holes and shafts. The likelihood of falling into a hole is possibly and likely to occur at some time, which may yield moderate consequences. These features should not be trafficked with a 4x4 vehicle. **3C = Medium 12.**
- No noxious or flammable gasses were detected within these features. **1E = Low 1.**

Category 4: Shallow holes and shafts – soft / unknown base conditions

There exists a medium/potential risk of voids opening up and collapsing / subsidence due to the presence of unstable base conditions as evidenced by the geotechnical investigation. The potential exists for a false floor at the base of these features and poses risk to the rehabilitation method and construction personnel. Should a void open up beneath the rehabilitated feature, this may cause small surface settlement or the reformation of the void, possibly generating moderate injuries to humans, and is considered a medium risk. **3C = Medium 12.**

- The features are typically shallow holes and shafts. These features, in their current state, may pose medium risk of injury to humans, livestock, and pets due to trips, falls, falling into the holes and shafts. The likelihood of falling into a hole is possibly and likely to occur at some time, which may yield moderate consequences. These features should not be trafficked with a 4x4 vehicle. **3C = Medium 12.**
- No noxious or flammable gasses were detected within these features. **1E = Low 1.**

Category 5: Open cuts / shafts filled with rubbish and debris – unknown base and wall conditions

- There exists a medium/potential risk of voids opening up and collapsing / subsidence due to unknown base conditions of these features (e.g. potential for a false floor exists). ERT and GPR scans from the geophysical survey suggest no presence of lateral workings within the top 20 m of these areas and low risk of voids. This risk is possibly and likely to occur at some time. Should a void open up, this may cause small surface settlement, possibly generating moderate injuries to humans, and is considered at medium risk. **3C = Medium 12.**
- The features are typically open cuts and shafts filled to the brim with debris and rubbish. The depths of these features and base conditions are typically unknown and limited assessment of rock mass quality on the side walls has been made. Additionally, the available historical information indicates these features are located around the main shaft and are potentially located on top of significant underground mine workings (drives / lateral workings / stopes). These features pose high risk to human life (major consequence) due to fallings into the features / major injury, cuts / disease. **4C = High 19**
- The risk of void collapse is low, as these features were mapped as cuts on the available historical mine working maps, and the mining seams within the area are relatively narrow. The likelihood of falling into a hole is possibly and likely to occur at some time, which may yield moderate consequences. These features should not be trafficked with a 4x4 vehicle. **3C = Medium 12.**
- No noxious or flammable gasses were detected within these features. **1E = Low 1.**

Category 6: Deep shafts – within fenced / gated area

- These features are at least 3 m deep shafts, two of which contain groundwater within (hence, are of unknown depth) situated within fenced off and gated areas. The available historical information suggests these are typically main shafts and extend to significant depths beneath the ground surface and comprise of several lateral workings / drives. However, ERT and GPR scans from the geophysical survey suggest no presence of lateral workings within the top 20 m of these areas and medium to high risk of voids. **2D = Low 2.**
- As these features currently lie within a gated / fenced area, the risk to humans, livestock, pets, and vehicles has been controlled as access is restricted / limited. However, there exists the risk of someone cutting or climbing over the fence or the fence failing with age, and tripping or falling into the shaft (and drowning). Thus, these features pose high risk to human life as falling down a deep shaft may result in death, yet this event unlikely to occur but could happen, especially if the fence deteriorates. **5D = High 21.**
- The available historical information indicates the lodes are relatively wide, increasing with depth; assuming they have been extensively mined and not backfilled (worst case), these features pose risk of further subsidence along strike, due to large voids below the ground. These mining features have been open for over 150 years and based on the existing landform, have seemingly remained stable. However, these features have been historically mapped to be relatively wide, thus, there exists a medium risk of subsidence along strike between the voids, particularly under any machinery / vehicle loads. **3C = Medium 12.**
- No noxious or flammable gasses were detected within these features. Additionally, some of these features contain groundwater, displacing any potential gas. **1E = Low 1.**

Category 7: Deep shafts

S0145123 & S0145126

- These features are 4 m deep shafts that are easily accessible to the public, located in poorly lit areas. 3D LiDAR void scanning, visual assessments, ERT and GPR scans from the geophysical survey suggest no presence of lateral workings within the top 20 m of these areas and low risk of voids. The depth and extent of these features is unknown and poses risk to the rehabilitation method and construction personnel. Should a void open up beneath the rehabilitated feature, this may cause small surface settlement, possibly generating moderate injuries to humans, and is considered a medium risk. **3C = Medium 12.**
- There exists an open trench (S0145122) to the north of feature S0145126, which poses risk of serious injury due to falls, when approaching the opening of the shaft. These features are relatively deep shafts of unknown extent and pose high risk to human life as falling down a deep shaft may result in death, yet this event unlikely to occur but could happen. **5D = High 21.**
- No noxious or flammable gasses were detected within these features. **1E = Low 1.**

S0145140

- This feature is an 8 m deep shaft that is easily accessible to the public, located in a poorly lit area. The available historical information suggests this is a main shaft and extends to a significant depth beneath the ground surface and comprise of several lateral workings / drives. ERT and GPR scans from the geophysical survey suggest no presence of lateral workings within the top 20 m of these areas and low risk of voids. This mining feature has been open for over 150 years and based on the existing landform, has seemingly remained stable. The ground immediately surrounding the shaft is stable. **2D = Low 2.**
- The available historical information indicates the lodes are relatively small and narrow at Commonage and should any surface subsidence occur due to collapse of underground lateral workings, it is expected that the ground would experience little movement. These features pose low risk of further subsidence within the feature and the surrounding area, due to small voids below the ground. ERT and GPR scans undertaken during the geophysical survey support the historical data. These features pose low risk of subsidence. **2D = Low 2.**
- There exists high risk of humans, livestock, and pets tripping and falling into the shaft, which ultimately, can lead to significant injury or death. This event is possibly and likely to occur at some time. **5C = High 22.**
- No noxious or flammable gasses were detected within these features. **1E = Low 1.**

S0145165

- This feature is an 8 m deep shaft that is easily accessible to the public, located in a poorly lit area. The rim of the shaft consists of loose crumbly rock mass, thus, is unstable at the edge, making this feature particularly hazardous to people approaching the edge of the feature to look down the hole.
- 3D LiDAR void scanning, visual assessments indicate the existence of two drives extending north and south at least 2 m and 5 m below ground; these drives extend at least 2 m. However, ERT and GPR scans from the geophysical survey suggest no presence of lateral workings within the top 20 m to the east and west of this feature.
- Lateral workings may extend further than the 3D scan identified due to partial blockage / collapse or turns. This poses risk to the rehabilitation method and construction personnel should the loading of construction equipment collapse the void. **5C = High 22.**
- A false floor may exist at the base of this feature. Should a void open up beneath the rehabilitated feature, this may cause small surface settlement, possibly generating moderate injuries to humans, and is considered a medium risk. **3C = Medium 12.**
- These features are relatively deep shafts of unknown extent and pose high risk to human life as falling down a deep shaft may result in death, yet this event unlikely to occur but could happen. **5D = High 21.**
- No noxious or flammable gasses were detected within these features. **1E = Low 1.**

Wn1

- This feature is 3.5 m deep shaft that is easily accessible to the public, located in a poorly lit area. ERT and GPR scans from the geophysical survey suggest no presence of lateral workings within the top 20 m of these areas and low risk of voids. These features pose low risk of subsidence, particularly under any machinery / vehicle loads (subsidence is unlikely to occur but could happed which may cause minor consequence to humans). **C2 = Medium 9.**
- There exists high risk of humans, livestock, and pets tripping and falling into the shaft, which ultimately, can lead to significant injury or death. This event is possibly and likely to occur at some time. **5C = High 22.**
- No noxious or flammable gasses were detected within these features. **1E = Low 1.**

Table 2: Risk assessment matrix

LIKELIHOOD	CONSEQUENCE					
		1. Insignificant – Dealt with by in house first aid	**2. Minor** – Treated by medical professionals, hospital outpatients	**3. Moderate** – Significant non-permanent injury overnight hospital stays	**4. Major** – Extensive permanent injury e.g. loss of fingers, extended hospital stay	**5. Catastrophic** – Death, permanent injury e.g. loss of hand, quadriplegia
	A. Almost certain to occur in most circumstances	**MEDIUM 8**	**HIGH 16**	**HIGH 18**	**CRITICAL 23**	**CRITICAL 25**
	B. Likely to occur frequently	**MEDIUM 7**	**MEDIUM 10**	**HIGH 17**	**HIGH 20**	**CRITICAL 24**
	C. Possibly and likely to occur at some time	**LOW 3**	**MEDIUM 9**	**MEDIUM 12**	**HIGH 19**	**HIGH 22**
	D. Unlikely to occur but could happen	**LOW 2**	**LOW 5**	**MEDIUM 11**	**MEDIUM 14**	**HIGH 21**
	E. May occur but only in rare circumstances	**LOW 1**	**LOW 4**	**LOW 6**	**MEDIUM 13**	**MEDIUM 15**

5 CLOSURE

This report is intended for distribution to the public.

We trust that the information provided within this report satisfies your present requirements and meets with your approval. Should you have any queries, please do not hesitate to contact the author of this report.

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6 REFERENCES

1. Geological Series Map 1:250,000 Scale ‘Geraldton’.
2. Standards Australia. 2017. *Geotechnical Site Investigations*. AS 1726:2017. SAI Global.

LIMITATIONS

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WML have undertaken investigations, performed consulting services, and prepared this report based on the Client's specific requirements, documents and information supplied, and previous experience. If changes occur in the nature or design of the project, however minor, it is recommended WML review this report to assess their impacts and provide additional recommendations, if any. WML does not assume any responsibility or liability for problems that arise due to developments on site of which we were not informed.

This report utilises data and information provided by third parties, including, but not limited to sub-consultants, published data, and the Client. This information has been assumed to be correct unless otherwise stated. WML assumes no responsibility for assessments made partly or entirely based on information provided by third parties or for the adequacy, incompleteness, inaccuracies, or reliability of any data provided by third parties.

It is the responsibility of the Client to transmit the information, recommendations, and limitations of this report to the appropriate organisations or people involved in design of the project, including, but not limited to developers, builders, owners, buyers, architects, engineers, and designers.

WML's opinions are based on upon information that existed at the time of the production of this report and ground conditions encountered at the time the site study was performed. This geotechnical report should not be relied upon if its adequacy has been affected by: the passage of time, by man-made events, such as construction on or adjacent to the site, or by natural events, such as floods, earthquakes, or groundwater fluctuations. In the event of the above changes, WML should be contacted to determine if this report is still reliable or whether additional testing is required.

The subsurface conditions identified within this report are based only upon investigation locations where subsurface tests have been conducted and / or samples obtained, which are explicitly representative of the specific sample or test location. Interpretation of conditions between such points cannot be assumed to represent actual subsurface information and unknowns or variations in ground conditions between test locations that cannot be inferred or predicted. Actual subsurface conditions may differ significantly from those indicated in this report. Specific warning is also given that many factors, either natural or artificial, may render ground conditions different from those which pertained at the time of the investigation. WML does not accept any responsibility for any variance in the ground conditions that may exist across the site. If unexpected subsurface conditions are encountered, WML shall be notified immediately to review those conditions and provide additional and/or modified recommendations, as necessary.

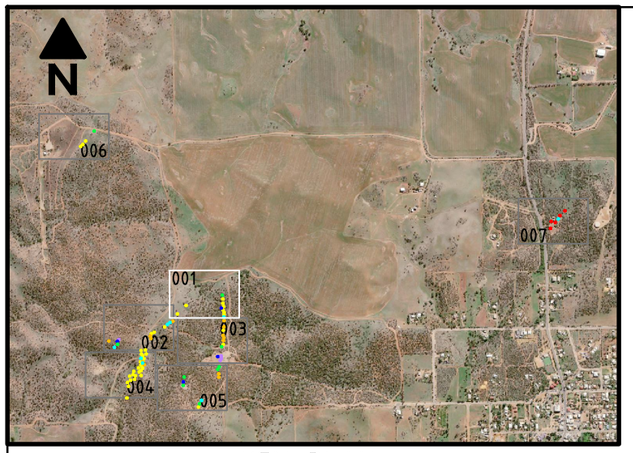
This geotechnical assessment is based upon judgment of the investigation data, visual observations of the site and materials encountered, along with the proposed land use and project specifications. The findings and recommendations presented within this report represent professional opinions and estimates and should not be taken as fact unless explicitally stated. In general, statements of fact are are limited to what was done and / or what was observed on site.

The recommendations provided in this report are preliminary only; final recommendations can only be given after observing the actual subsurface conditions revealed during construction. WML does not assume responsibility or liability for the recommendations in this report if construction observation has not been performed by a WML geotechnical engineer.

Our services did not include any contamination or environmental assessment of the site or adjacent sites. The equipment and techniques used to perform a geoenvironmental study differ from those used to perform a geotechnical investigation. If you require any geoenvironmental information for your project, WML can advise on further steps to be undertaken.

WML have performed our professional services in accordance with generally accepted geotechnical engineering principles and practices currently employed in the area; no warranty, expressed or implied, is made as to the professional advice included in this report.

DRAWINGS



KEY PLAN

N.T.S.

LEGEND

- CATEGORY 1
- CATEGORY 2
- CATEGORY 3
- CATEGORY 4
- CATEGORY 5
- CATEGORY 6
- CATEGORY 7

SCALE 1:1000

A3

WML Consulting Engineers
Civil | Geotechnical | Structural

BUNBURY +61 8 9722 3544
KALGOORLIE +61 8 9021 1811
PERTH +61 8 9722 3566
wml.com.au

REVISIONS				
A	ISSUED FOR CLIENT REVIEW	I.G.	03.04.2025	C.H.
N°.	DESCRIPTION	APPROVED	DATE	DRAWN

NAMES PRINTED IN FULL		DATE
DESIGNED	I. GOLIJANIN	APR' 25
DRAWN	C. HICK	APR' 25
VERIFIED	I. GOLIJANIN	APR' 25
APPROVED	S. MARIS	APR' 25

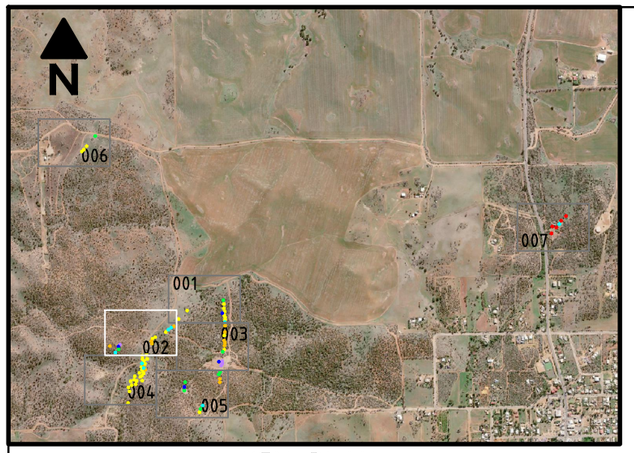
CLIENT
DEMIRS

PROJECT
COMMONAGE MINE VOID REHABILITATION

DRAWING TITLE
COMMONAGE MINE VOID REHABILITATION
FEATURE CATEGORY
MAP AREA
SHEET 1

CONSULTANT DRAWING NUMBER
11126-G-D-001

11126-G-D-001 A



KEY PLAN

N.T.S.

N

S0145107
S0145120
S0145111
S0145108
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S0145110
S0145144
S0145146

SCALE 1:1000

A3

LEGEND

- CATEGORY 1
- CATEGORY 2
- CATEGORY 3
- CATEGORY 4
- CATEGORY 5
- CATEGORY 6
- CATEGORY 7

WML Consulting Engineers
Civil | Geotechnical | Structural

BUNBURY +61 8 9722 3544
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PERTH +61 8 9722 3566
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DESIGNED	I. GOLIJANIN	APR' 25
DRAWN	C. HICK	APR' 25
VERIFIED	I. GOLIJANIN	APR' 25
APPROVED	S. MARIS	APR' 25

CLIENT
DEMIRS

PROJECT
COMMONAGE MINE VOID REHABILITATION

DRAWING TITLE
COMMONAGE MINE VOID REHABILITATION
FEATURE CATEGORY
MAP AREA
SHEET 2

CONSULTANT DRAWING NUMBER
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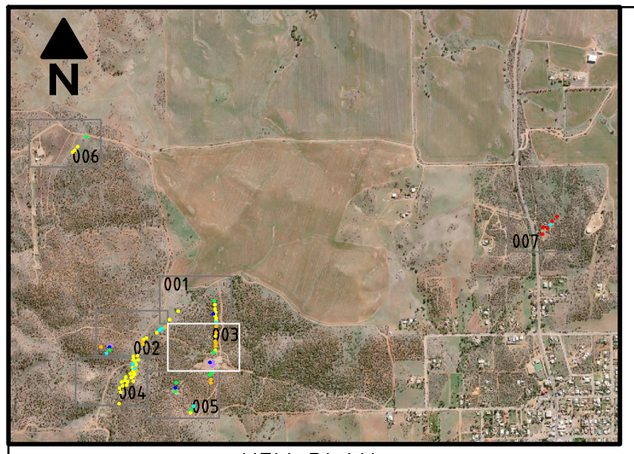
11126-G-D-002 A



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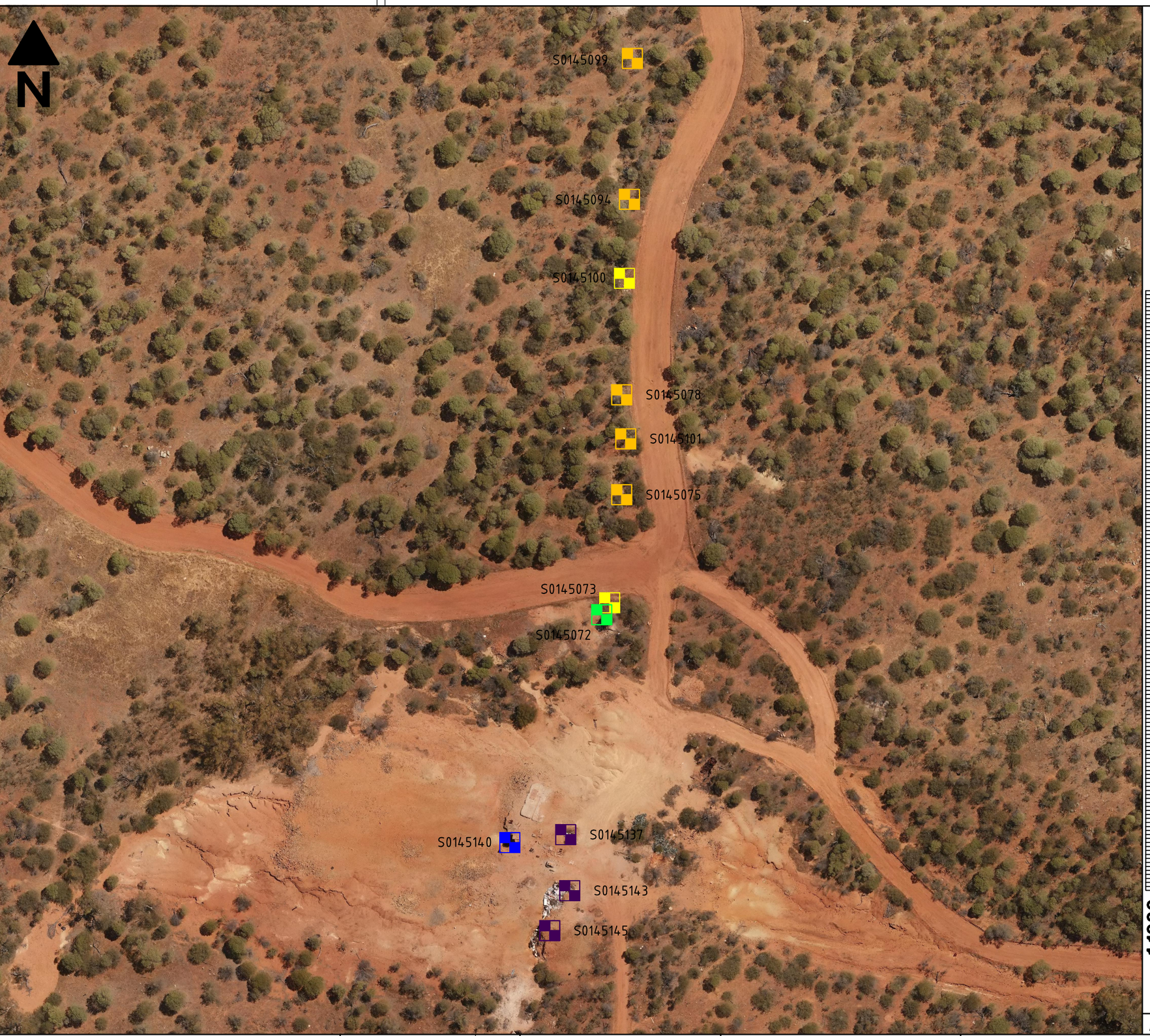

LEGEND

- CATEGORY 1
- CATEGORY 2
- CATEGORY 3
- CATEGORY 4
- CATEGORY 5
- CATEGORY 6
- CATEGORY 7

SCALE 1:1000

A3

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DESIGNED	I. GOLIJANIN	NOV '24
DRAWN	C. HICK	NOV '24
VERIFIED		
APPROVED		

CLIENT
DEMIRS

PROJECT
YALGOO MINE VOID REHABILITATION

DRAWING TITLE
YALGOO MINE REHABILITATION
FEATURE CATEGORY
MAP AREA
SHEET 1

CONSULTANT DRAWING NUMBER
11715-G-D-001

11715-G-D-001 **B**

LEGEND

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- CATEGORY 6
- CATEGORY 7

N

S0145142
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S0145126
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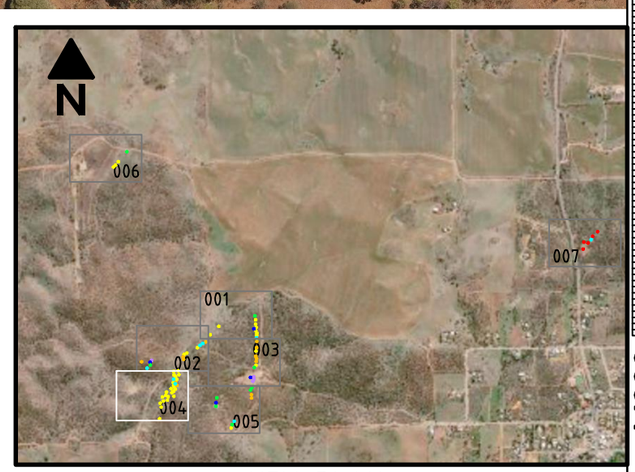

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DRAWN	C. HICK	NOV '24
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APPROVED		

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PROJECT
YALGOO MINE VOID REHABILITATION

DRAWING TITLE
YALGOO MINE REHABILITATION
FEATURE CATEGORY
MAP AREA
SHEET 1

CONSULTANT DRAWING NUMBER
11715-G-D-001

11715-G-D-001 B

LEGEND

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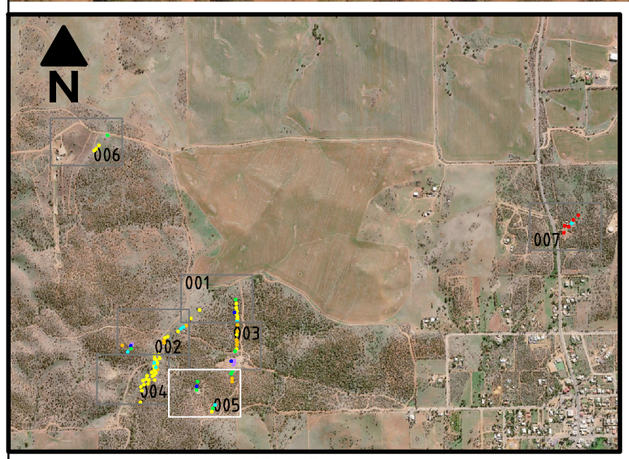

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APPROVED	S. MARIS	APR' 25

CLIENT
DEMIRS

PROJECT
COMMONAGE MINE VOID REHABILITATION

DRAWING TITLE
COMMONAGE MINE VOID REHABILITATION
FEATURE CATEGORY
MAP AREA
SHEET 5

CONSULTANT DRAWING NUMBER
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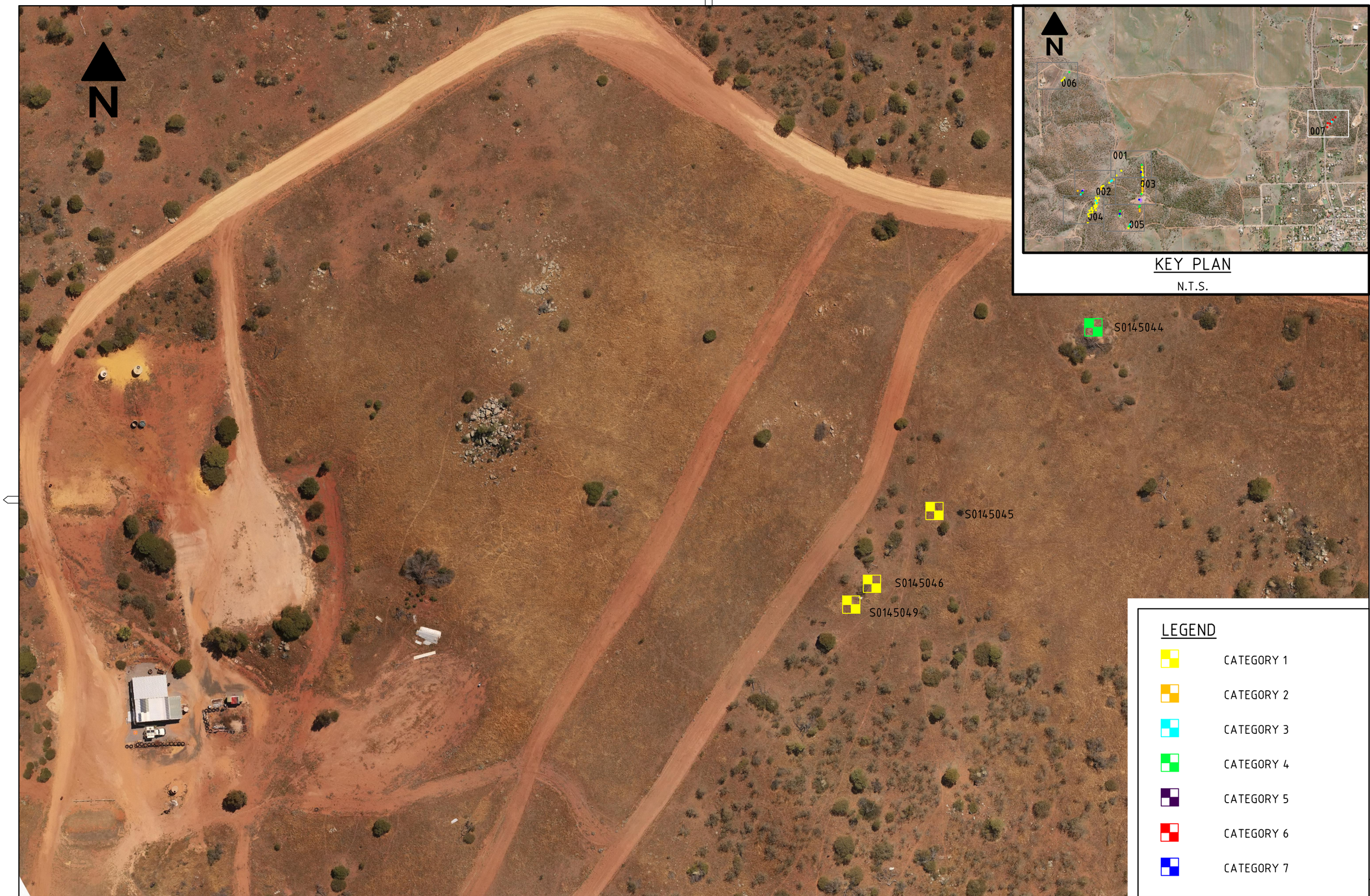

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LEGEND

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- CATEGORY 6
- CATEGORY 7

SCALE 1:1000

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CLIENT
DEMIRS

PROJECT
COMMONAGE MINE VOID REHABILITATION

DRAWING TITLE
COMMONAGE MINE VOID REHABILITATION
FEATURE CATEGORY
MAP AREA
SHEET 6

CONSULTANT DRAWING NUMBER
11126-G-D-006

11126-G-D-006 A

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S0145093-D

S0145093-A

S0145093-C

S0145093-B

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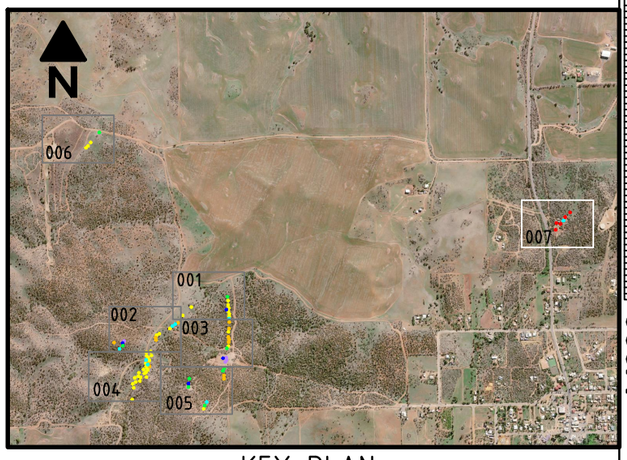

KEY PLAN

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DEMIRS

PROJECT
COMMONAGE MINE VOID REHABILITATION

DRAWING TITLE
WANERENOOKA MINE VOID REHABILITATION
FEATURE CATEGORY
MAP AREA
SHEET 7

CONSULTANT DRAWING NUMBER
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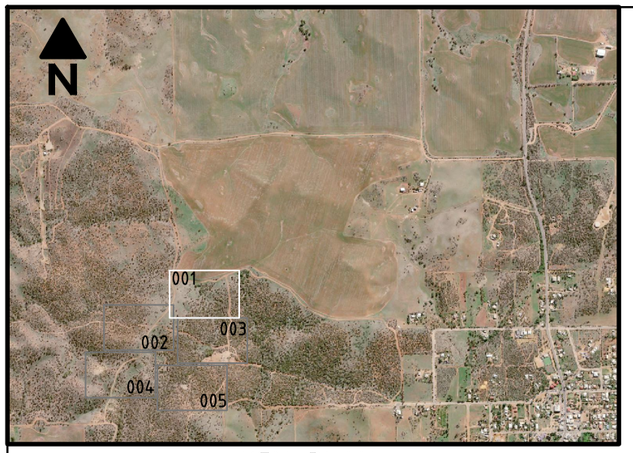
11126-G-D-007 A



KEY PLAN

N.T.S.

LEGEND

- BH13 BORE HOLE LOCATION
- TP3 TEST PIT LOCATION

SCALE 1:1000

A3

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VERIFIED	I. GOLIJANIN	APR' 25
APPROVED	S. MARIS	APR' 25

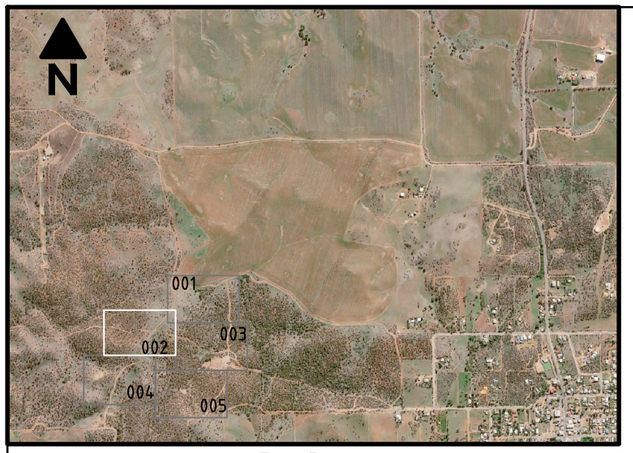
CLIENT
DEMIRS

PROJECT
COMMONAGE MINE VOID REHABILITATION

DRAWING TITLE
COMMONAGE MINE VOID REHABILITATION
BOREHOLE LOCATION PLAN
MAP AREA
SHEET 1

CONSULTANT DRAWING NUMBER
11126-G-D-008

11126-G-D-008 A



KEY PLAN

N.T.S.

SCALE 1:1000

A3

LEGEND

BH13 BORE HOLE LOCATION

TP3 TEST PIT LOCATION

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APPROVED	S. MARIS	APR' 25

CLIENT
DEMIRS

PROJECT
COMMONAGE MINE VOID REHABILITATION

DRAWING TITLE
COMMONAGE MINE VOID REHABILITATION
BOREHOLE LOCATION PLAN
MAP AREA
SHEET 2

CONSULTANT DRAWING NUMBER
11126-G-D-009

11126-G-D-009 A

KEY PLAN

N.T.S.

LEGEND

- BH13 BORE HOLE LOCATION
- TP3 TEST PIT LOCATION

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VERIFIED	I. GOLIJANIN	APR' 25
APPROVED	S. MARIS	APR' 25

CLIENT
DEMIRS

PROJECT
COMMONAGE MINE VOID REHABILITATION

DRAWING TITLE
COMMONAGE MINE VOID REHABILITATION
BOREHOLE LOCATION PLAN
MAP AREA
SHEET 3

CONSULTANT DRAWING NUMBER
11126-G-D-010

11126-G-D-010 **A**

LEGEND

BH13 BORE HOLE LOCATION

TP3 TEST PIT LOCATION

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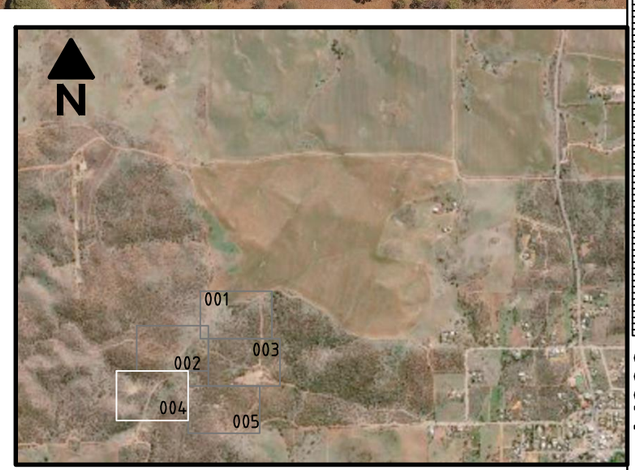
BH27

BH28

BH29



KEY PLAN

N.T.S.

SCALE 1:1000

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NAMES PRINTED IN FULL		DATE
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DRAWN	C. HICK	APR' 25
VERIFIED	I. GOLIJANIN	APR' 25
APPROVED	S. MARIS	APR' 25

CLIENT: DEMIRS

PROJECT: COMMONAGE MINE VOID REHABILITATION

DRAWING TITLE: COMMONAGE MINE VOID REHABILITATION
BOREHOLE LOCATION PLAN
MAP AREA
SHEET 4

CONSULTANT DRAWING NUMBER: 11126-G-D-011

11126-G-D-011 A

LEGEND

BH13 BORE HOLE LOCATION

TP3 TEST PIT LOCATION

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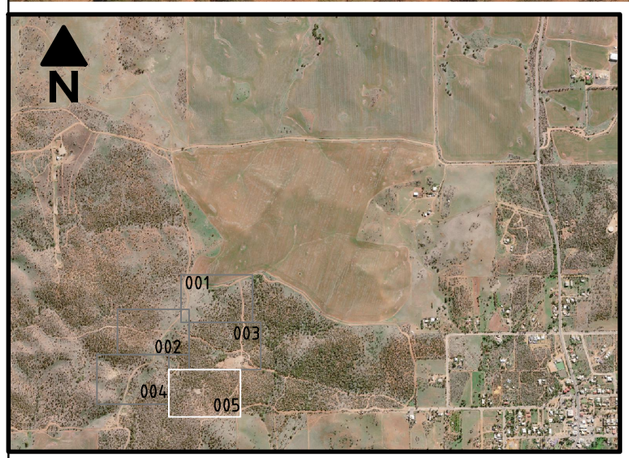
TP2

BH18

BH10

BH9

BH8



KEY PLAN

N.T.S.

SCALE 1:1000

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DRAWN	C. HICK	APR' 25
VERIFIED	I. GOLIJANIN	APR' 25
APPROVED	S. MARIS	APR' 25

CLIENT
DEMIRS

PROJECT
COMMONAGE MINE VOID REHABILITATION

DRAWING TITLE
COMMONAGE MINE VOID REHABILITATION
BOREHOLE LOCATION PLAN
MAP AREA
SHEET 5

CONSULTANT DRAWING NUMBER
11126-G-D-012

11126-G-D-012 A

APPENDIX A

FIELD NOTES

CATEGORY 1 FEATURES

PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145045	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145046	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145049	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 1

WML Consulting Engineers	Feature S0145073	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145076	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 3

Figure 4

WML Consulting Engineers	Feature S0145076	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145083	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 3

Figure 4

WML Consulting Engineers	Feature S0145083	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145098	Project No:	11126
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PHOTOGRAPHS

Figure 1

Figure 2

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PHOTOGRAPHS

Figure 1

Figure 2

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PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145108	Project No:	11126
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PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145109	Project No:	11126
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PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145121	Project No:	11126
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PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145128 & S0145132	Project No:	11126
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PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145129	Project No:	11126
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PHOTOGRAPHS

Figure 1

Figure 2

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PHOTOGRAPHS

Figure 1

Figure 2

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PHOTOGRAPHS

Figure 1

Figure 2

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PHOTOGRAPHS

Figure 1

Figure 2

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PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145142	Project No:	11126
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PHOTOGRAPHS

Figure 3

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PHOTOGRAPHS

Figure 1

Figure 2

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PHOTOGRAPHS

Figure 1

Figure 2

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PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145149	Project No:	11126
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PHOTOGRAPHS

Figure 3

Figure 4

WML Consulting Engineers	Feature S0145149	Project No:	11126
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PHOTOGRAPHS

Figure 1

Figure 2

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PHOTOGRAPHS

Figure 3

Figure 4

WML Consulting Engineers	Feature S0145151	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 1

Figure 2

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PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature WML01 – Additional Feature	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature WML02	Project No:	11126
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CATEGORY **2** FEATURES

PHOTOGRAPHS

Figure 1

Figure 2

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PHOTOGRAPHS

Figure 3

Figure 4

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PHOTOGRAPHS

Figure 1

Figure 2

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PHOTOGRAPHS

Figure 3

WML Consulting Engineers	Feature S0145078	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145094	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 3

Figure 4

WML Consulting Engineers	Feature S0145094	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 1

Figure 2

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PHOTOGRAPHS

Figure 1

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PHOTOGRAPHS

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WML Consulting Engineers	Feature S0145101	Project No:	11126
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PHOTOGRAPHS

Figure 1

Figure 2

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PHOTOGRAPHS

Figure 3

Figure 4

WML Consulting Engineers	Feature S0145107	Project No:	11126
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PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145110	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145150	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 3

Figure 4

WML Consulting Engineers	Feature S0145150	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145153	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 3

Figure 4

WML Consulting Engineers	Feature S0145153	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

CATEGORY **3** FEATURES

PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145082	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 3

WML Consulting Engineers	Feature S0145082	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145093-D	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 3

Figure 4

WML Consulting Engineers	Feature S0145093-D	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145111	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 3

Figure 4

WML Consulting Engineers	Feature S0145111	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145120	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 3

Figure 4

WML Consulting Engineers	Feature S0145120	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145174	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 3

Figure 4

WML Consulting Engineers	Feature S0145174	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

CATEGORY **4** FEATURES

PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145044	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145072	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 3

Figure 4

WML Consulting Engineers	Feature S0145072	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145124	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 3

Figure 4

WML Consulting Engineers	Feature S0145124	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145130	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145141	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 3

Figure 4

WML Consulting Engineers	Feature S0145141	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145163	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 3

Figure 4

WML Consulting Engineers	Feature S0145163	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145171	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 3

Figure 4

WML Consulting Engineers	Feature S0145171	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145177	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 3

Figure 4

WML Consulting Engineers	Feature S0145177	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

CATEGORY **5** FEATURES

PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145137	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 3

Figure 4

WML Consulting Engineers	Feature S0145137	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145143	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

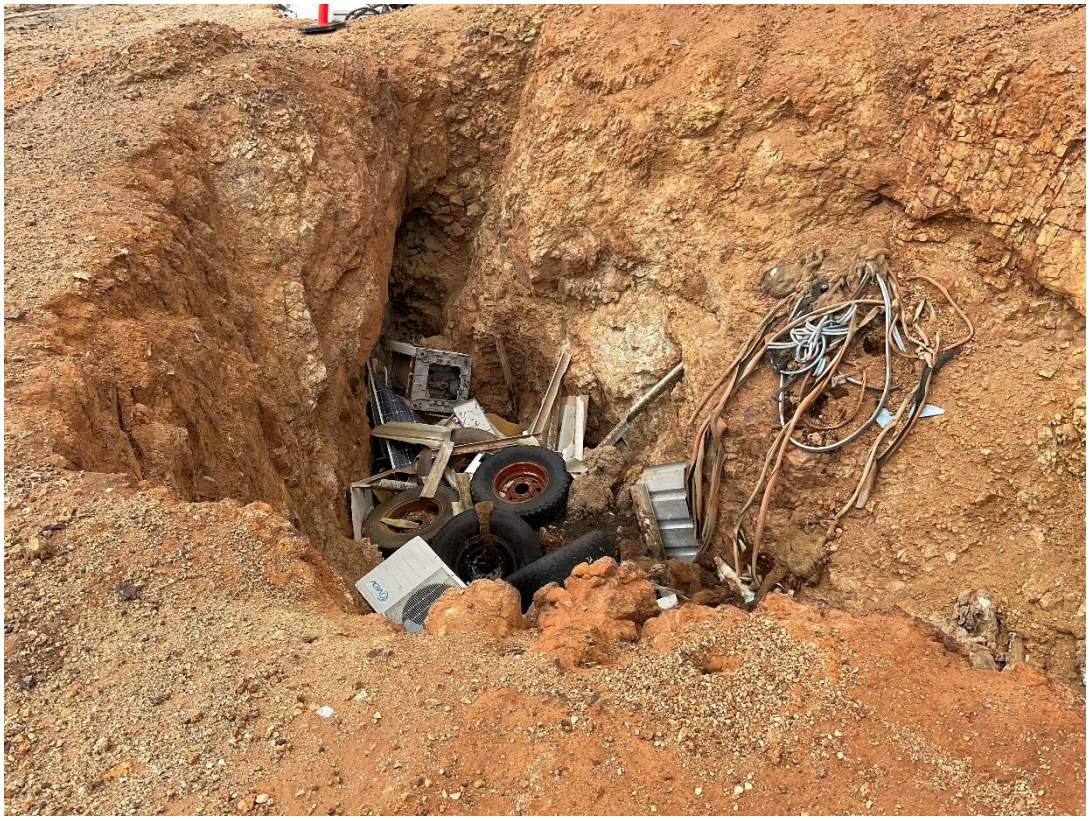


Figure 1

Figure 2

WML Consulting Engineers	Feature S0145145	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

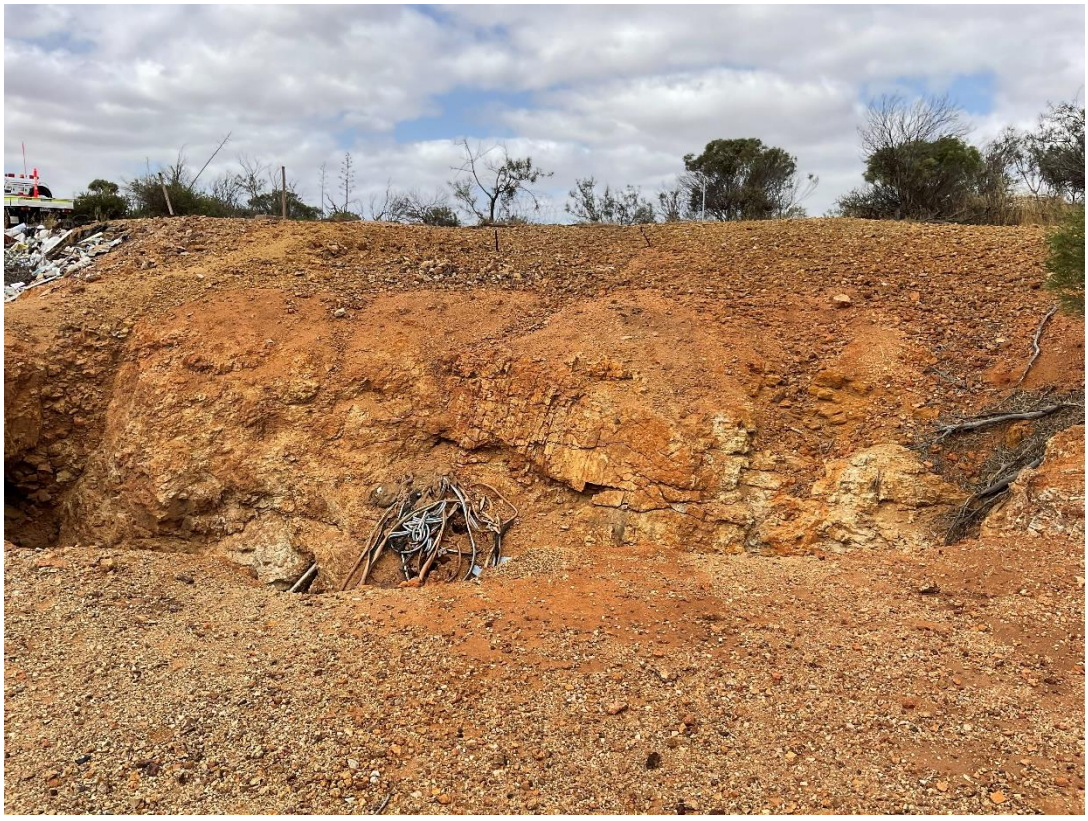


Figure 3

Figure 4

WML Consulting Engineers	Feature S0145145	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

CATEGORY **6** FEATURES

PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145093-A	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

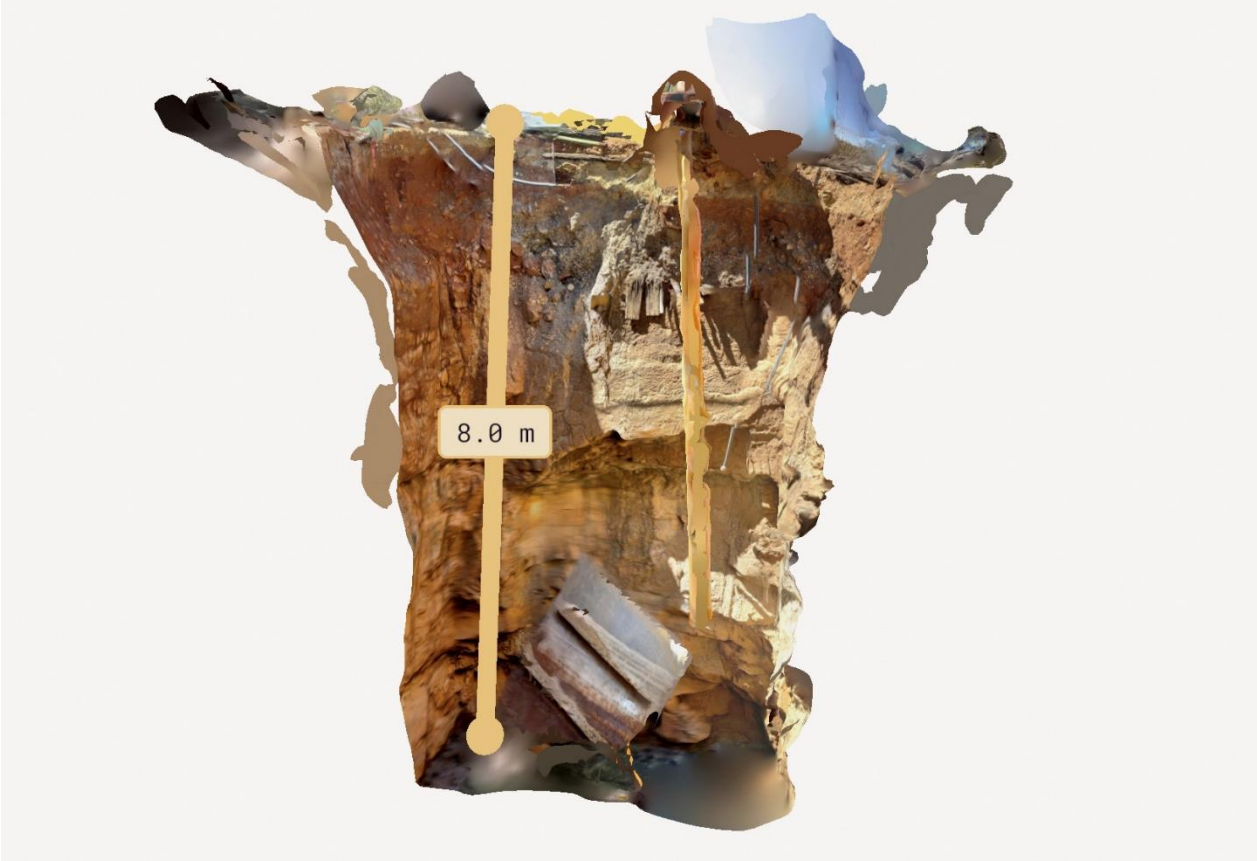
PHOTOGRAPHS

Figure 3

Figure 4

WML Consulting Engineers	Feature S0145093-A	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

3D SCANNING – LIDAR DATA



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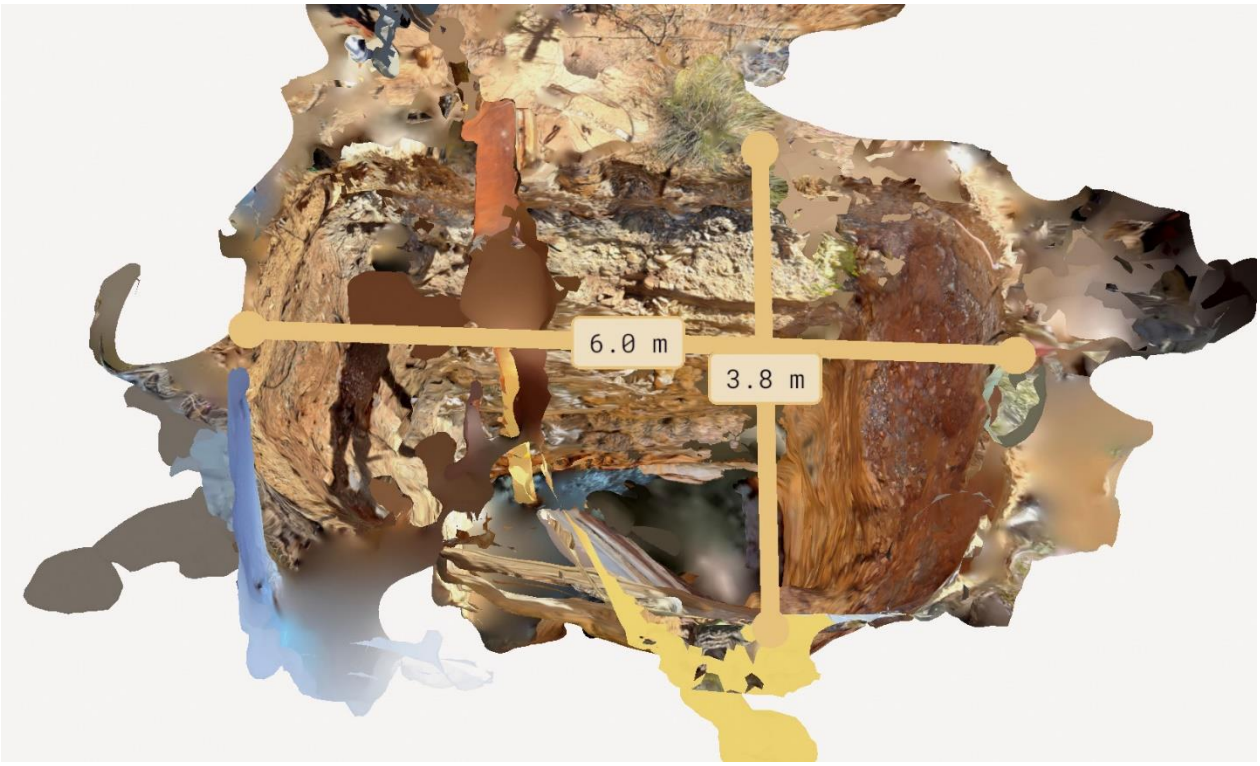


Figure 2

WML Consulting Engineers	Feature S0145093-A	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

3D SCANNING – LIDAR DATA

Figure 3

WML Consulting Engineers	Feature S0145093-A	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145093-B	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 3

WML Consulting Engineers	Feature S0145093-B	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

Figure 1

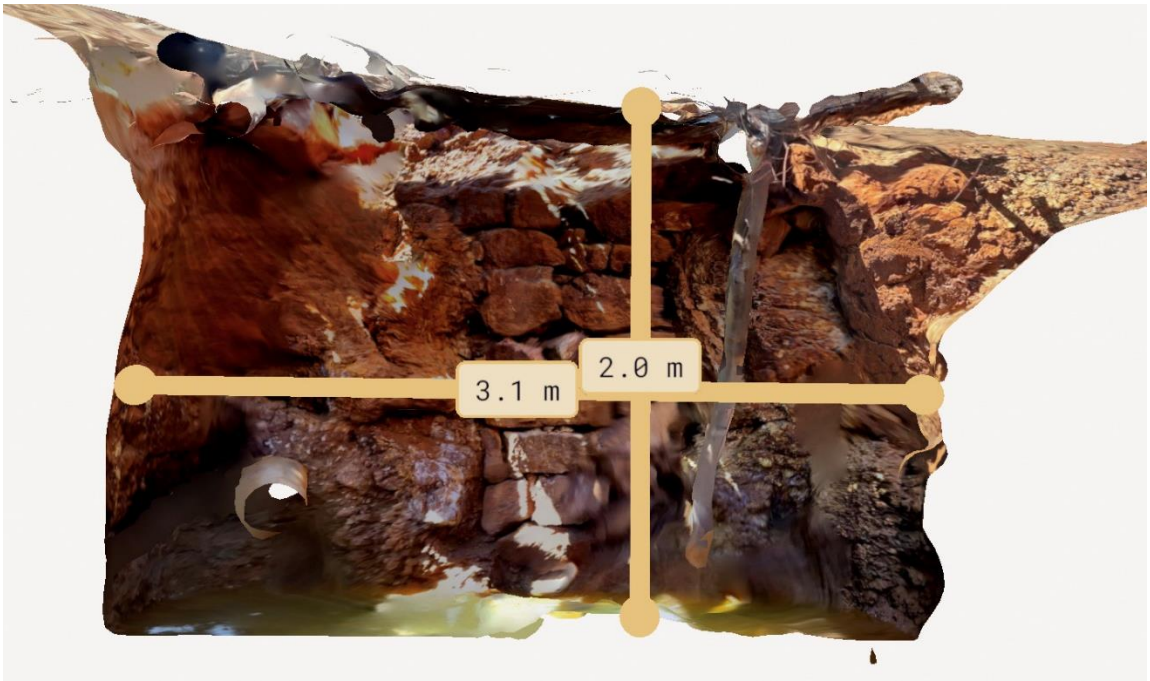


Figure 2

WML Consulting Engineers	Feature S0145093-B	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

3D SCANNING – LIDAR DATA

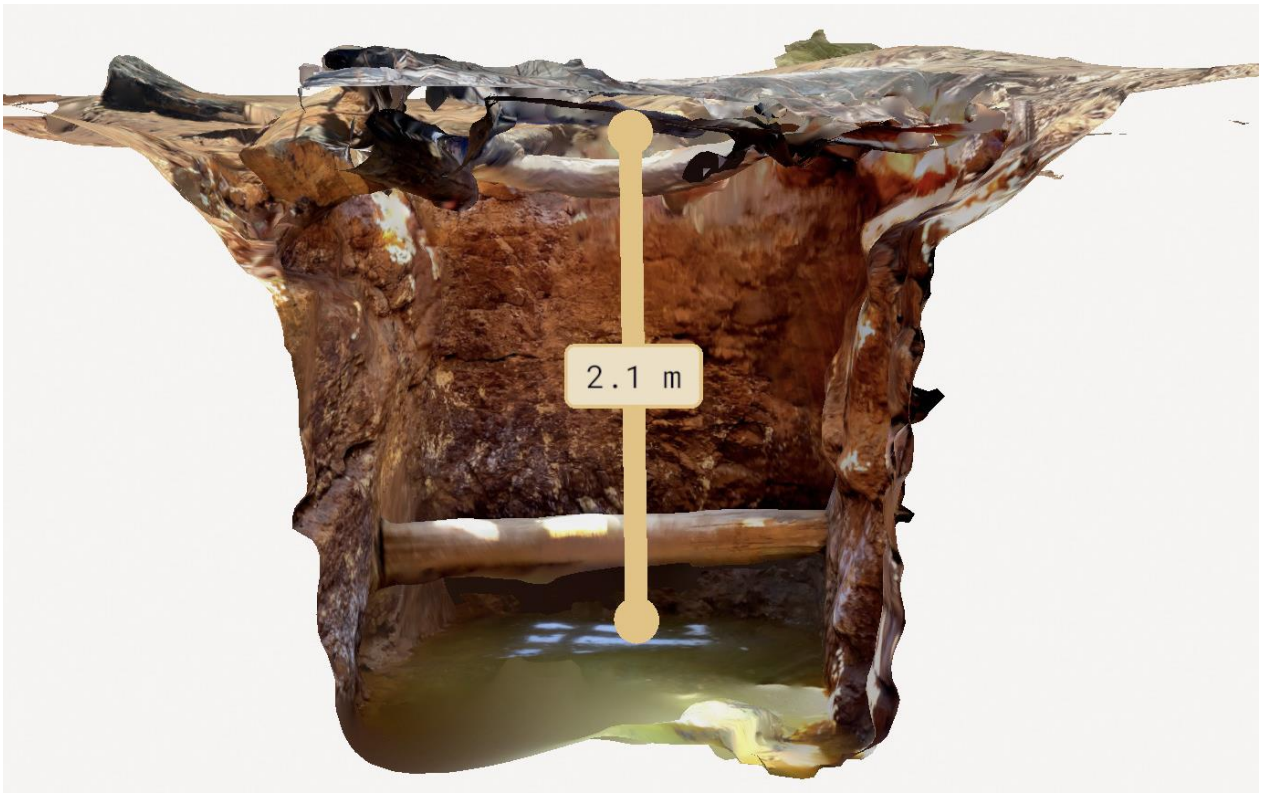


Figure 3

WML Consulting Engineers	Feature S0145093-B	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145093-C	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

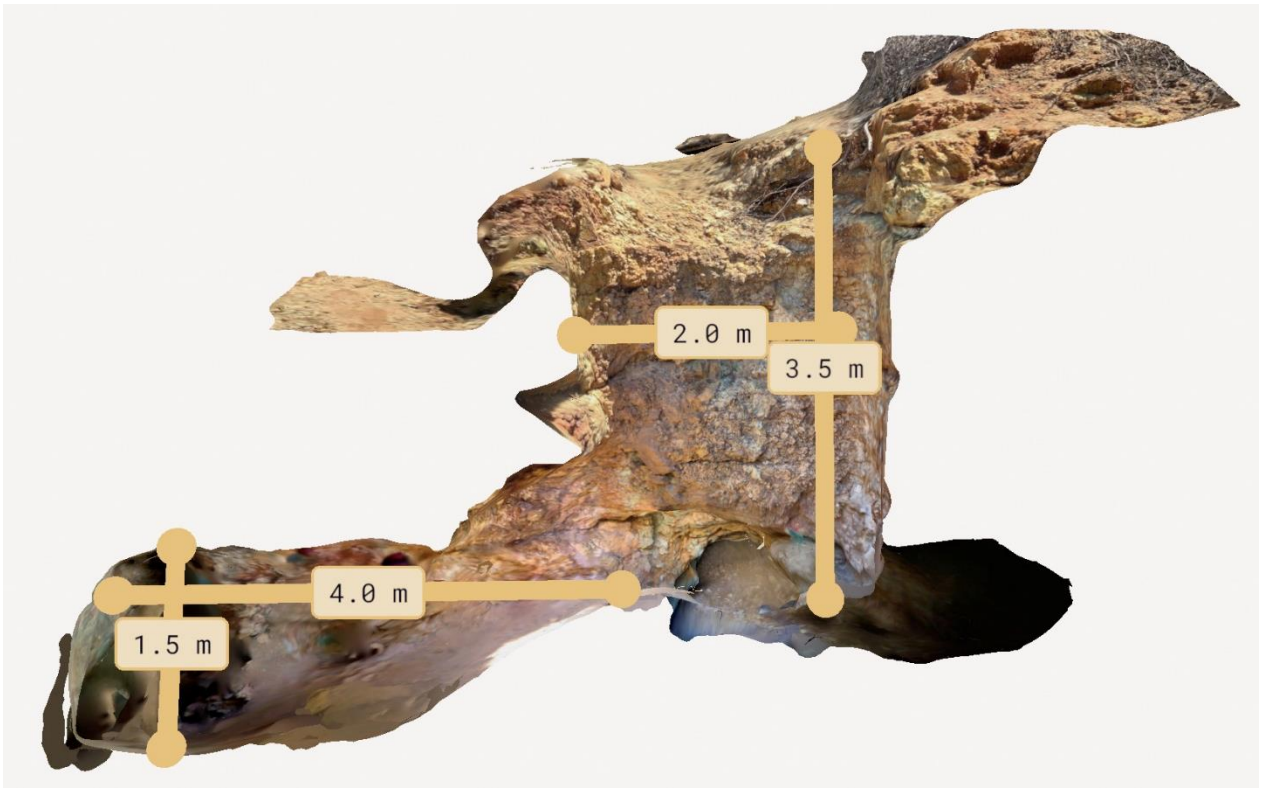
PHOTOGRAPHS

Figure 3

Figure 4

WML Consulting Engineers	Feature S0145093-C	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

3D SCANNING – LIDAR DATA



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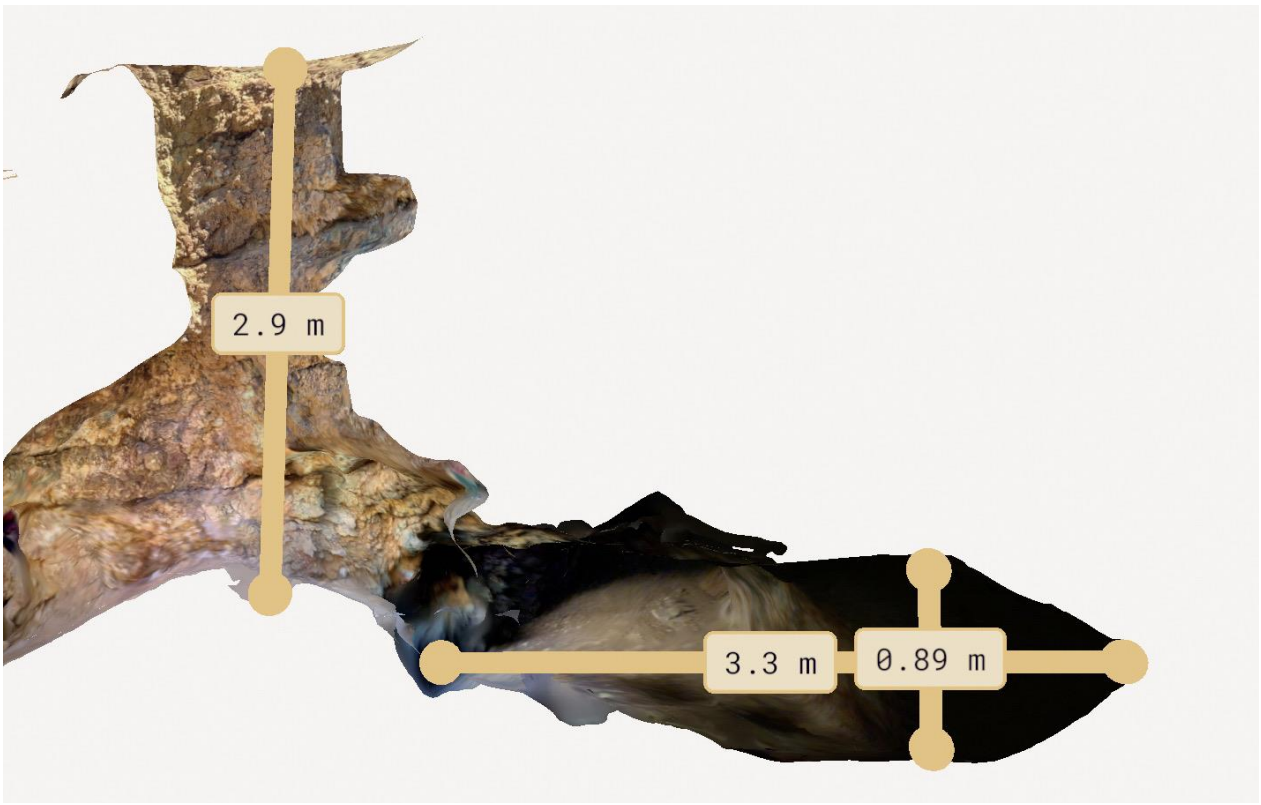


Figure 2

WML Consulting Engineers	Feature S0145093-C	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature Wn2	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

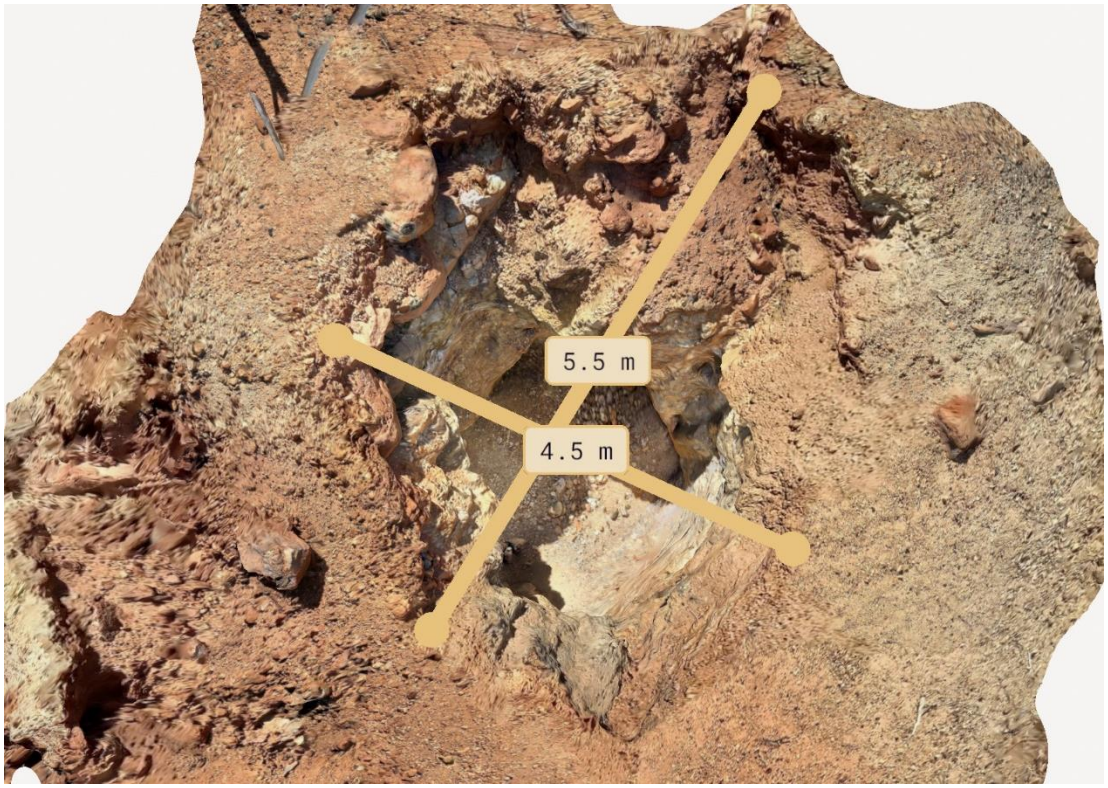
PHOTOGRAPHS

Figure 3

Figure 4

WML Consulting Engineers	Feature Wn2	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

3D SCANNING – LIDAR DATA



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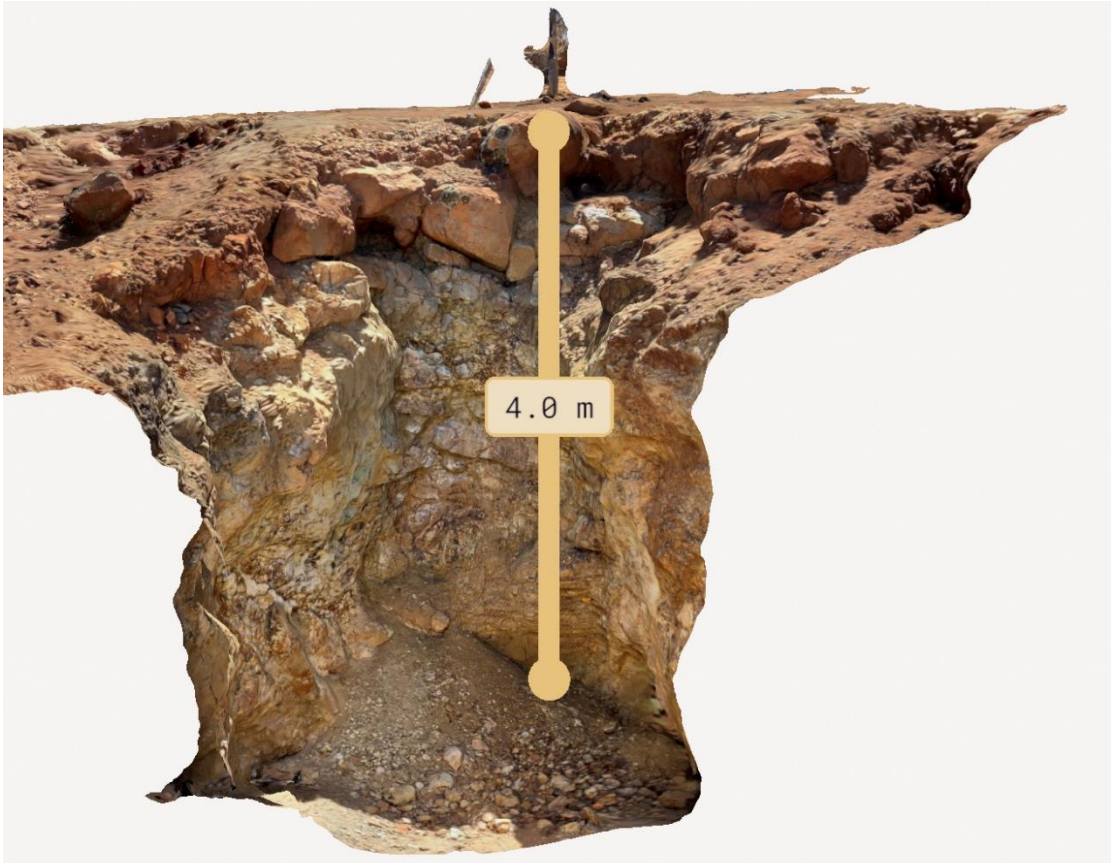


Figure 2

WML Consulting Engineers	Feature Wn2	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

3D SCANNING – LIDAR DATA

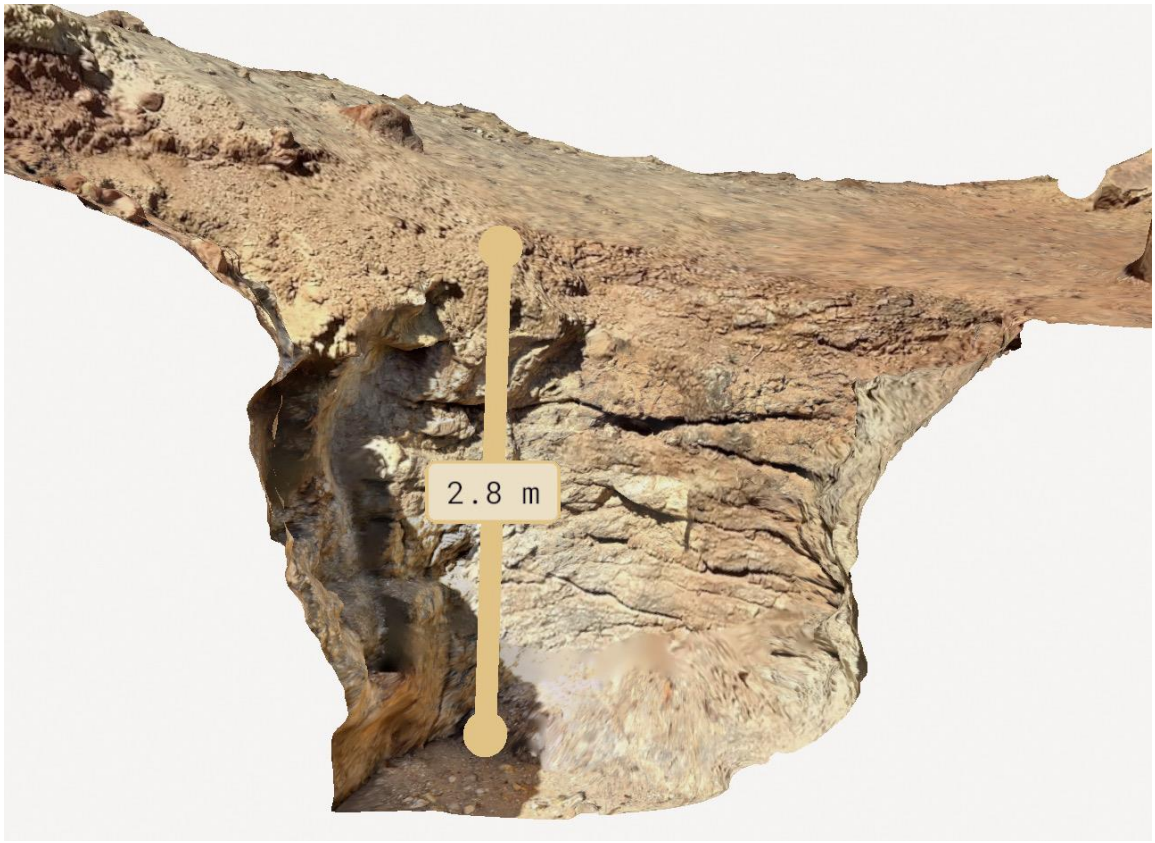


Figure 3

WML Consulting Engineers	Feature Wn2	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

CATEGORY **7** FEATURES

PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145126 & S0145122	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 3

Figure 4

WML Consulting Engineers	Feature S0145139 & S0145122	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

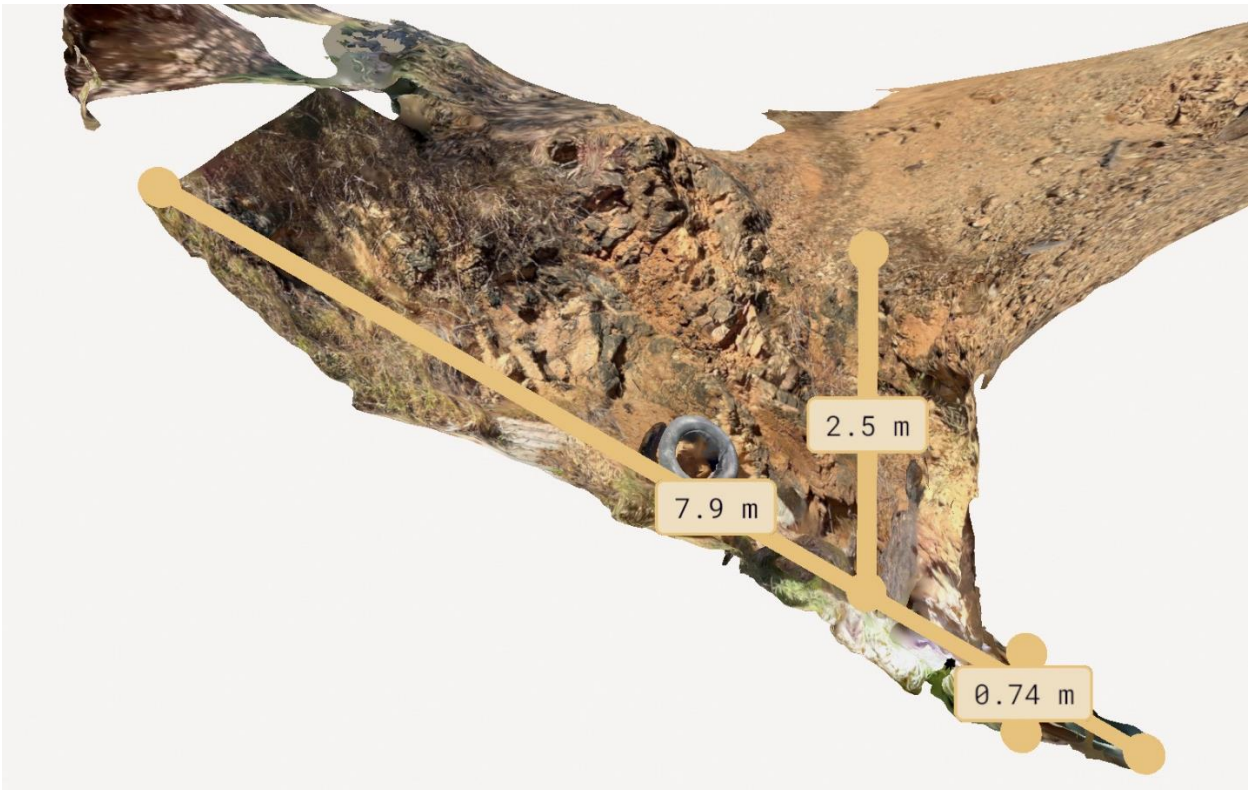
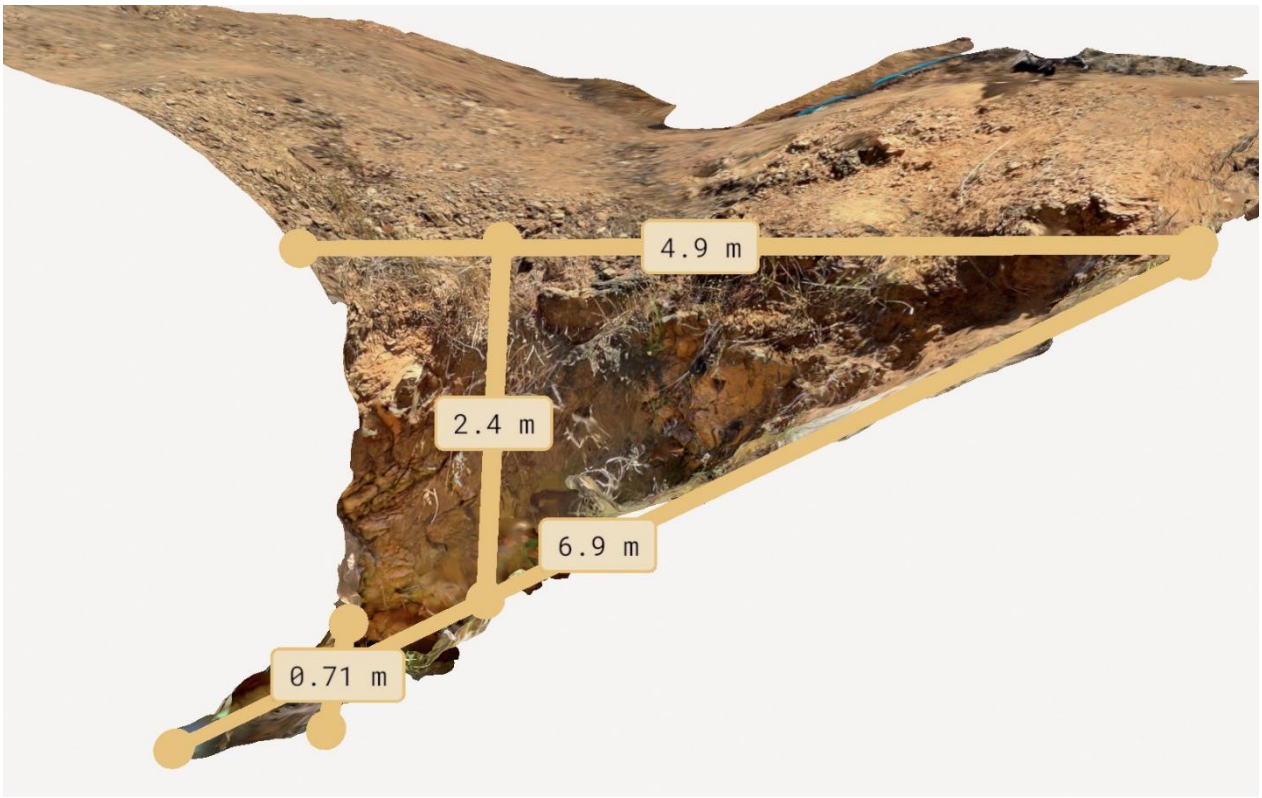


Figure 2



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WML Consulting Engineers	Feature S0145122	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

Figure 4

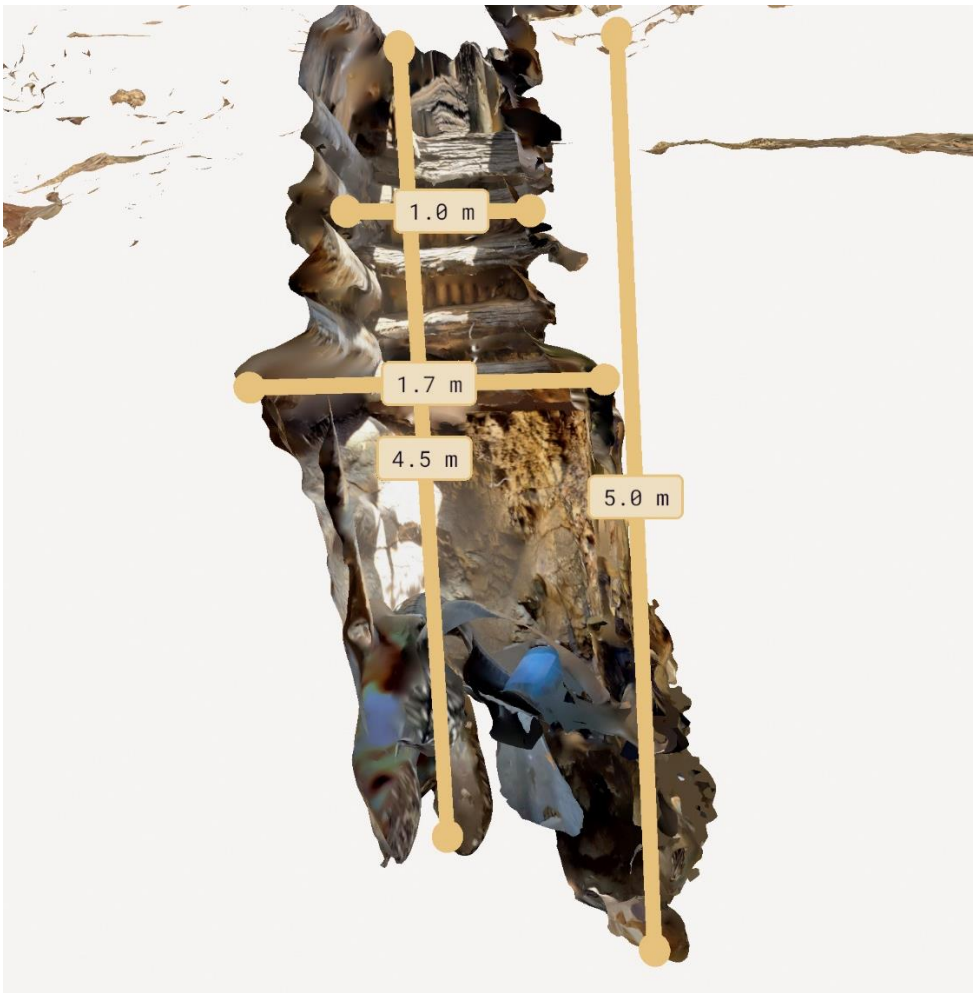


Figure 5

PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145123	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 3

WML Consulting Engineers	Feature S0145123	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145140	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 3

Figure 4

WML Consulting Engineers	Feature S0145140	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

3D SCANNING – LIDAR DATA

Figure 1

WML Consulting Engineers	Feature S0145140	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

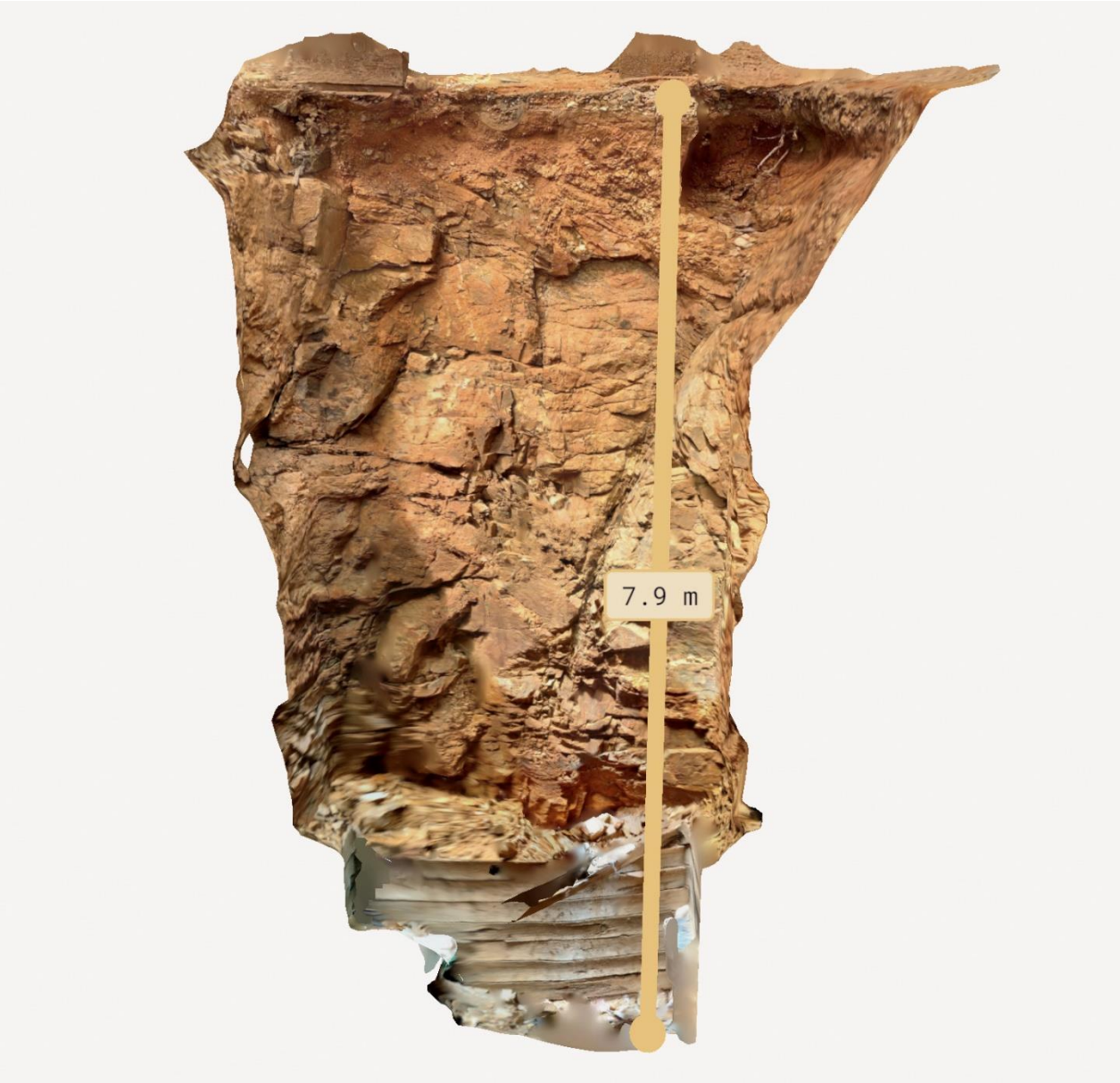


Figure 2

WML Consulting Engineers	Feature S0145140	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature S0145165	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

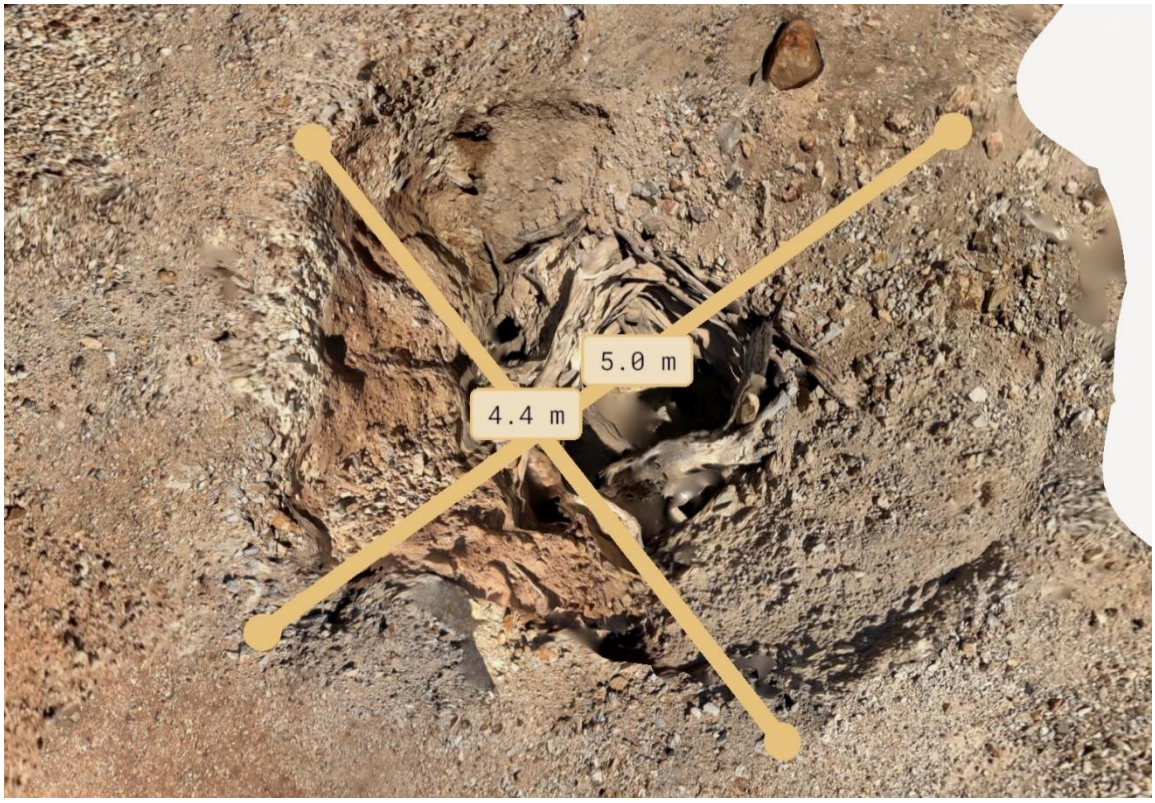
PHOTOGRAPHS

Figure 3

Figure 4

WML Consulting Engineers	Feature S0145165	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

3D SCANNING – LIDAR DATA



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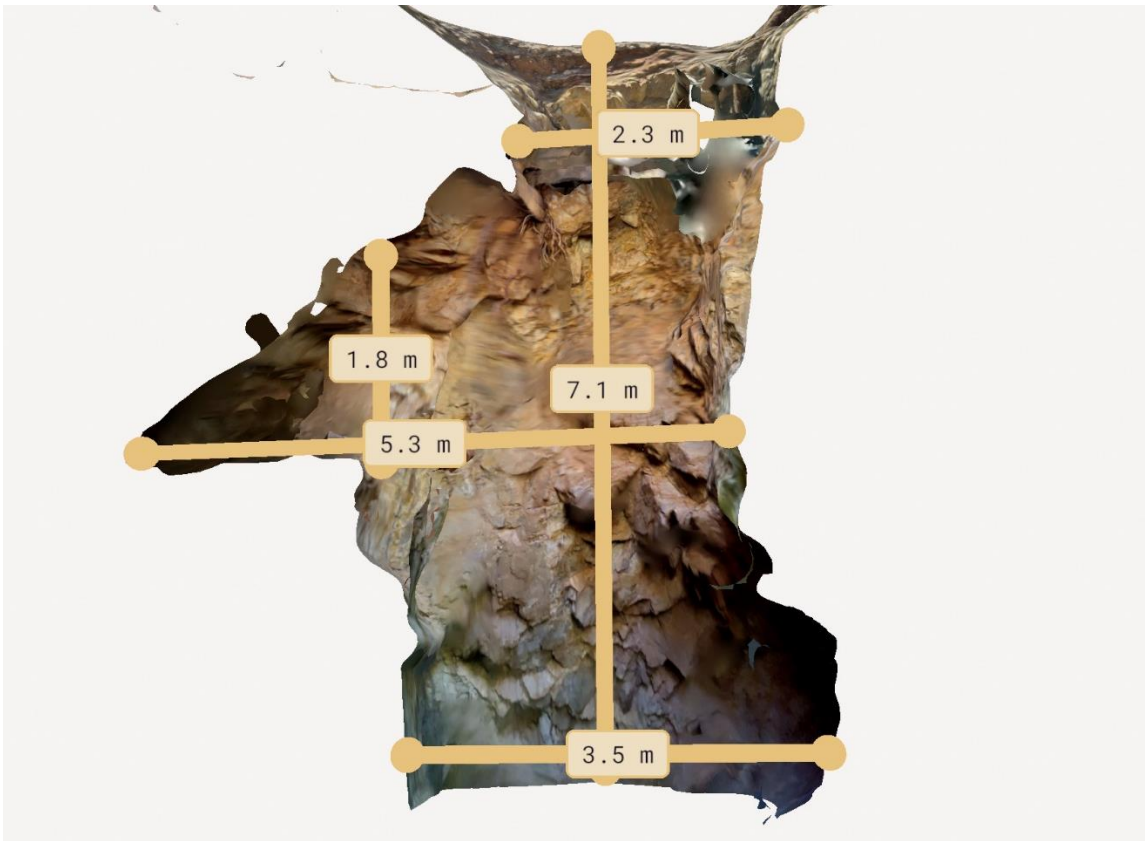

Figure 2

WML Consulting Engineers	Feature S0145165	Project No:	11126
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3D SCANNING – LIDAR DATA

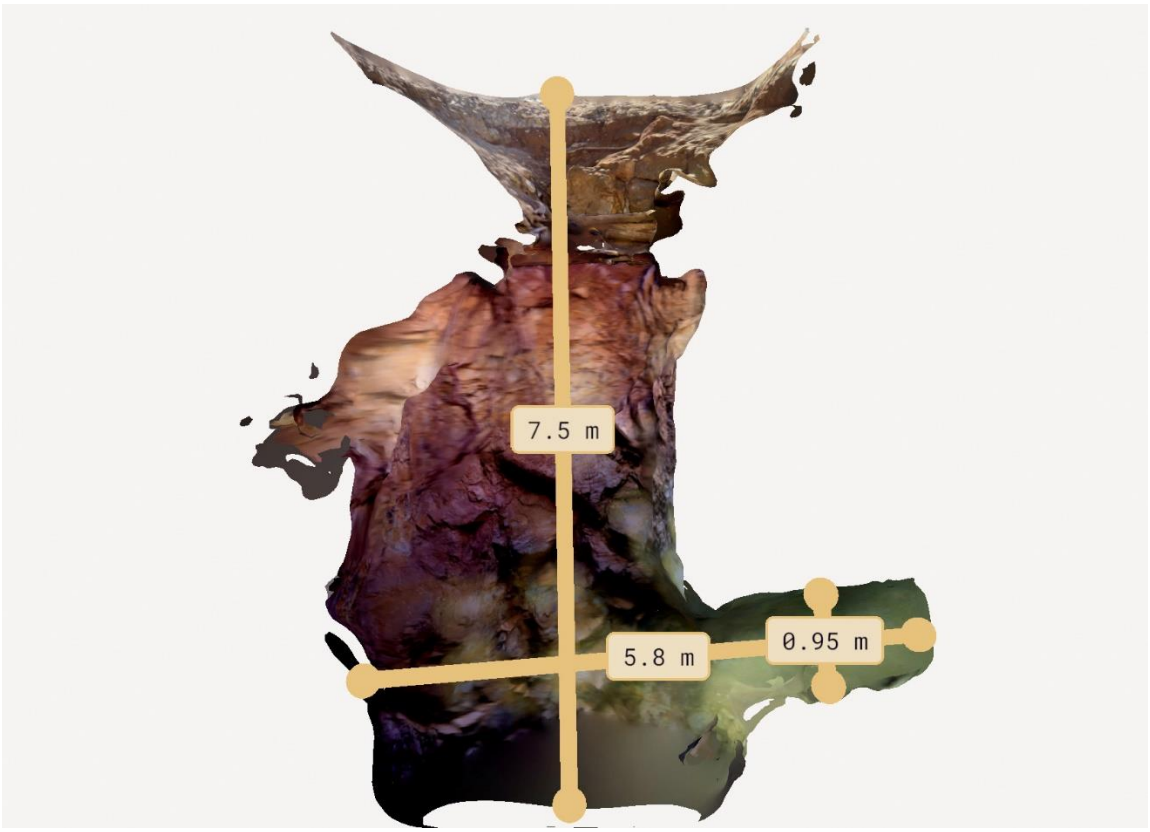


Figure 3

WML Consulting Engineers	Feature S0145165	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

PHOTOGRAPHS

Figure 1

Figure 2

WML Consulting Engineers	Feature Wn1	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

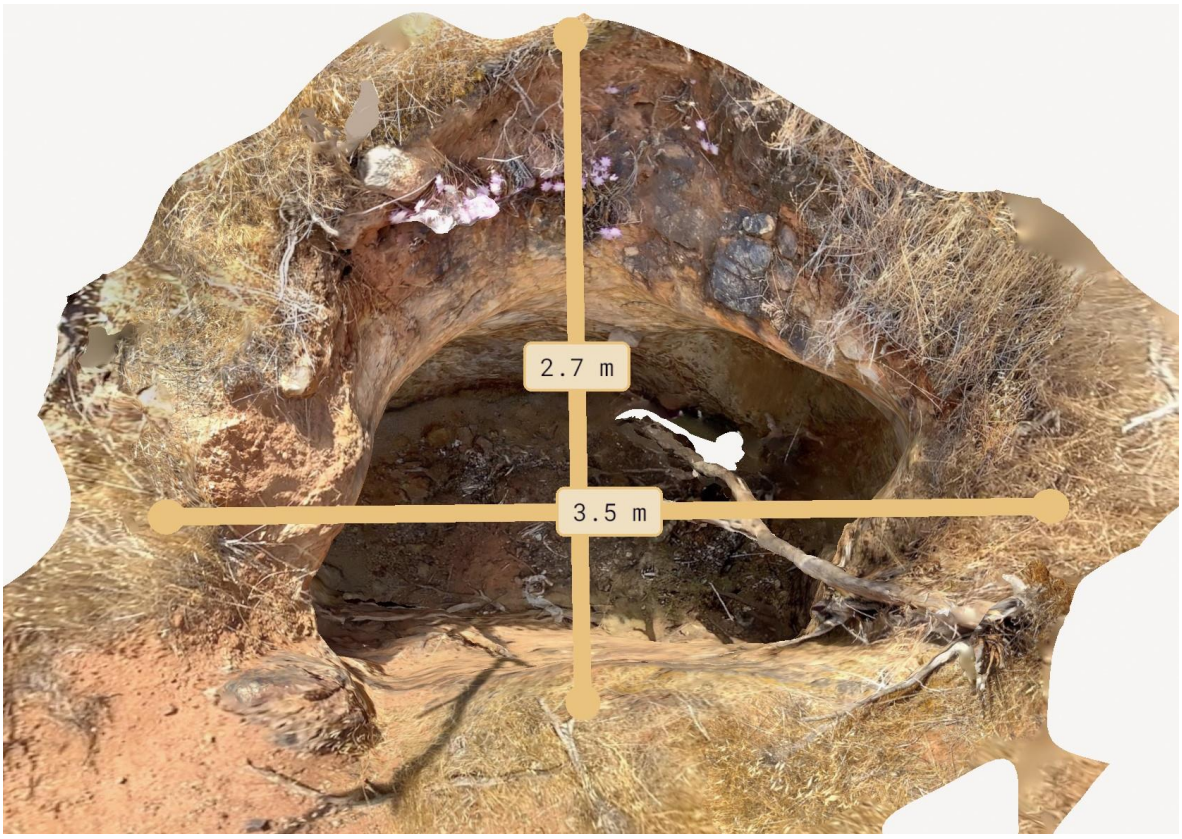
PHOTOGRAPHS

Figure 3

Figure 4

WML Consulting Engineers	Feature Wn1	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

3D SCANNING – LIDAR DATA



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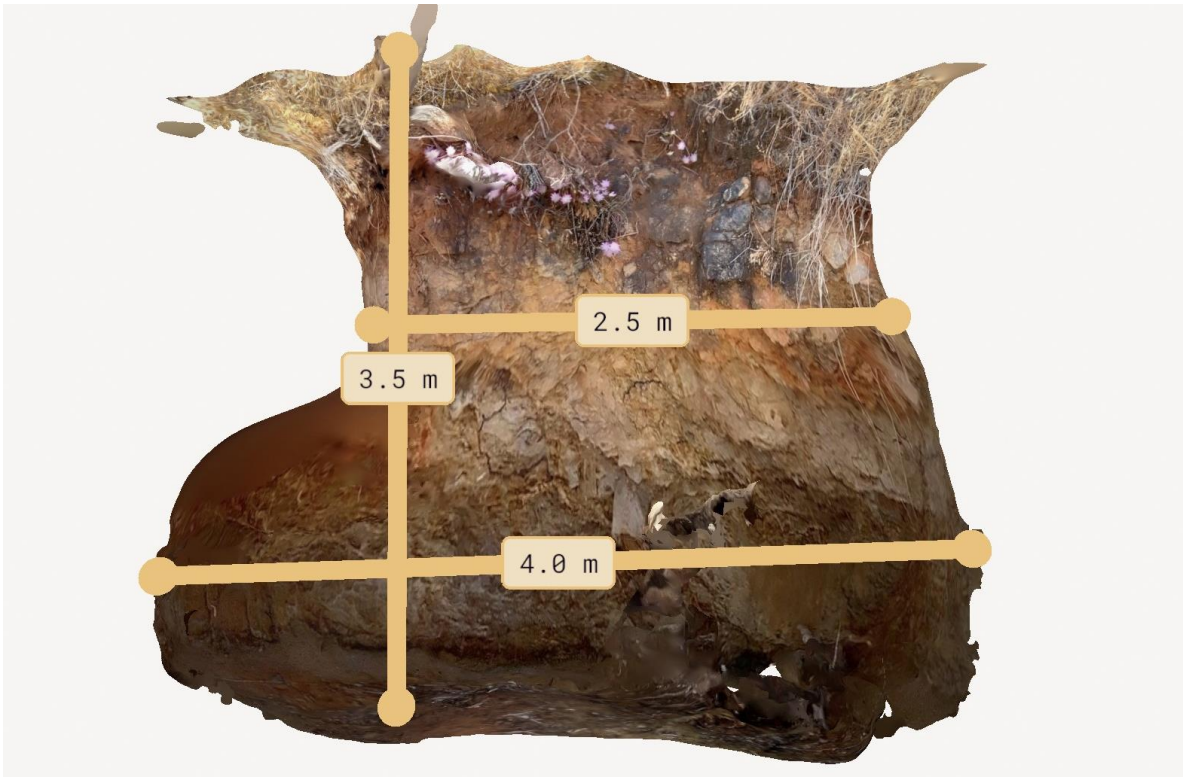
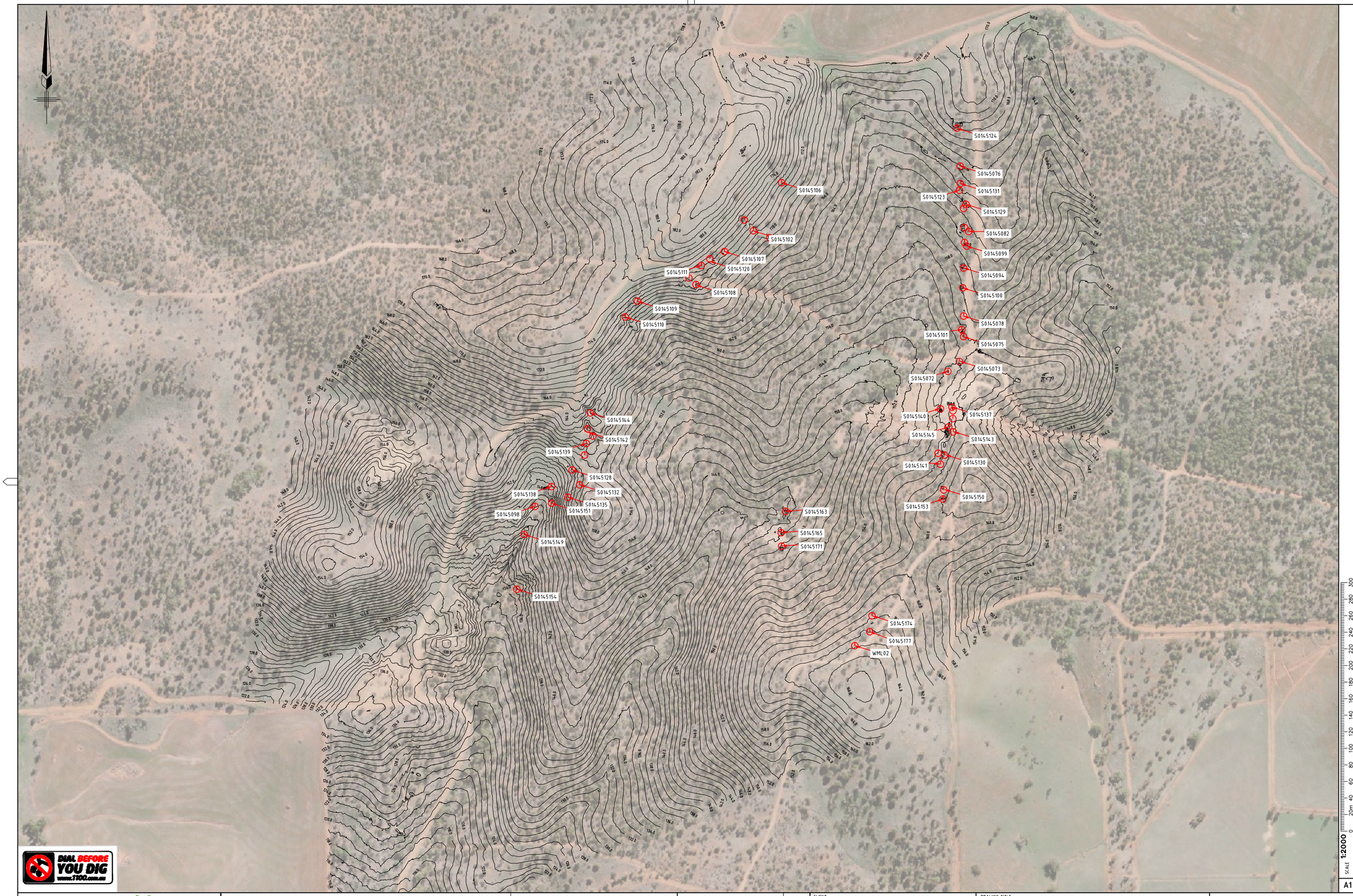


Figure 2

WML Consulting Engineers	Feature Wn1	Project No:	11126
	Client: Department of Mines, Industry, Regulation and Safety (DMIRS)	Date:	10/10/2023

APPENDIX B

SURVEY



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WML Consulting Engineers
Civil | Geotechnical | Structural

BUNBURY +61 8 9722 3544
KALGOORLIE +61 8 9021 1811
PERTH +61 8 9722 3566
wml.com.au

REVISIONS

N°	DESCRIPTION	APPROVED	DATE	DRAWN
A	ISSUED FOR INFORMATION	G.TOMASINI	18\12\23	JIC

Department of Energy, Mines, Industry Regulation and Safety
GOVERNMENT OF WESTERN AUSTRALIA

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PROJECT
NORTHAMPTON COMMONAGE AND WANERENOOKA VOIDS

DRAWING TITLE
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WML Consulting Engineers
Civil | Geotechnical | Structural
BUNBURY +61 8 9722 3344
KALGOORLIE +61 8 9021 1811
PERTH +61 8 9722 3566
wml.com.au

REVISIONS				
N°.	DESCRIPTION	APPROVED	DATE	DRAWN
A	ISSUED FOR INFORMATION	G.TOMASINI	18\12\23	JIC

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APPENDIX C

GEOPHYSICAL REPORT

GB Geotechnics (Australia) Pty Ltd
Web: gbg-group.com.au
E-Mail: info@gbgoz.com.au
ABN 77 009 550 869

Report

Geophysical Investigation for Abandoned Mine Features.

Commonage and Wannerenooka WA.

Date: 10 November 2023
Report Ref: 3091

DOCUMENT HISTORY

DETAILS

Project number	3091
Document Title	Geophysical Investigation for Abandoned Mine Features
Site Address	Commonage and Wannerenooka, Western Australia
Report prepared for	WML Consulting Engineers

STATUS AND REVIEW

Revision	Prepared by	Reviewed by	Date issued
0	Andrew Spyrou	Stephen Kelly	10 November 2023

DISTRIBUTION

Revision	Electronic	Paper	Issued to
0	1	0	Simon Maris, Ivana Golijanin

COMPANY DETAILS

Business name	GB Geotechnics (Australia) Pty Ltd
ABN	77 009 550 869
Business address	1/11 Gympie Way, Willetton WA 6155
Phone	0438 398 800
Web	gbg-group.com.au
Email	info@gbgoz.com.au

CONTENTS

WML Consulting Engineers
Civil | Geotechnical | Structural

BUNBURY
+61 8 9722 3344
KALGOORLIE
+61 8 9021 1811
PERTH
+61 8 9722 3566
wml.com.au

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Department of Energy, Mines, Industry Regulation and Safety
GOVERNMENT OF WESTERN AUSTRALIA

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CLIENT
DEPT OF MINES, INDUSTRY REGULATION AND SAFETY

PROJECT
NORTHAMPTON COMMONAGE AND WANERENOOKA VOIDS

DRAWING TITLE
SITE PLAN

THIS DRAWING SHALL BE TREATED AS PRELIMINARY AND IS NOT TO BE USED FOR CONSTRUCTION PURPOSES UNLESS SIGNED AS APPROVED.

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SCALE 1:500 (0 5m 10 15 20 25 30 35 40 45 50 55 60 65 70 75)

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1 INTRODUCTION

At the request of WML Consulting Engineers, GBG Group carried out a geophysical investigation as part of the Geotechnical Engineering Services for Abandoned Mine Features at Commonage and Wannerenooka, Shire of Northampton Western Australia.

During the investigation Electrical Resistivity Tomography (ERT) and Ground Penetrating Radar (GPR) data was acquired as a series of transects extending around the perimeter of recorded abandoned surface mine features. The acquired ERT data was processed to obtain subsurface electrical resistivity models to a target depth of greater than 20m Below Ground Level (BGL), whilst the GPR data was processed to obtain shallow subsurface reflection imagery to a maximum depth of 4m BGL. The processed data was subsequently analysed for the detection and mapping of potential underground mine workings emanating from the identified surface mine features and to inform targeted intrusive testing of these features by WML.

The results of the geophysical investigation forms part of a broader scope geotechnical study by WML and commissioned by the Department of Mines, Industry Regulation and Safety for the Abandoned Mines Program. The aim of the study is to support the assessment and rehabilitation of the Commonage and Wannerenooka sites to mitigate the public safety risk posed by the abandoned mine features.

2 INVESTIGATION SITE

The geophysical investigation was carried out at the Commonage and Wannerenooka sites within the Shire of Northampton Western Australia. An overview map of the sites with the locations of recorded abandoned surface mine features is shown in Figure 1.

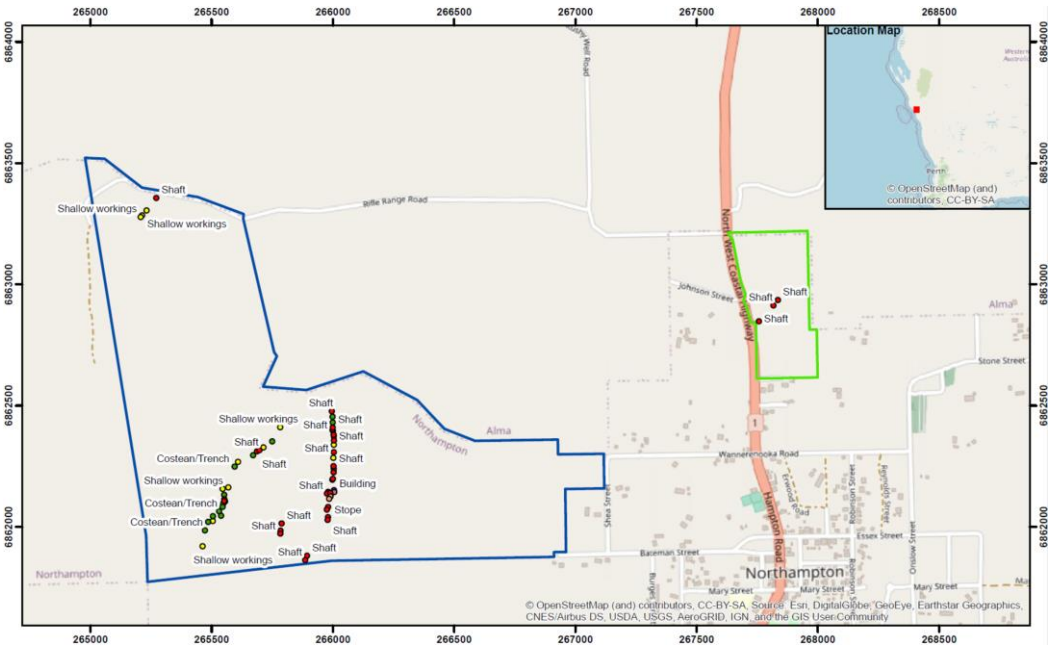


Figure 1: Site map of Commonage (blue polygon) and Wannerenooka (green polygon) showing abandoned surface mine features (datum GDA2020). Drawing from DMIRS, 7 December 2022.

Surface conditions at the sites were suitable for geophysical data acquisition and included sparse to moderate vegetation with low trees and open areas with remnant mining infrastructure. Photographs showing the typical site conditions are presented in Figure 2 for Commonage and Figure 3 for Wannerenooka.

Figure 2: Typical ground surface conditions at Commonage.

Figure 3: Typical ground surface conditions at Wannerenooka.

3 GEOPHYSICAL DATA ACQUISITION

3.1 SITE WORK LOGISTICS

The geophysical investigation site work was carried out over 8 days from the 13 to 20 October 2023 by a two-person team from GBG Group including a qualified geophysicist and field assistant.

ERT data was acquired as 21 transects totalling 4095m at Commonage and 5 transects totalling 795m at Wannerenooka as outlined in Tables 1 and 2. GPR data was acquired as multiple transects within targeted and accessible areas at the east, west and northern parts of Commonage and at Wannerenooka. Maps showing the extent of the ERT transects and GPR test areas at both sites are provided in Appendix A 3091-01 and 3091-02.

Table 1: Acquired ERT Transects at Commonage (coordinates in GDA2020, Zone 50)

Transect ID	Length (m)	Start		End	
		Easting	Northing	Easting	Northing
COM-1	159	265866.49	6861829.83	265939.28	6861967.87
COM-2	321	265949.13	6861995.98	266020.37	6862307.90
COM-3	321	265963.40	6861996.54	266035.61	6862306.00
COM-4	321	266013.64	6862209.10	265995.95	6862522.47
COM-5	213	265865.27	6862111.86	266070.05	6862161.77
COM-6	213	265864.24	6862122.81	266070.79	6862178.12
COM-7	159	265780.70	6861910.01	265774.45	6862067.94
COM-8	159	265790.41	6861910.49	265783.31	6862067.39
COM-9	159	265714.70	6861974.25	265873.39	6861975.77
COM-10	159	265706.11	6861986.30	265864.51	6861988.95
COM-11	159	265710.46	6861999.67	265867.63	6862003.81
COM-12	159	265546.26	6862038.34	265546.18	6862192.88
COM-13	159	265553.52	6862030.95	265553.31	6862187.42
COM-14	159	265474.85	6862130.12	265625.31	6862080.31
COM-15	159	265479.78	6862138.14	265626.83	6862085.00
COM-16	159	265478.50	6862149.87	265624.85	6862094.20
COM-17	213	265415.34	6861913.56	265530.89	6862087.87
COM-18	213	265590.39	6862237.98	265765.07	6862356.67
COM-19	213	265577.37	6862249.06	265754.95	6862366.81
COM-20	159	265748.93	6862258.02	265648.86	6862378.28
COM-21	159	265182.35	6863253.77	265281.30	6863377.80

Table 2: Acquired ERT Transects at Wannerenooka (coordinates in GDA2020, Zone 50)

Transect ID	Length (m)	Start		End	
		Easting	Northing	Easting	Northing
WAN-1	159	267756.78	6862824.41	267848.57	6862947.47
WAN-2	159	267748.21	6862830.64	267836.25	6862958.59
WAN-3	159	267728.95	6862861.71	267876.13	6862812.43
WAN-4	159	267731.15	6862892.66	267872.87	6862838.56
WAN-5	159	267723.81	6862911.14	267871.89	6862867.84

3.2 ELECTRICAL RESISTIVITY TOMOGRAPHY

ERT data was acquired using a Syscal Pro 72 (IRIS Instruments) resistivity receiver. ERT acquisition parameters are provided in Table 3. Photographs of ERT data acquisition are shown in Figure 4.

Data acquisition involved hammering up to 72 electrodes into the ground along the transects at 3m increments for a total maximum array length of 213m and connecting these to the control unit situated at the centre of the array via multicore cables. To improve electrical contact, saline water was poured onto the ground about the electrodes where required. A contact test was then run where the electrical resistance between pairs of electrodes was measured.

Following a successful contact test, a pre-programmed automated control sequence was run that controlled which pair of electrodes along the array was used for current injection with the resulting potential difference measured across multiple electrode pairs. Resistivity measurements were made using Dipole-Dipole array type providing both high vertical resolution and sensitivity to lateral variations. On completion of the control sequence the electrode array was moved with a 108m roll-along where electrodes 1 to 36 were removed and redeployed past electrodes 37 to 72 and a new set of readings taken. This process was repeated until the end of the transect was reached.

Table 3: ERT Acquisition Parameters

Acquisition Parameter	Value
Max no. electrodes	72
Electrode spacing	3 m
Max array length	213 m
Array type	Dipole-Dipole
Injection on/off time	500 ms
Injection voltage	200 mV
Number of stacks	4
Quality factor	2%
Roll-along (number of electrodes / distance)	36 / 108 m
Quadripoles (full spread / roll-along)	2350 / 1765

Figure 4: ERT data acquisition.

3.3 GROUND PENETRATING RADAR

GPR data was acquired using a DF (GSSI Instruments) system with dual frequency 300MHz and 800MHz ground coupled antennas. Acquisition parameters are provided in Table 4. A photograph of GPR data acquisition is shown in Figure 5. Data acquisition was carried out by moving the cart-based system along transects over accessible portions of the ground surface.

Table 4: GPR Acquisition Parameters

Acquisition Parameter	Value
Antenna centre frequency	300MHz / 800MHz
Two-way travel time	80ns / 40ns
Uncalibrated imaging depth	3m / 5m
Scans per metre	50
Sample number	1024
Sample rate	32 bits
Radar wave velocity	0.12m/ns

Figure 5: GPR data acquisition.

3.4 SPATIAL POSITIONING

Spatial positioning of the acquired geophysical transects was achieved using a S631 (Hemisphere) GNSS receiver with Atlas L band satellite corrections and with an expected accuracy of +/-0.25m for both vertical and horizontal components. Note a reduction in accuracy is expected in areas where dense tree cover was present.

While acquiring the data, the spatial position (easting, northing and surface level) for each electrode location and GPR start and end point was surveyed. Coordinates have been provided in GDA2020, MGA zone 50 for horizontal component and Australian Height Datum (mAHD) for vertical component.

4 GEOPHYSICAL DATA PROCESSING

4.1 ELECTRICAL RESISTIVITY TOMOGRAPHY

The ERT data was processed using Prosys II (Iris Instruments) and EarthImager 2D (v2.4.4, AGI Software) with the following processing routine:

1. Import acquired resistivity data files including topographic data.
2. Plot apparent resistivity pseudo-sections and filter to remove spurious values outside the designated resistivity range and quality factor.
3. Initial inversion of the pseudo-sections using smoothness-constrained least-squares technique with multiple iterations performed.
4. View the resulting misfit histogram and rerun the inversion procedure with outliers removed for the generation of a final electrical resistivity model.

The inverted resistivity models were compiled and gridded in Surfer (v25, Golden Software) to produce 2D geo-electrical sections. The resulting contoured cross-sections show the variation in the modelled electrical resistivity of the subsurface material in Ohm metres laterally along each of the transects and with elevation.

4.2 GROUND PENETRATING RADAR

The GPR data was processed using ReflexW V10.0 (Sandmeier Software, 2022) with the following processing routine.

1. **Surface correction** – set GPR zero time to the first crossing of the reflection wavelet.
2. **Manual gain curve** – apply a gain curve function in the y-direction (time-depth) to counter GPR signal attenuation with depth.
3. **1D frequency filter** – high-cut and low-cut frequency filter to improve signal to noise ratio.
4. **2D filter** – background removal and running average filters to suppress horizontally coherent energy, effectively emphasising signals which vary laterally.

The processed GPR data was analysed for hyperbolic reflection anomalies related to shallow subsurface features such as potential open mine workings and previously excavated material. Examples of processed radar-grams from this investigation are shown in Figures 6 and 7.

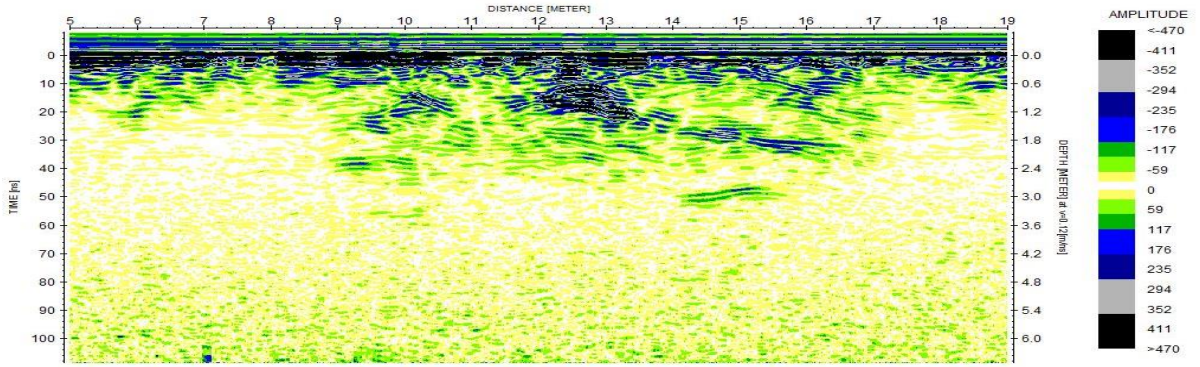


Figure 5: GPR radar-gram showing an anomaly at x=12.5m, y = 0.6m relating to a potential underground mine working.

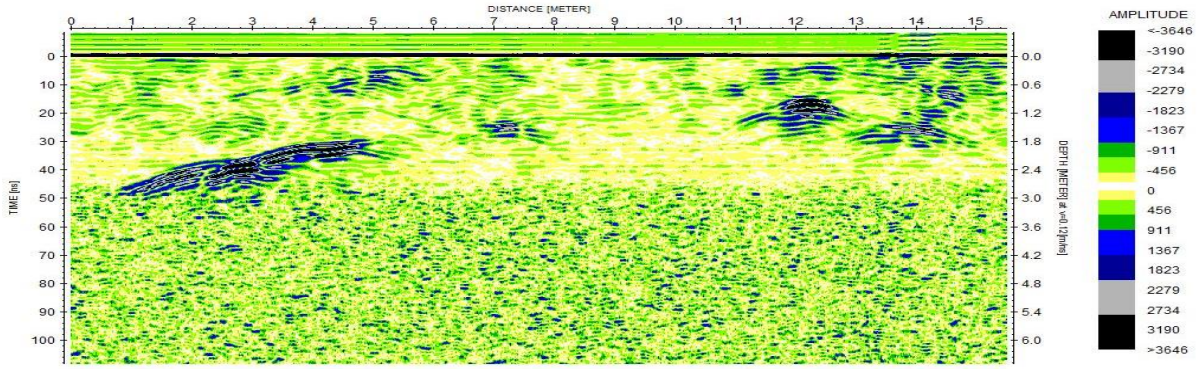


Figure 6: GPR radar-gram showing an anomaly at x=3m, y=2.4m relating to a potential underground mine working.

5 RESULTS AND INTERPRETATION

5.1 PRESENTATION OF RESULTS

The results of the geophysical investigation carried out at Commonage and Wannerenooka are presented in Appendices B and C of this report as follows:

Appendix B – Electrical Resistivity Sections

- **3091-03.** Commonage Transect COM-01.
- **3091-04.** Commonage Transect COM-02 & COM-03
- **3091-05.** Commonage Transect COM-04.
- **3091-06.** Commonage Transect COM-05 & COM-06
- **3091-07.** Commonage Transect COM-07 & COM-08.
- **3091-08.** Commonage Transect COM-09, COM-10 & COM-11.

- **3091-09.** Commonage Transect COM-12 & COM-13.
- **3091-10.** Commonage Transect COM-14, COM-15 & COM-16.
- **3091-11.** Commonage Transect COM-17.
- **3091-12.** Commonage Transect COM-18, COM-19 & COM-20.
- **3091-13.** Commonage Transect COM-21.
- **3091-14.** Wannerenooka Transect WAN-01 & WAN-02.
- **3091-15.** Wannerenooka Transect WAN-03, WAN-04 & WAN-05.

Appendix C – Ground Penetrating Radar Maps

- **3091-16.** Commonage East GPR interpretation map
- **3091-17.** Commonage South GPR interpretation map
- **3091-18.** Commonage West GPR interpretation map
- **3091-19.** Wannerenooka GPR interpretation map

5.2 MODELLED ELECTRICAL RESISTIVITY SECTIONS

The sections for each ERT transect show the variation in modelled electrical resistivity of the subsurface material in Ohm metres (Ω.m). Dominant factors affecting the bulk electric resistivity of soil or rock are:

- Porosity and permeability including the presence of voids and cavities
- Degree of saturation – the fraction of pore space/fractures filled with fluid
- Fluid type, including salt content – the composition of the fluid filling the pore spaces/fractures
- Presence of clays with moderate to high cation exchange capacity (CEC)

For this investigation high resistivity responses typically greater than 1500 Ω.m have been interpreted as potential subsurface mine workings. These have been marked on the sections as Targets for intrusive testing and the locations of which are provided in Tables 5 and 6. The following limitations should be noted for interpretation of the electrical resistivity sections:

- It is assumed that the subsurface material modelled during this investigation sits above the local water table, and as such where present mine workings will have little to no water content. The presence of groundwater within voided or loose ground will alter the interpretation.
- For several transects, zones of high electrical resistivity especially where of significant extent may represent a fresh rock layer which exhibit similar electrical resistivity with open cavities.
- Due to vertical and lateral resolution of the ERT method which is primarily a function of the electrode spacing used during data acquisition, the Targets of interest displayed on the modelled sections may not be representative of their actual physical lateral and vertical dimensions.
- The approximate depths to the Targets of interest are based on the centre of the resistivity anomaly, the actual depth to the top of the physical features is likely to be shallower than this due to the lateral resolution of the ERT method.

- A priority rating has been given for each Target including (1) high priority, typically shallow potential mine workings within the remnant mining area, (2) moderate priority, typically deeper workings with limited extent, and (3) low priority, typically for the deepest workings.

Table 5: Identified Targets from Commonage Modelled Resistivity Sections

Transect	ID	Approx depth (mBGL)	Easting (GDA2020)	Northing (GDA2020)	Priority
COM-01	1	3.2	265892.1	6861888.1	1
	2	3.2	265897.2	6861898.9	1
	3	7.9	265898.5	6861901.7	1
COM-02	4	13.1	265952.4	6862016.2	2
	5	9.4	265965.2	6862056.5	1
	6	18.5	265973.3	6862084.9	2
	7	18.0	265999.6	6862218.7	2
	8	8.7	266001.9	6862234.2	1
	9	14.8	266012.6	6862276.2	2
COM-03	10	8.3	265971.3	6862026.5	1
	11	18.4	265980.1	6862071.7	2
	12	9.0	265991.5	6862110.6	1
	13	18.4	265999.1	6862150.1	2
	14	8.8	266003.4	6862175.7	1
	15	5.4	266005.5	6862190.8	1
	16	10.0	266009.9	6862203.0	1
	17	21.7	266015.8	6862226.1	2
	18	9.0	266025.4	6862266.5	1
	19	15.2	266028.2	6862281.0	2
COM-04	20	6.0	266010.3	6862248.1	2
	21	6.5	266006.0	6862320.2	1
	22	6.0	266007.8	6862335.1	1
	23	6.6	266010.3	6862352.8	1
	24	10.2	266007.7	6862361.2	1
	25	5.8	266004.0	6862423.2	2
	26	12.5	266003.1	6862464.2	1
	27	8.7	266004.6	6862499.5	1
COM-05	28	8.9	265895.4	6862114.3	1
	29	13.3	265931.0	6862121.9	2
	30	11.5	265940.8	6862124.7	2
	31	7.2	265966.7	6862131.2	1
	32	27.8	265991.3	6862136.2	3
	33	6.9	266009.3	6862144.2	1
	34	6.5	266020.9	6862147.6	1
	35	2.5	266035.8	6862151.7	1
	36	8.9	266046.7	6862155.3	1
COM-06	37	16.7	265884.7	6862128.2	3
	38	8.0	265897.6	6862132.4	2
	39	8.2	265927.5	6862142.0	2
	40	11.7	265942.3	6862146.6	2
	41	9.3	265964.4	6862152.9	2
	42	11.9	265989.4	6862158.8	1
	43	13.1	266012.9	6862163.4	2
	44	6.3	266040.8	6862168.6	2

Table 5 (Continued): Identified Targets from Commonage Modelled Resistivity Sections

Transect	ID	Approx depth (mBGL)	Easting (GDA2020)	Northing (GDA2020)	Priority
COM-07	45	5.1	265782.7	6861933.5	1
	46	12.7	265779.3	6861966.6	1
	47	6.6	265776.5	6862017.2	1
	48	3.1	265774.5	6862053.1	1
COM-08	49	4.8	265789.9	6861924.0	1
	50	11.7	265790.9	6861951.2	1
	51	10.4	265791.3	6861976.5	3
	52	10.6	265784.0	6862022.3	2
	53	6.5	265782.2	6862045.5	1
COM-09	54	6.2	265726.7	6861975.2	3
	55	9.6	265753.7	6861975.1	3
	56	7.8	265785.4	6861975.2	2
	57	8.2	265799.4	6861976.4	3
	58	6.7	265829.4	6861976.2	3
	59	7.4	265841.7	6861975.8	3
COM-10	60	5.1	265733.4	6861987.3	1
	61	1.8	265747.4	6861985.5	1
	62	9.0	265752.7	6861986.9	2
	63	8.0	265762.6	6861987.2	1
	64	10.0	265786.7	6861984.8	2
	65	4.1	265805.2	6861986.3	1
	66	6.4	265822.5	6861987.5	3
COM-11	67	5.7	265728.8	6862002.0	2
	68	7.5	265744.6	6862004.4	2
	69	10.6	265752.9	6862006.1	2
	70	5.5	265786.6	6862003.1	1
	71	9.3	265804.4	6862003.5	2
	72	4.4	265828.5	6862002.7	3
	73	5.0	265844.2	6862004.9	3
COM-12	74	7.4	265543.7	6862099.5	2
COM-13	No Targets Identified				
COM-14	No Targets Identified				
COM-15	75	14.7	265556.7	6862108.1	1
COM-16	76	7.3	265506.2	6862139.0	3
COM-17	No Targets Identified				
COM-18	77	8.9	265735.0	6862334.6	2
COM-19	78	15.4	265614.3	6862271.9	3
	79	22.8	265665.8	6862304.4	3
	80	6.6	265733.1	6862347.8	1
COM-20	81	1.3	265652.8	6862373.0	1
	82	8.5	265671.4	6862350.2	1
COM-21	83	7.9	265236.8	6863321.3	1
	84	4.7	265245.6	6863333.5	1
	85	4.8	265256.8	6863348.0	3
	86	8.1	265270.3	6863363.7	3

Table 6: Identified Targets from Wannerenooka Modelled Resistivity Sections

Transect	ID	Approx depth (mBGL)	Easting (GDA2020)	Northing (GDA2020)	Priority
WAN-01	No Targets Identified				
WAN-02	87	3.2	267814.0	6862922.3	1
	88	6.9	267821.7	6862936.7	1
WAN-03	89	7.5	267799.2	6862840.0	3
	90	7.7	267811.9	6862835.6	3
	91	6.6	267827.3	6862828.0	1
	92	4.7	267849.6	6862818.6	1
WAN-04	93	5.2	267741.2	6862889.2	1
	94	19.4	267780.6	6862873.4	3
	95	6.1	267802.6	6862859.0	1
WAN-05	96	5.7	267740.4	6862907.5	2
	97	8.3	267757.4	6862903.4	1
	98	13.0	267775.8	6862892.8	1
	99	8.7	267817.5	6862882.2	1
	100	2.9	267842.4	6862876.5	1
	101	6.2	267856.4	6862875.1	2

5.3 GROUND PENETRATING RADAR

Analysis of the processed GPR dataset has identified a number of subsurface anomalies potentially related to shallow mine workings within the areas investigated. The lateral extent of the identified features are shown in the provided maps with 3 anomaly types being interpreted as follows:

Type 1 GPR anomaly (shown as yellow lines) – these linear features have been tracked along multiple GPR transects and may represent shallow mine workings typically less than 2m BGL.

Type 2 GPR anomaly (shown as orange hatched areas) – these features are interpreted to represent areas of previously worked ground which have been back filled and with a high potential to contain multiple small voids and loose material.

Type 3 GPR anomaly (shown as brown hatched areas) – these features are interpreted to represent areas of previously worked ground which have been back filled and with a low potential to contain multiple small voids and loose material.

6 PROJECT SUMMARY

A geophysical subsurface investigation has been carried out as part the Geotechnical Engineering Services for Abandoned Mine Features at Commonage and Wannerenooka, Northampton Western Australia. During the investigation, ERT and GPR datasets were acquired as a series of transects extending around the perimeter of recorded abandoned surface mine features.

The acquired ERT dataset was inverted to model the electrical resistivity distribution of the subsurface material along the transects to a target depth of greater than 20mBGL. The modelled electrical resistivity

sections were subsequently analysed and interpreted for the presence of potential voids or cavities relating to underground mine workings. A number of targets have been provided which are recommended for further testing using intrusive methods to verify their condition and to calibrate the geophysical dataset.

The acquired GPR dataset was processed and analysed for features relating to shallow mine workings with a number of features being identified and relating to near surface previously worked ground.

The methods used during the investigation are geophysical and as such the results are based on indirect measurements and the processing and interpretation of electrical wave signals. At the time of the investigation, calibration of the geophysical results with intrusive geotechnical testing has not been carried out. The findings in this report represent the professional opinions of the authors, based on experience gained during previous similar investigations.

We trust that this report and the attached drawings provide you with the information required. If you require clarification on any points arising from this geophysical investigation, please do not hesitate to contact the undersigned on 08 9354 6300.

For and on behalf of
GBG GEOTECHNICS (AUSTRALIA)

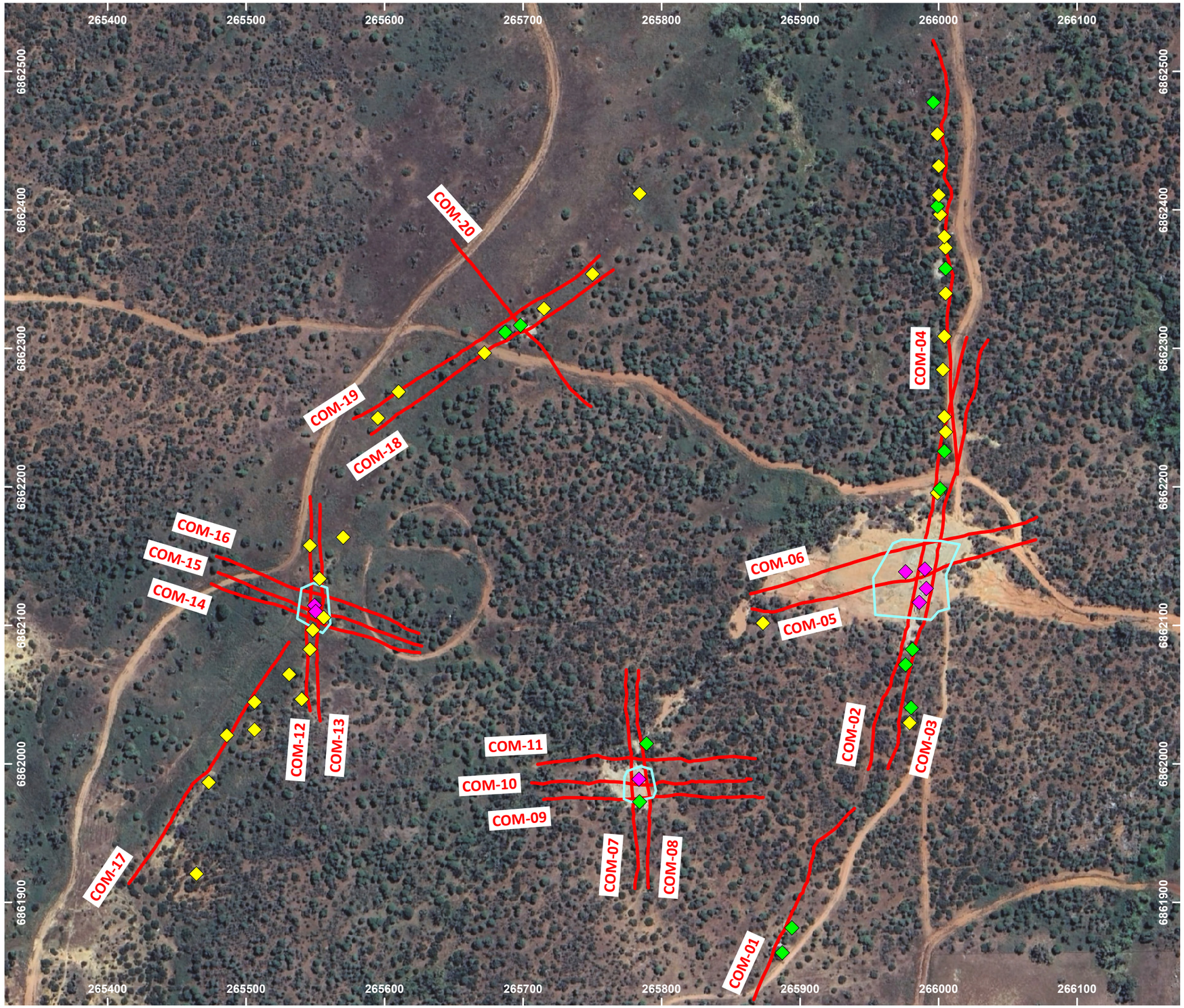
ANDREW SPYROU
Operations Manager, Western Australia / Senior Geophysicist

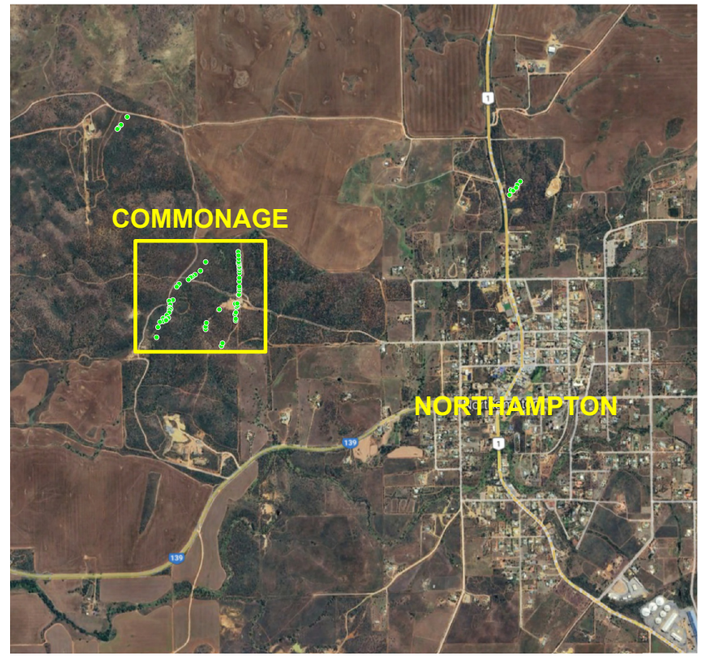
APPENDIX A – INVESTIGATION SITE MAPS

GBGGROUP

GEOPHYSICAL INVESTIGATION FOR ABANDONED MINE FEATURES, SHIRE OF NORTHAMPTON WESTERN AUSTRALIA.

COMMONAGE INVESTIGATION SITE MAP





Legend

- Acquired ERT transect
- COM-1 ERT transect ID
- GPR investigation area

Abandoned surface mine feature (WML)

- Deeper shafts
- Potential for deeper shafts
- Shallow workings

NOTES

Drawing to be used in conjunction with Report 3091.
Map Projection GDA2020 MGA Zone 50.
Aerial image from Google Earth Pro.

0 25 50 75 100
Distance (metres)

N

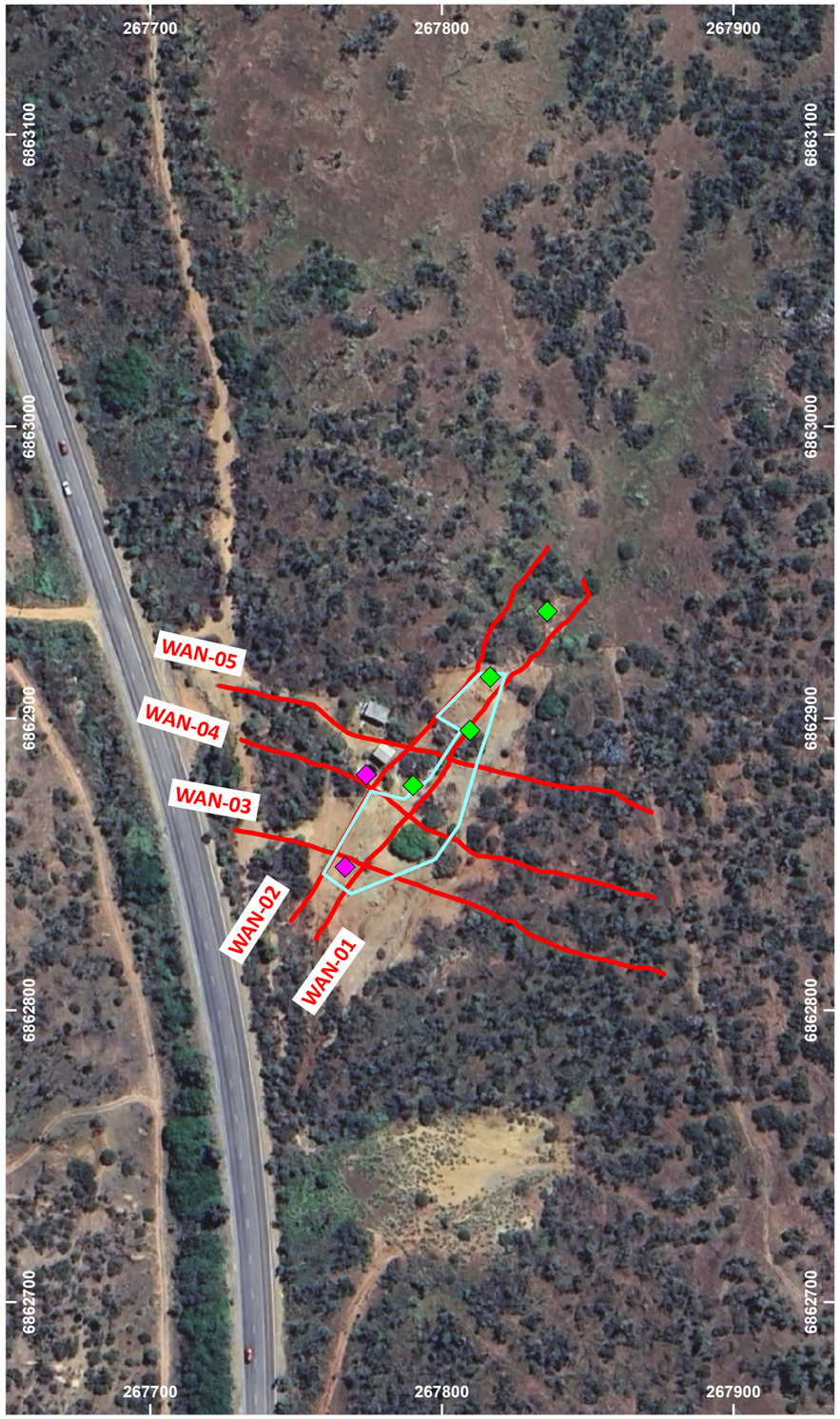
CLIENT	WML CONSULTING ENGINEERS	Date	26 September 2023	Paper Size	A3
	GEOPHYSICAL INVESTIGATION FOR ABANDONED MINE FEATURES COMMONAGE AND WANNERENOOKA WA	Scale	1:3000	Drawn	AHWS
		Drawing	3091-01	Revision	0

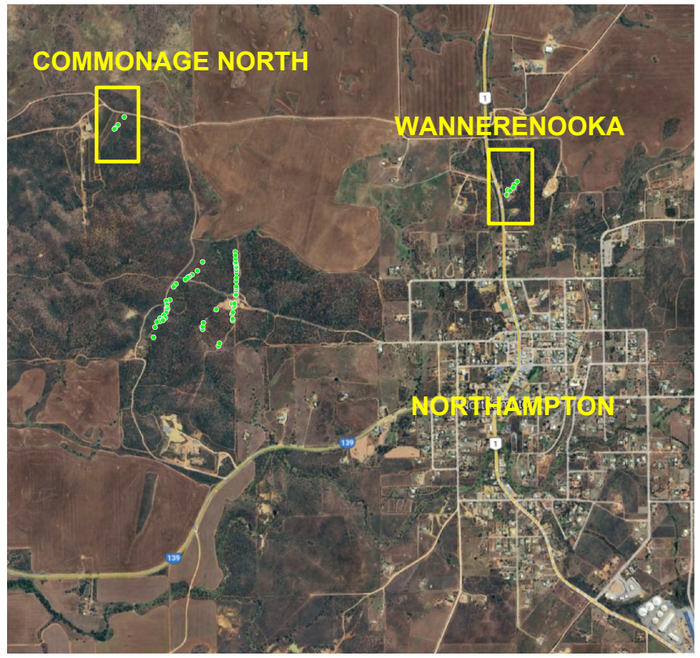
GBGGROUP
G B Geotechnics (Australia) Pty Ltd
1/11 Gympie Way Willetton WA 6155
ABN: 77 009 550 869
Telephone: 02 9890 2122
Email: info@gbgoz.com.au

GBGGROUP

GEOPHYSICAL INVESTIGATION FOR ABANDONED MINE FEATURES, SHIRE OF NORTHAMPTON WESTERN AUSTRALIA.

COMMONAGE NORTH AND WANNERENOOKA INVESTIGATION SITE MAP





Legend

- Acquired ERT transect
- COM-1 — ERT transect ID
- GPR investigation area

Abandoned surface mine feature (WML)

- Deeper shafts
- Potential for deeper shafts
- Shallow workings

NOTES

Drawing to be used in conjunction with Report 3091.
Map Projection GDA2020 MGA Zone 50.
Aerial image from Google Earth Pro.

0 25 50 75 100
Distance (metres)

N

CLIENT	WML CONSULTING ENGINEERS	Date	26 September 2023	Paper Size	A3
	GEOPHYSICAL INVESTIGATION FOR ABANDONED MINE FEATURES COMMONAGE AND WANNERENOOKA WA	Scale	1:2000	Drawn	AHWS
		Drawing	3091-02	Revision	0

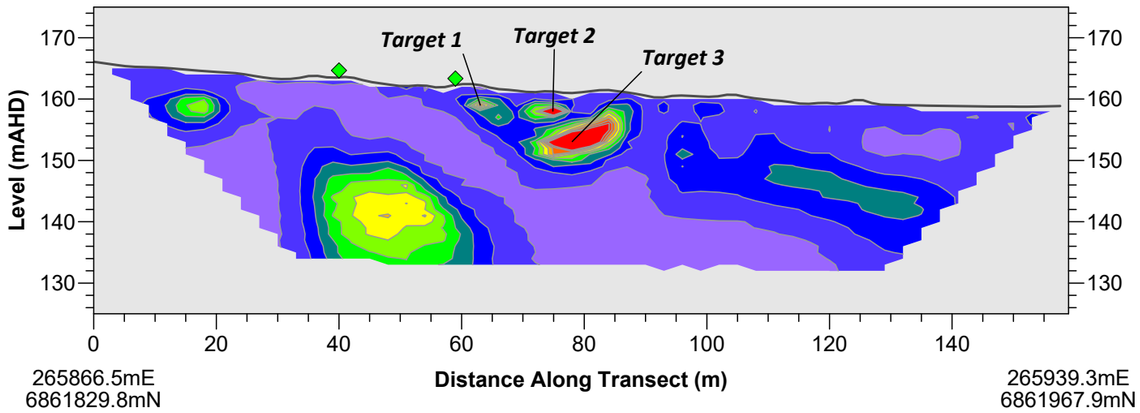
GBGGROUP
G B Geotechnics (Australia) Pty Ltd
1/11 Gympie Way Willetton WA 6155
ABN: 77 009 550 869
Telephone: 02 9890 2122
Email: info@gbgoz.com.au

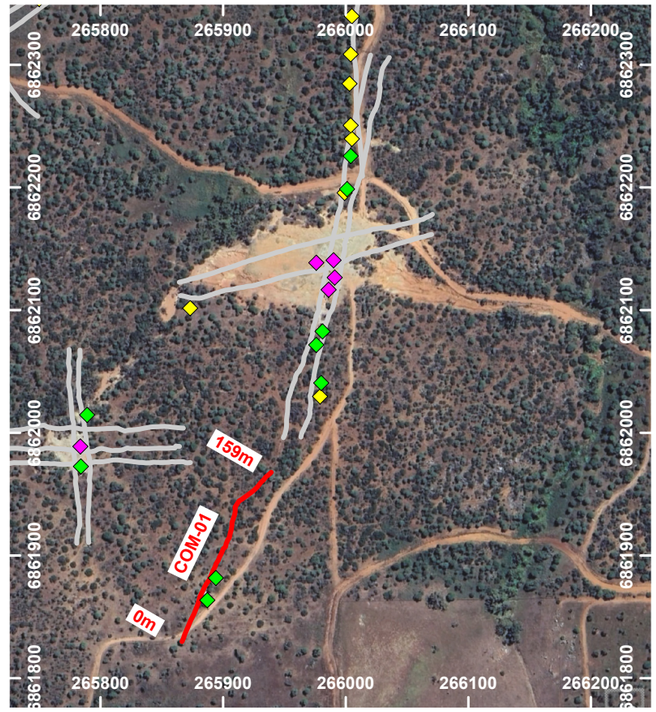
APPENDIX B –ELECTRICAL RESISTIVITY SECTIONS

GEOPHYSICAL INVESTIGATION FOR ABANDONED MINE FEATURES, SHIRE OF NORTHAMPTON WESTERN AUSTRALIA.

COMMONAGE ELECTRICAL RESISTIVITY SECTIONS

COM-01 - ELECTRICAL RESISTIVITY MODEL



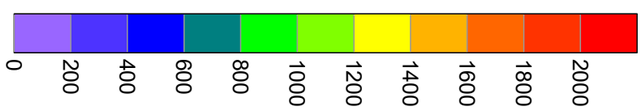


Legend

- Acquired ERT transect
- COM-1 — ERT transect ID
- Abandoned surface mine feature (WML, 2023)
- *Target 1* — Identified anomalous subsurface feature (refer to report for details)

Abandoned surface mine feature (WML)

- Deeper shafts
- Potential for deeper shafts
- Shallow workings



Electrical Resistivity (Ohm.metres)

NOTES

Drawing to be used in conjunction with Report 3091.
Map Projection GDA2020 MGA Zone 50.
Aerial image from Google Earth Pro.

CLIENT	WML CONSULTING ENGINEERS	Date	26 October 2023	Paper Size	A3
GEOPHYSICAL INVESTIGATION FOR ABANDONED MINE FEATURES COMMONAGE AND WANNERENOOKA WA		Scale	1:1000	Drawn	PJE
		Drawing	3091-03	Revision	0

GBGGROUP
G B Geotechnics (Australia) Pty Ltd
1/11 Gympie Way Willetton WA 6155
ABN: 77 009 550 869
Telephone: 02 9890 2122
Email: info@gbgoz.com.au

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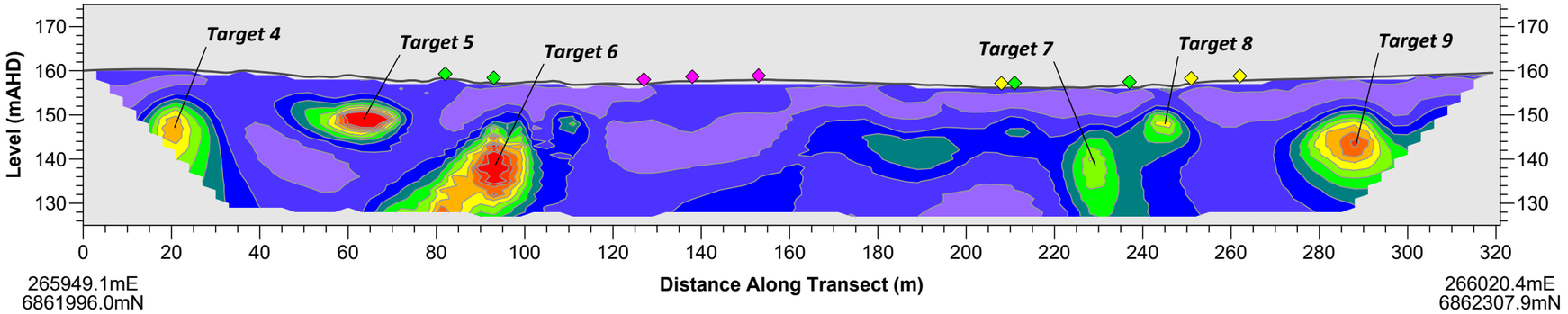
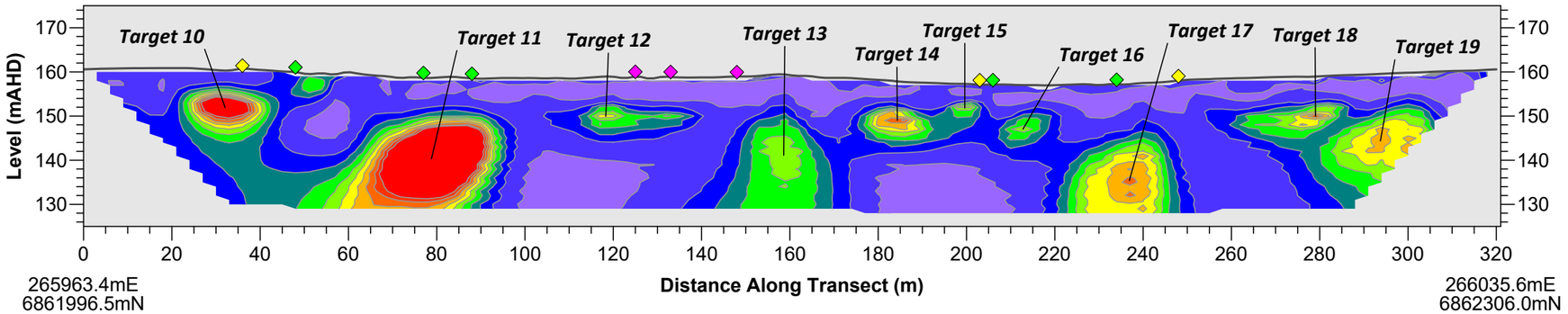
GEOPHYSICAL INVESTIGATION FOR ABANDONED MINE FEATURES, SHIRE OF NORTHAMPTON WESTERN AUSTRALIA.

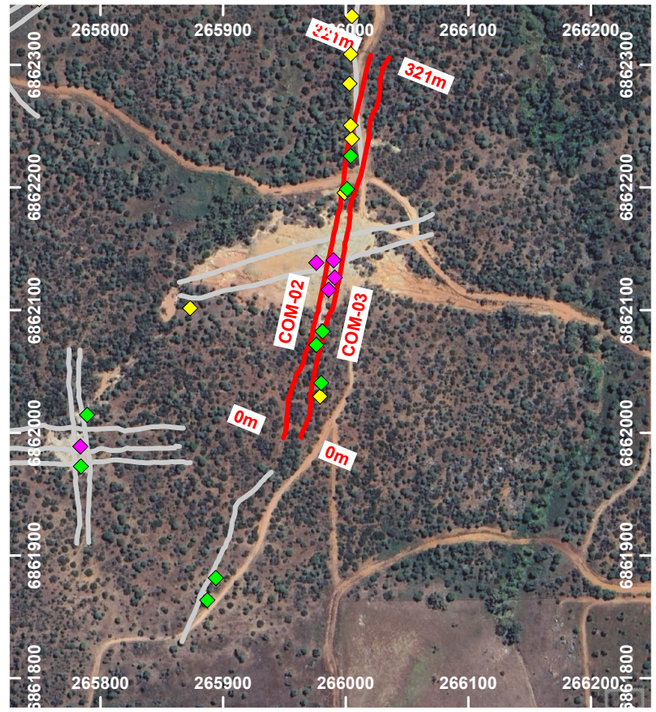
COMMONAGE ELECTRICAL RESISTIVITY SECTIONS

COM-02 - ELECTRICAL RESISTIVITY MODEL



COM-03 - ELECTRICAL RESISTIVITY MODEL





Legend

- Acquired ERT transect
- COM-1 — ERT transect ID
- Abandoned surface mine feature (WML, 2023)
- *Target 1* — Identified anomalous subsurface feature (refer to report for details)

Abandoned surface mine feature (WML)

- Deeper shafts
- Potential for deeper shafts
- Shallow workings

NOTES

Drawing to be used in conjunction with Report 3091.
Map Projection GDA2020 MGA Zone 50.
Aerial image from Google Earth Pro.

CLIENT	WML CONSULTING ENGINEERS	Date	26 October 2023	Paper Size	A3
GEOPHYSICAL INVESTIGATION FOR ABANDONED MINE FEATURES COMMONAGE AND WANNERENOOKA WA		Scale	1:1250	Drawn	PJE
		Drawing	3091-04	Revision	0

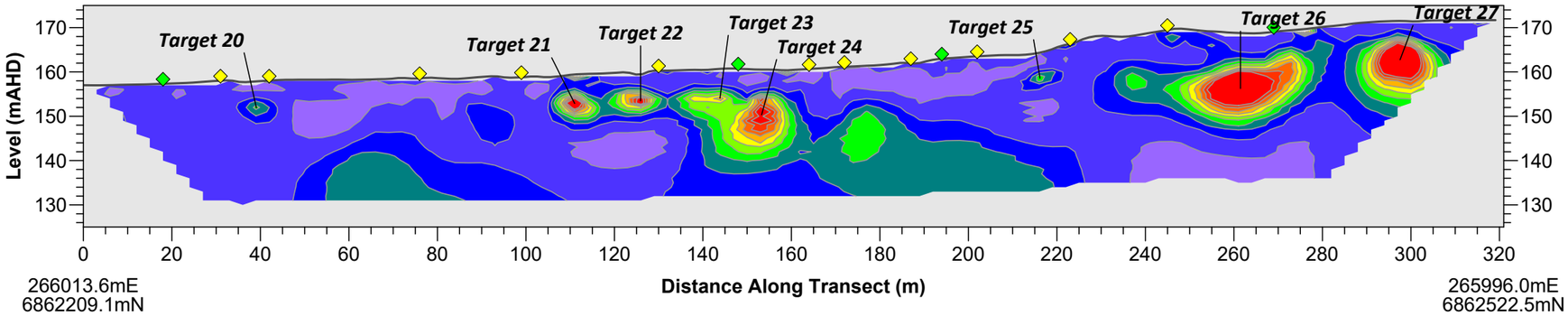
GBGGROUP
G B Geotechnics (Australia) Pty Ltd
1/11 Gympie Way Willetton WA 6155
ABN: 77 009 550 869
Telephone: 02 9890 2122
Email: info@gbgoz.com.au

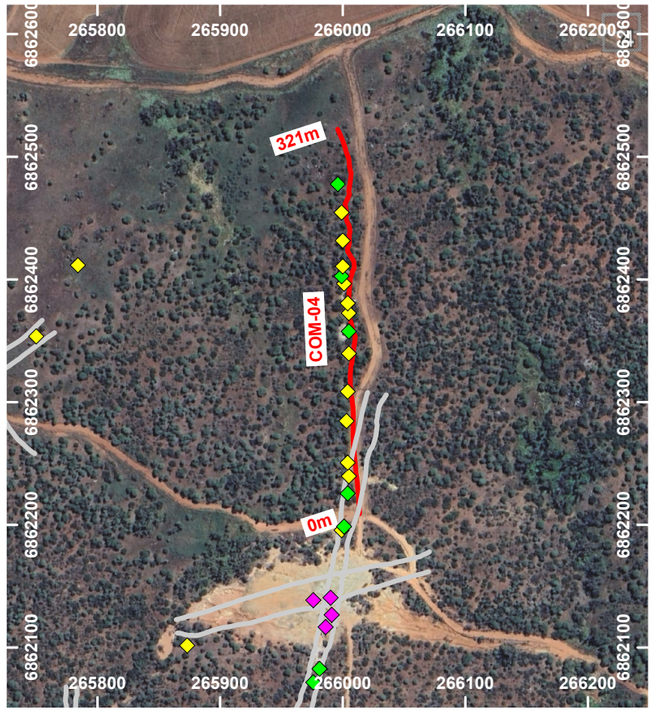
GBGGROUP

GEOPHYSICAL INVESTIGATION FOR ABANDONED MINE FEATURES, SHIRE OF NORTHAMPTON WESTERN AUSTRALIA.

COMMONAGE ELECTRICAL RESISTIVITY SECTIONS

COM-04 - ELECTRICAL RESISTIVITY MODEL



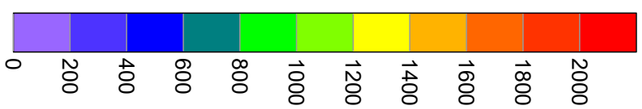


Legend

- Acquired ERT transect
- COM-1 — ERT transect ID
- Abandoned surface mine feature (WML, 2023)
- *Target 1* — Identified anomalous subsurface feature (refer to report for details)

Abandoned surface mine feature (WML)

- Deeper shafts
- Potential for deeper shafts
- Shallow workings



Electrical Resistivity (Ohm.metres)

NOTES

Drawing to be used in conjunction with Report 3091.
Map Projection GDA2020 MGA Zone 50.
Aerial image from Google Earth Pro.

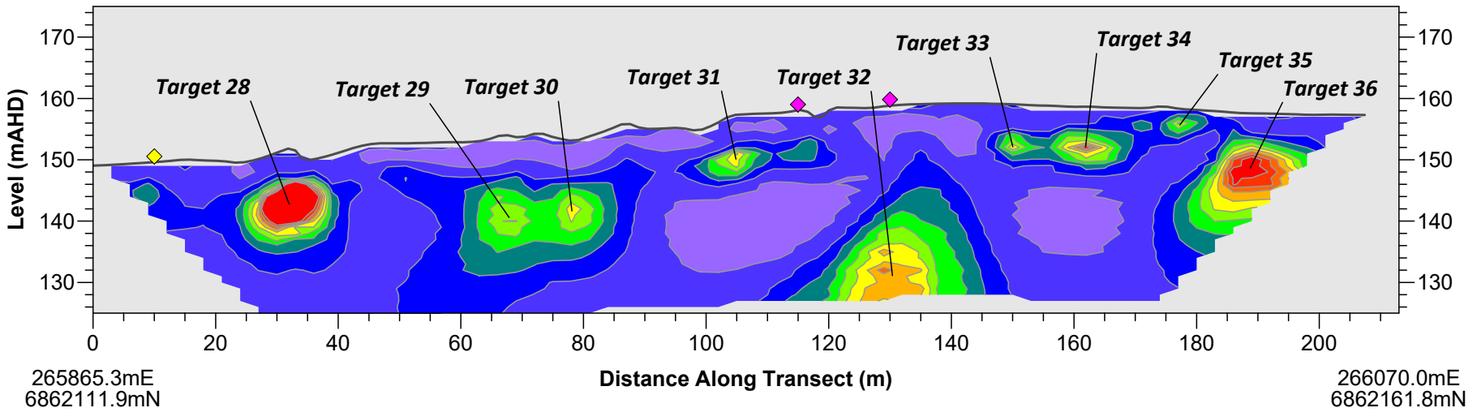
CLIENT	WML CONSULTING ENGINEERS	Date	26 October 2023	Paper Size	A3
	GEOPHYSICAL INVESTIGATION FOR ABANDONED MINE FEATURES COMMONAGE AND WANNERENOOKA WA	Scale	1:1250	Drawn	PJE
		Drawing	3091-05	Revision	0

GBGGROUP
G B Geotechnics (Australia) Pty Ltd
1/11 Gympie Way Willetton WA 6155
ABN: 77 009 550 869
Telephone: 02 9890 2122
Email: info@gbgoz.com.au

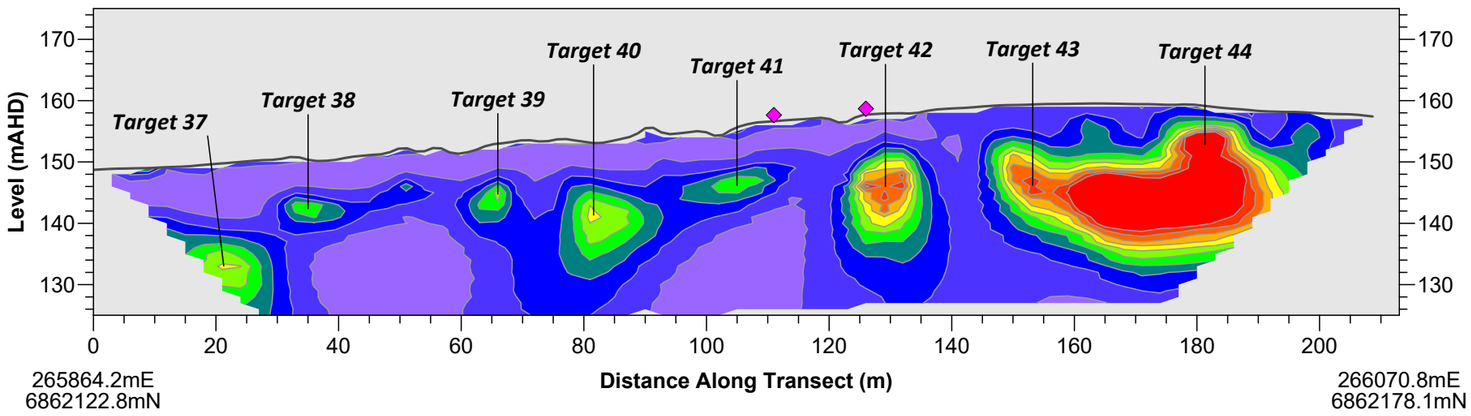
GEOPHYSICAL INVESTIGATION FOR ABANDONED MINE FEATURES, SHIRE OF NORTHAMPTON WESTERN AUSTRALIA.

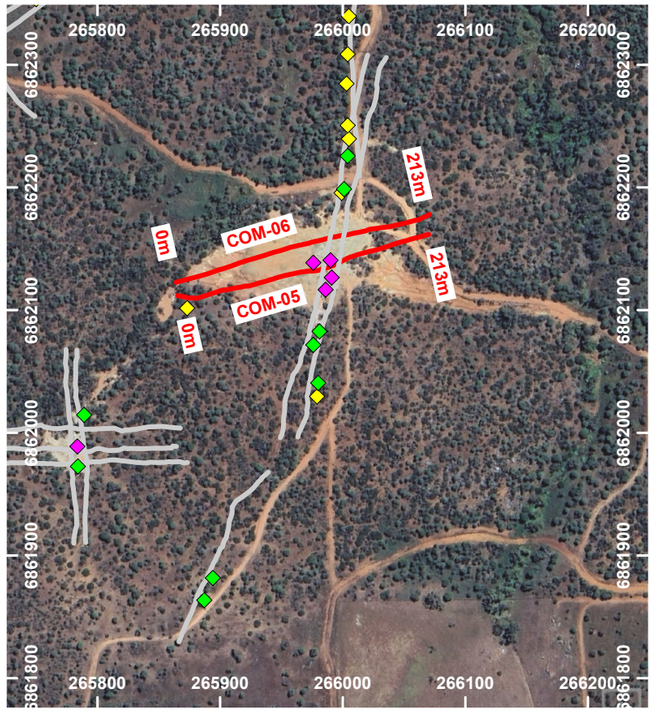
COMMONAGE ELECTRICAL RESISTIVITY SECTIONS

COM-05 - ELECTRICAL RESISTIVITY MODEL



COM-06 - ELECTRICAL RESISTIVITY MODEL



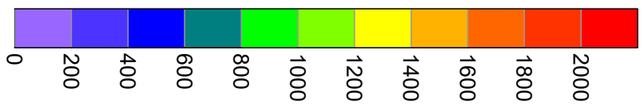


Legend

- Acquired ERT transect
- **COM-1** ERT transect ID
- Abandoned surface mine feature (WML, 2023)
- ***Target 1*** Identified anomalous subsurface feature (refer to report for details)

Abandoned surface mine feature (WML)

- Deeper shafts
- Potential for deeper shafts
- Shallow workings



NOTES

Drawing to be used in conjunction with Report 3091.
Map Projection GDA2020 MGA Zone 50.
Aerial image from Google Earth Pro.

CLIENT	WML CONSULTING ENGINEERS	Date	26 October 2023	Paper Size	A3
GEOPHYSICAL INVESTIGATION FOR ABANDONED MINE FEATURES COMMONAGE AND WANNERENOOKA WA		Scale	1:1000	Drawn	PJE
		Drawing	3091-06	Revision	0

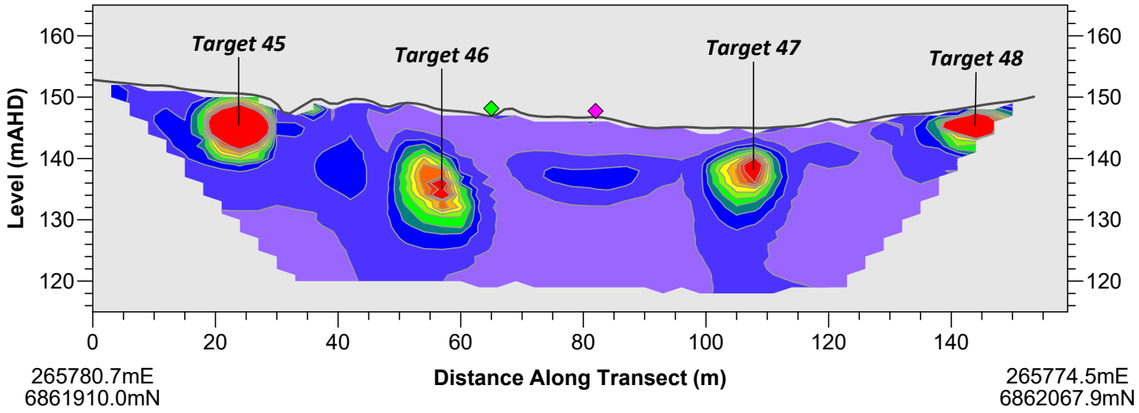
GBGGROUP
G B Geotechnics (Australia) Pty Ltd
1/11 Gympie Way Willetton WA 6155
ABN: 77 009 550 869
Telephone: 02 9890 2122
Email: info@gbgoz.com.au

GBGGROUP

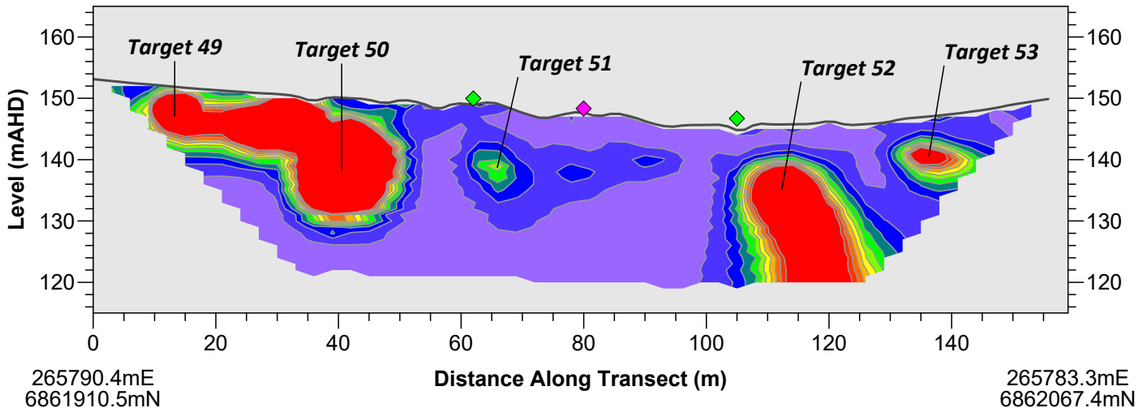
GEOPHYSICAL INVESTIGATION FOR ABANDONED MINE FEATURES, SHIRE OF NORTHAMPTON WESTERN AUSTRALIA.

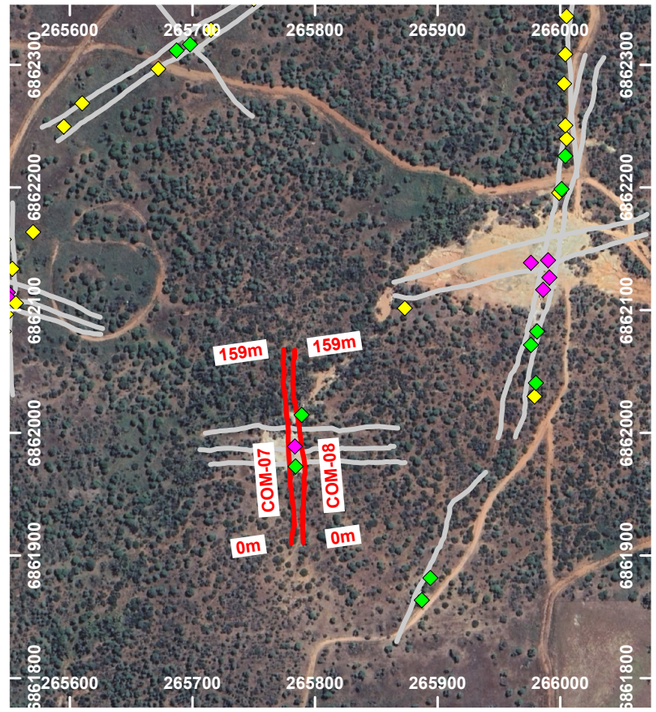
COMMONAGE ELECTRICAL RESISTIVITY SECTIONS

COM-07 - ELECTRICAL RESISTIVITY MODEL



COM-08 - ELECTRICAL RESISTIVITY MODEL





Legend

- Acquired ERT transect
- COM-1 — ERT transect ID
- Abandoned surface mine feature (WML, 2023)
- *Target 1* — Identified anomalous subsurface feature (refer to report for details)

Abandoned surface mine feature (WML)

- Deeper shafts
- Potential for deeper shafts
- Shallow workings

0 200 400 600 800 1000 1200 1400 1600 1800 2000

Electrical Resistivity (Ohm.metres)

NOTES

Drawing to be used in conjunction with Report 3091.
Map Projection GDA2020 MGA Zone 50.
Aerial image from Google Earth Pro.

CLIENT	WML CONSULTING ENGINEERS	Date	26 October 2023	Paper Size	A3
GEOPHYSICAL INVESTIGATION FOR ABANDONED MINE FEATURES COMMONAGE AND WANNERENOOKA WA		Scale	1:1000	Drawn	PJE
		Drawing	3091-07	Revision	0

GBGGROUP
G B Geotechnics (Australia) Pty Ltd
1/11 Gympie Way Willetton WA 6155
ABN: 77 009 550 869
Telephone: 02 9890 2122
Email: info@gbgoz.com.au

GBGGROUP

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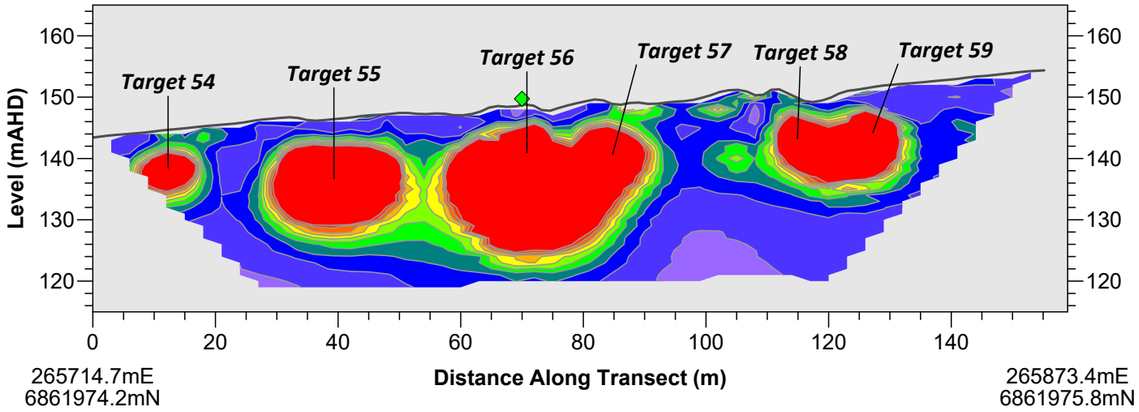
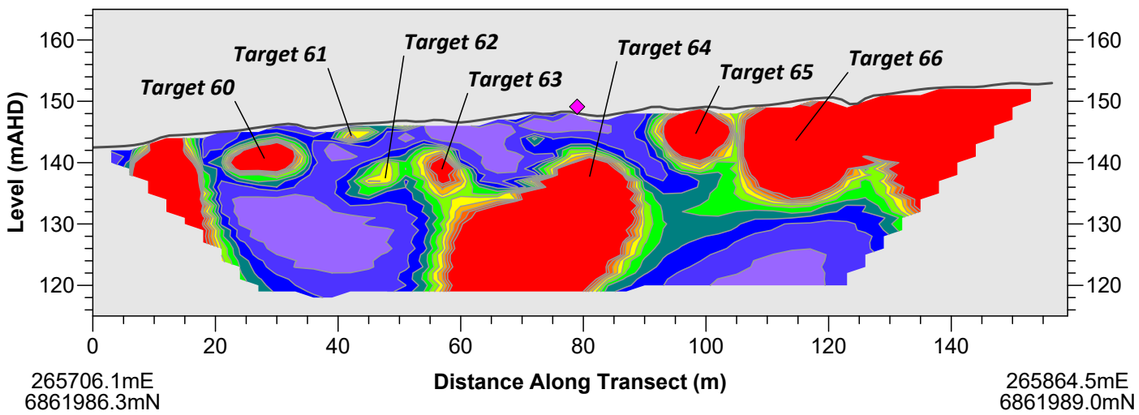
COMMONAGE ELECTRICAL RESISTIVITY SECTIONS

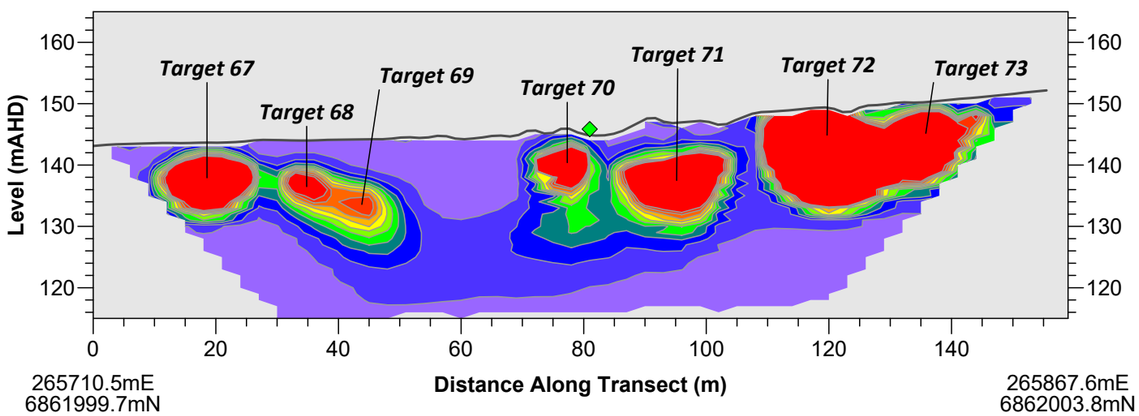
COM-09 - ELECTRICAL RESISTIVITY MODEL

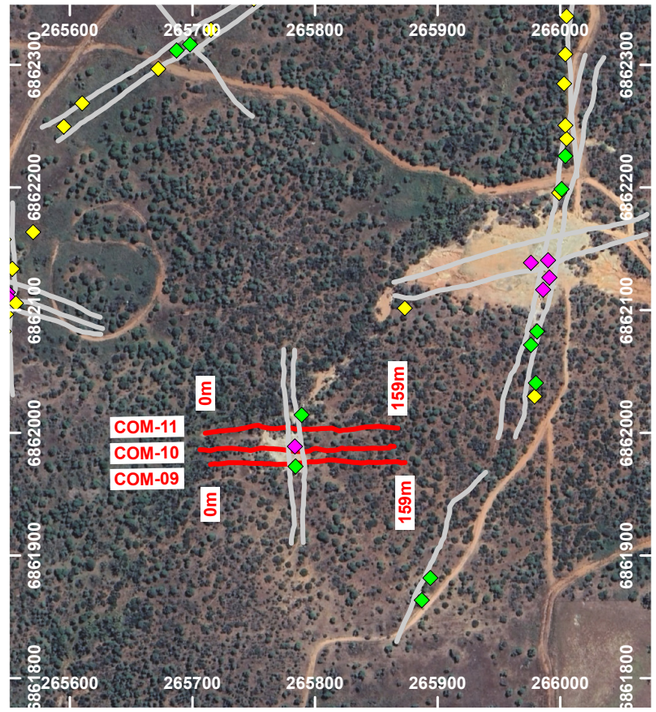


COM-10 - ELECTRICAL RESISTIVITY MODEL



COM-11 - ELECTRICAL RESISTIVITY MODEL





Legend

- Acquired ERT transect
- COM-1 — ERT transect ID
- Abandoned surface mine feature (WML, 2023)
- *Target 1* — Identified anomalous subsurface feature (refer to report for details)

Abandoned surface mine feature (WML)

- Deeper shafts
- Potential for deeper shafts
- Shallow workings

NOTES

Drawing to be used in conjunction with Report 3091.
Map Projection GDA2020 MGA Zone 50.
Aerial image from Google Earth Pro.

CLIENT	WML CONSULTING ENGINEERS	Date	26 October 2023	Paper Size	A3
GEOPHYSICAL INVESTIGATION FOR ABANDONED MINE FEATURES COMMONAGE AND WANNERENOOKA WA		Scale	1:1000	Drawn	PJE
		Drawing	3091-08	Revision	0

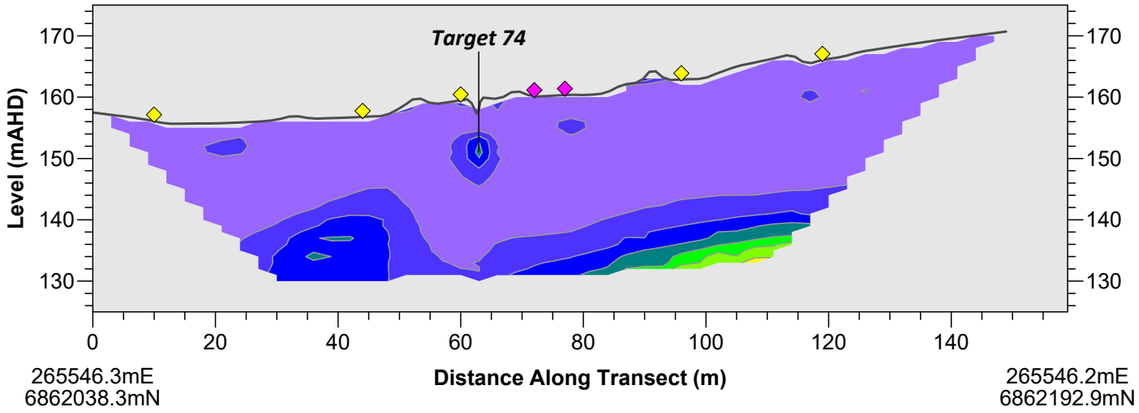
GBGGROUP
G B Geotechnics (Australia) Pty Ltd
1/11 Gympie Way Willetton WA 6155
ABN: 77 009 550 869
Telephone: 02 9890 2122
Email: info@gbgoz.com.au

GBGGROUP

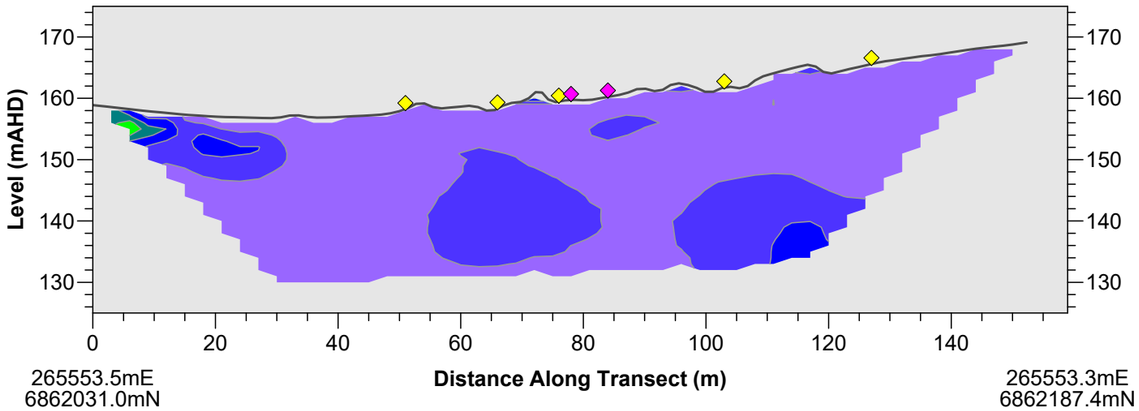
GEOPHYSICAL INVESTIGATION FOR ABANDONED MINE FEATURES, SHIRE OF NORTHAMPTON WESTERN AUSTRALIA.

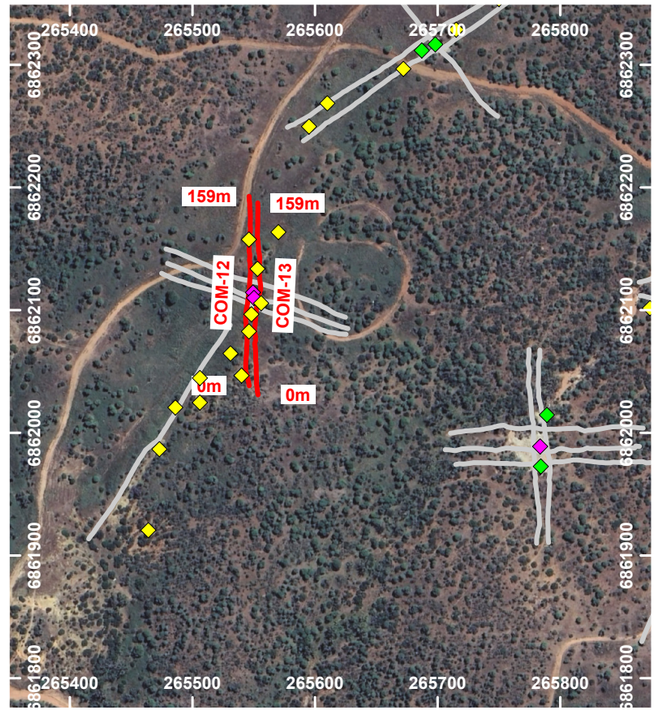
COMMONAGE ELECTRICAL RESISTIVITY SECTIONS

COM-12 - ELECTRICAL RESISTIVITY MODEL



COM-13 - ELECTRICAL RESISTIVITY MODEL



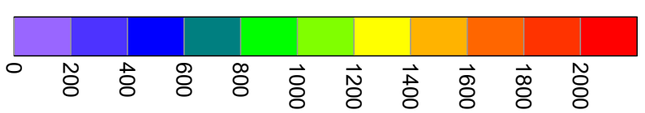


Legend

- Acquired ERT transect
- COM-1 — ERT transect ID
- Abandoned surface mine feature (WML, 2023)
- *Target 1* — Identified anomalous subsurface feature (refer to report for details)

Abandoned surface mine feature (WML)

- Deeper shafts
- Potential for deeper shafts
- Shallow workings



NOTES

Drawing to be used in conjunction with Report 3091.
Map Projection GDA2020 MGA Zone 50.
Aerial image from Google Earth Pro.

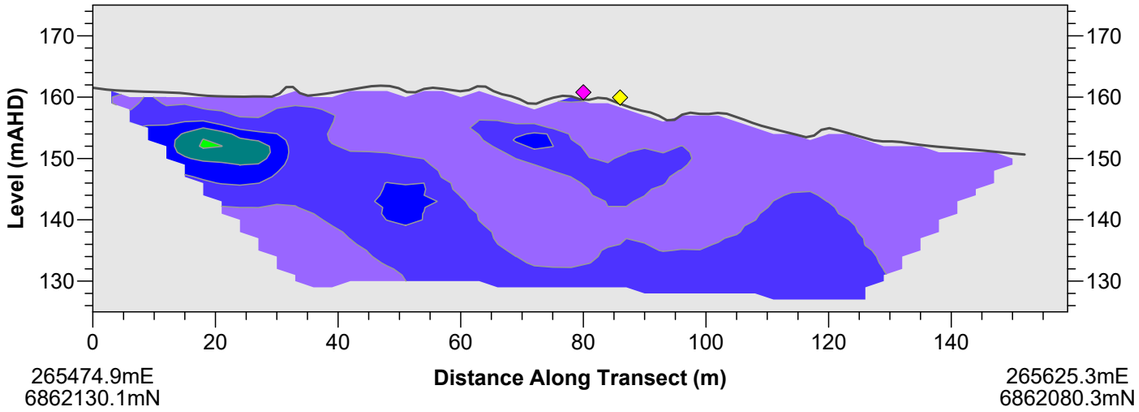
CLIENT	WML CONSULTING ENGINEERS	Date	26 October 2023	Paper Size	A3
GEOPHYSICAL INVESTIGATION FOR ABANDONED MINE FEATURES COMMONAGE AND WANNERENOOKA WA		Scale	1:1000	Drawn	PJE
		Drawing	3091-09	Revision	0

GBGGROUP
G B Geotechnics (Australia) Pty Ltd
1/11 Gympie Way Willetton WA 6155
ABN: 77 009 550 869
Telephone: 02 9890 2122
Email: info@gbgoz.com.au

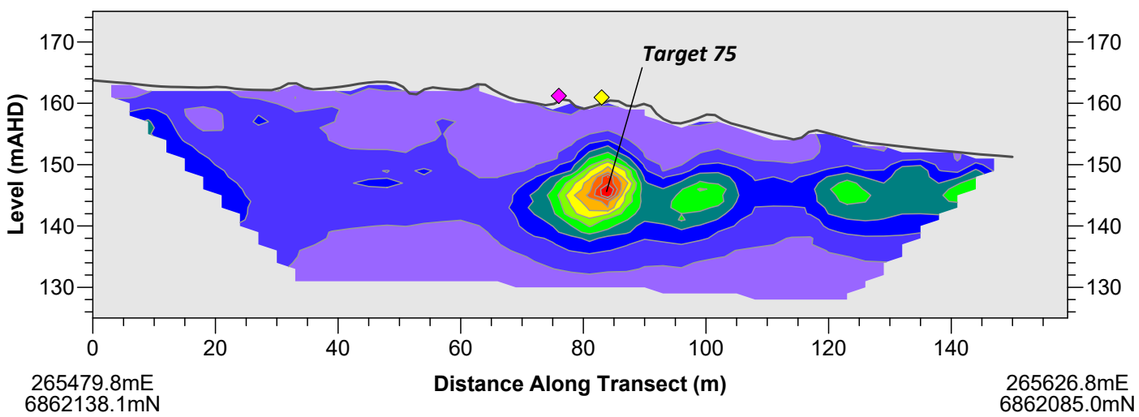
GEOPHYSICAL INVESTIGATION FOR ABANDONED MINE FEATURES, SHIRE OF NORTHAMPTON WESTERN AUSTRALIA.

COMMONAGE ELECTRICAL RESISTIVITY SECTIONS

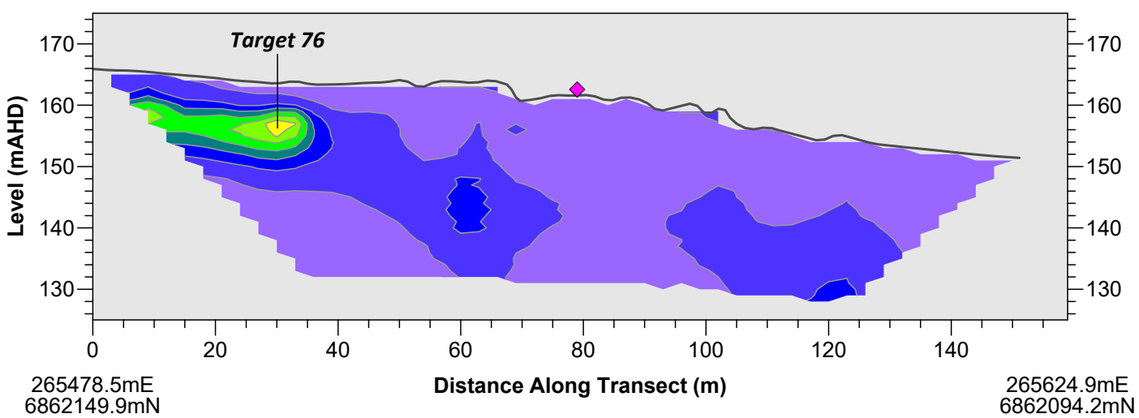
COM-14 - ELECTRICAL RESISTIVITY MODEL

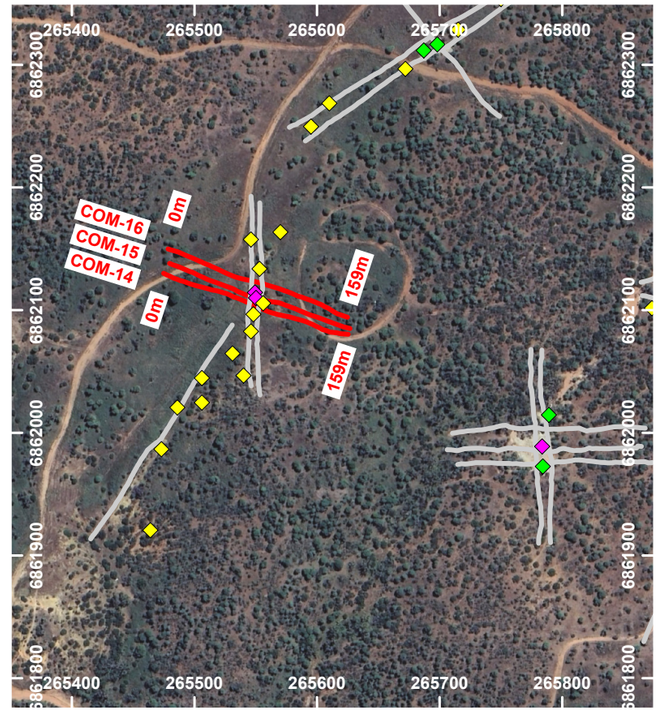


COM-15 - ELECTRICAL RESISTIVITY MODEL



COM-16 - ELECTRICAL RESISTIVITY MODEL





Legend

- Acquired ERT transect
- COM-1 — ERT transect ID
- Abandoned surface mine feature (WML, 2023)
- *Target 1* — Identified anomalous subsurface feature (refer to report for details)

Abandoned surface mine feature (WML)

- Deeper shafts
- Potential for deeper shafts
- Shallow workings

NOTES

Drawing to be used in conjunction with Report 3091.
Map Projection GDA2020 MGA Zone 50.
Aerial image from Google Earth Pro.

CLIENT	WML CONSULTING ENGINEERS	Date	26 October 2023	Paper Size	A3
GEOPHYSICAL INVESTIGATION FOR ABANDONED MINE FEATURES COMMONAGE AND WANNERENOOKA WA		Scale	1:1000	Drawn	PJE
		Drawing	3091-10	Revision	0

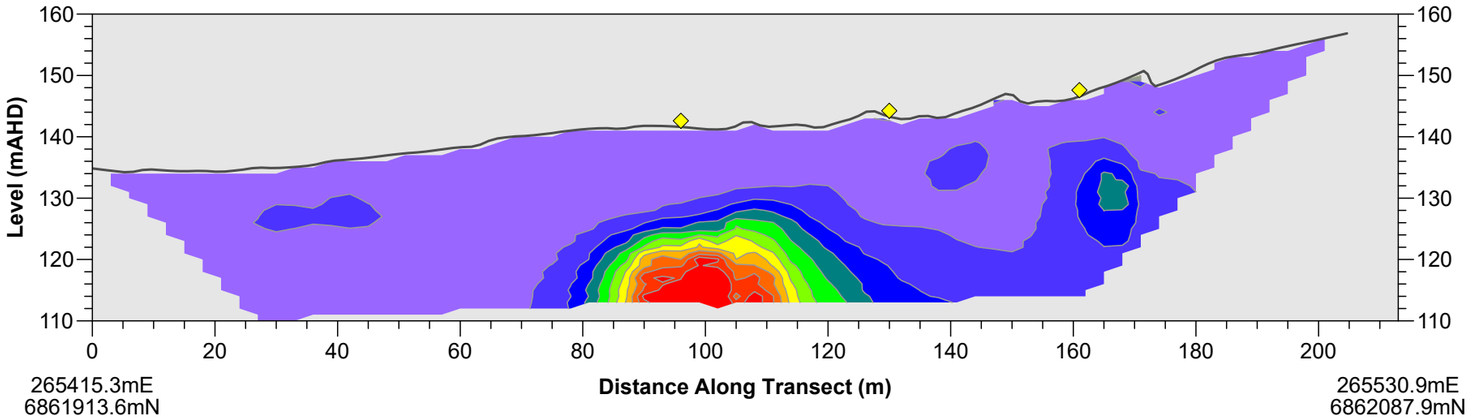
GBGGROUP
G B Geotechnics (Australia) Pty Ltd
1/11 Gympie Way Willetton WA 6155
ABN: 77 009 550 869
Telephone: 02 9890 2122
Email: info@gbgoz.com.au

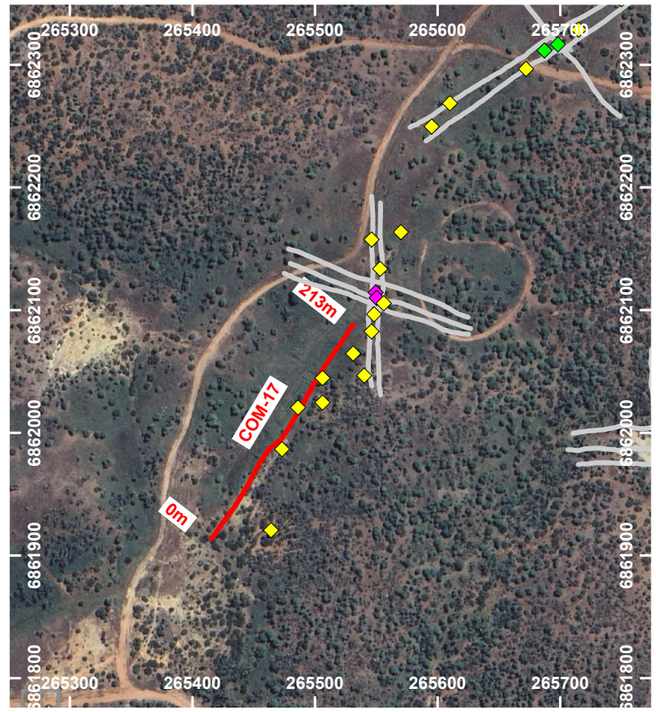
GBGGROUP

GEOPHYSICAL INVESTIGATION FOR ABANDONED MINE FEATURES, SHIRE OF NORTHAMPTON WESTERN AUSTRALIA.

COMMONAGE ELECTRICAL RESISTIVITY SECTIONS

COM-17 - ELECTRICAL RESISTIVITY MODEL



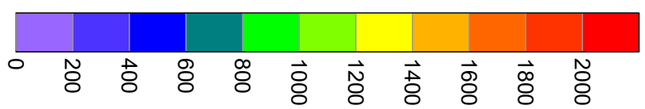


Legend

- Acquired ERT transect
- COM-1 — ERT transect ID
- Abandoned surface mine feature (WML, 2023)
- *Target 1* — Identified anomalous subsurface feature (refer to report for details)

Abandoned surface mine feature (WML)

- Deeper shafts
- Potential for deeper shafts
- Shallow workings



Electrical Resistivity (Ohm.metres)

NOTES

Drawing to be used in conjunction with Report 3091.
Map Projection GDA2020 MGA Zone 50.
Aerial image from Google Earth Pro.

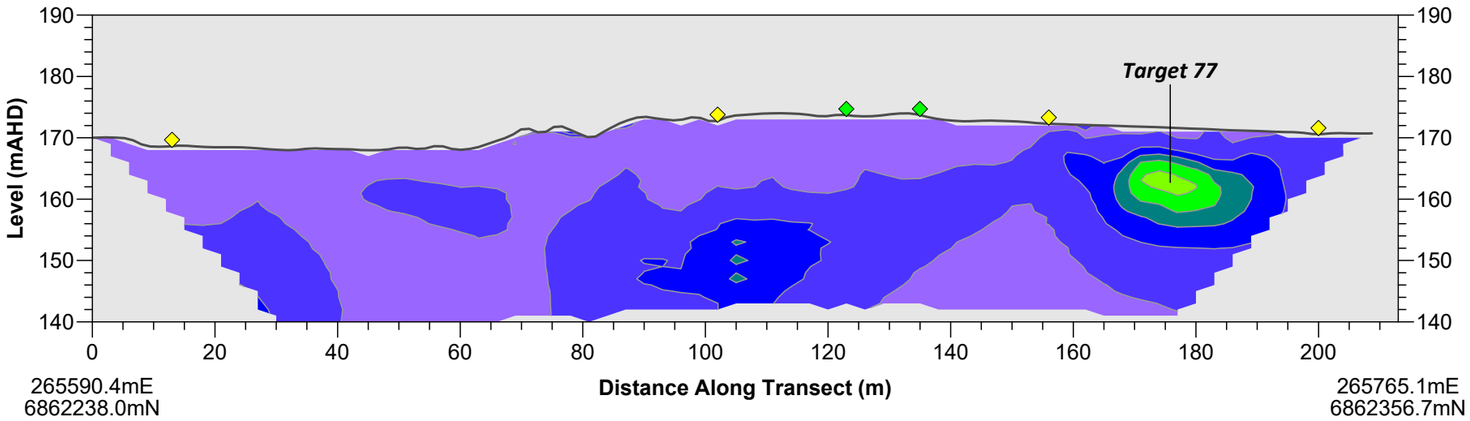
CLIENT	WML CONSULTING ENGINEERS	Date	26 October 2023	Paper Size	A3
	GEOPHYSICAL INVESTIGATION FOR ABANDONED MINE FEATURES COMMONAGE AND WANNERENOOKA WA	Scale	1:1000	Drawn	PJE
		Drawing	3091-11	Revision	0

GBGGROUP
G B Geotechnics (Australia) Pty Ltd
1/11 Gympie Way Willetton WA 6155
ABN: 77 009 550 869
Telephone: 02 9890 2122
Email: info@gbgoz.com.au

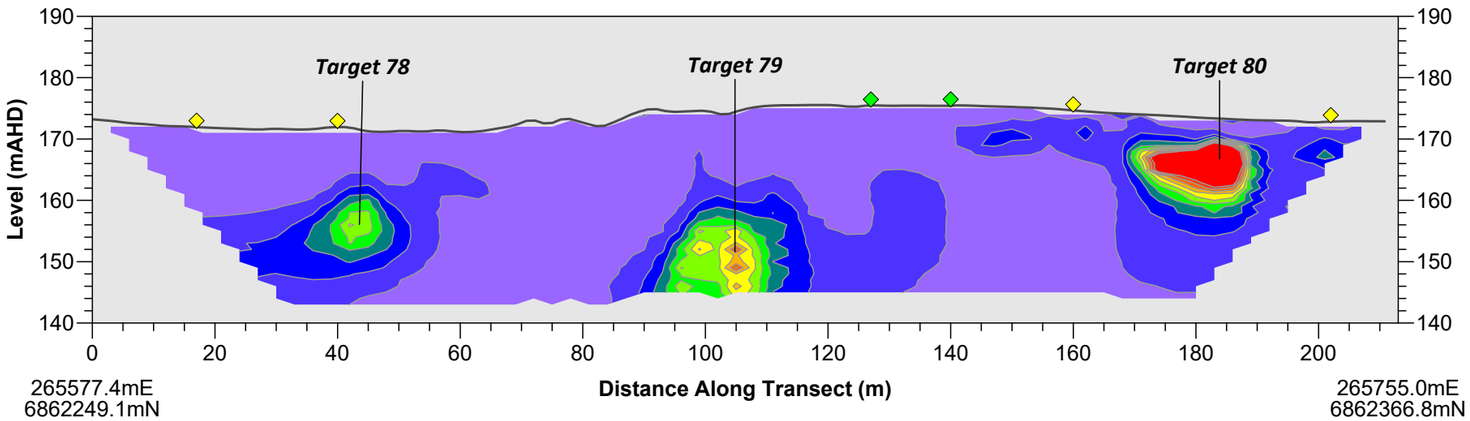
GEOPHYSICAL INVESTIGATION FOR ABANDONED MINE FEATURES, SHIRE OF NORTHAMPTON WESTERN AUSTRALIA.

COMMONAGE ELECTRICAL RESISTIVITY SECTIONS

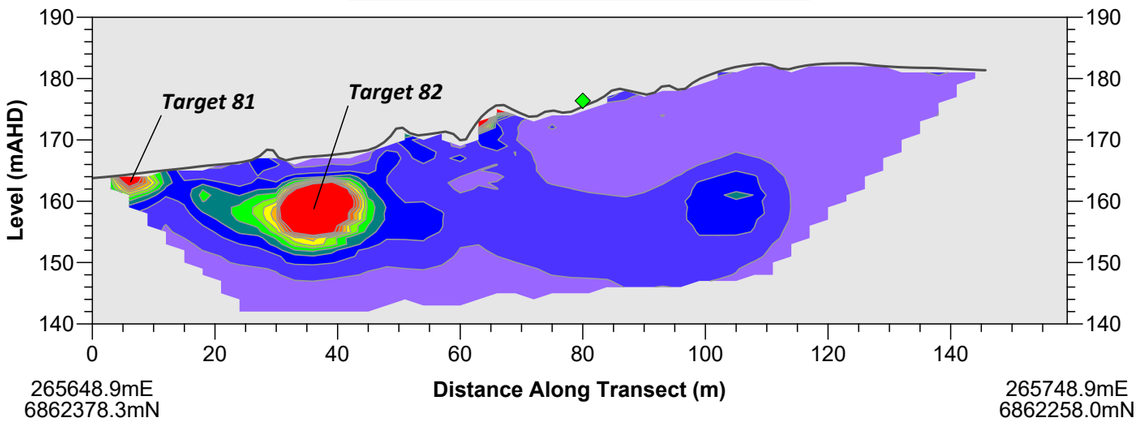
COM-18 - ELECTRICAL RESISTIVITY MODEL

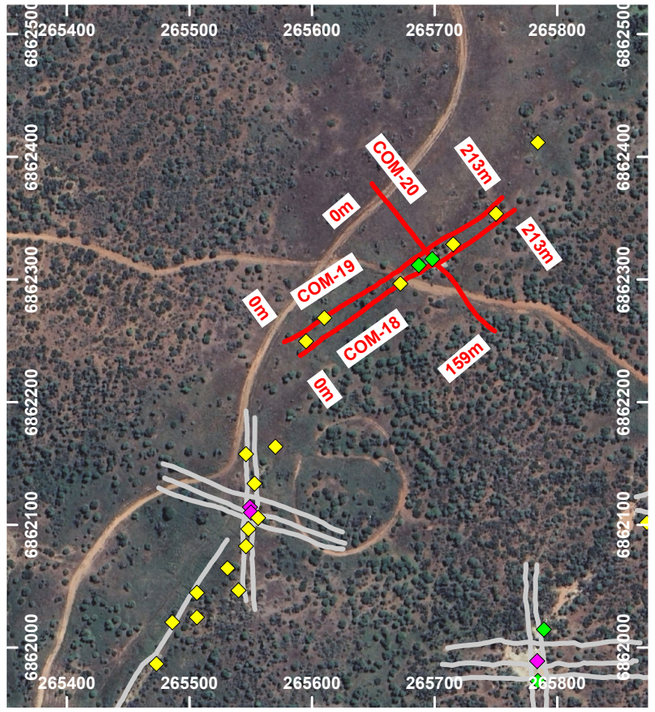


COM-19 - ELECTRICAL RESISTIVITY MODEL



COM-20 - ELECTRICAL RESISTIVITY MODEL



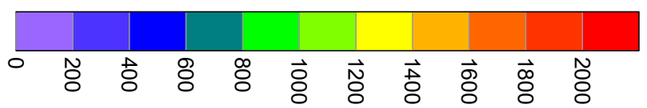


Legend

- Acquired ERT transect
- **COM-1** ERT transect ID
- Abandoned surface mine feature (WML, 2023)
- ***Target 1*** Identified anomalous subsurface feature (refer to report for details)

Abandoned surface mine feature (WML)

- Deeper shafts
- Potential for deeper shafts
- Shallow workings



NOTES

Drawing to be used in conjunction with Report 3091.
Map Projection GDA2020 MGA Zone 50.
Aerial image from Google Earth Pro.

CLIENT	WML CONSULTING ENGINEERS	Date	26 October 2023	Paper Size	A3
GEOPHYSICAL INVESTIGATION FOR ABANDONED MINE FEATURES COMMONAGE AND WANNERENOOKA WA		Scale	1:1000	Drawn	PJE
		Drawing	3091-12	Revision	0

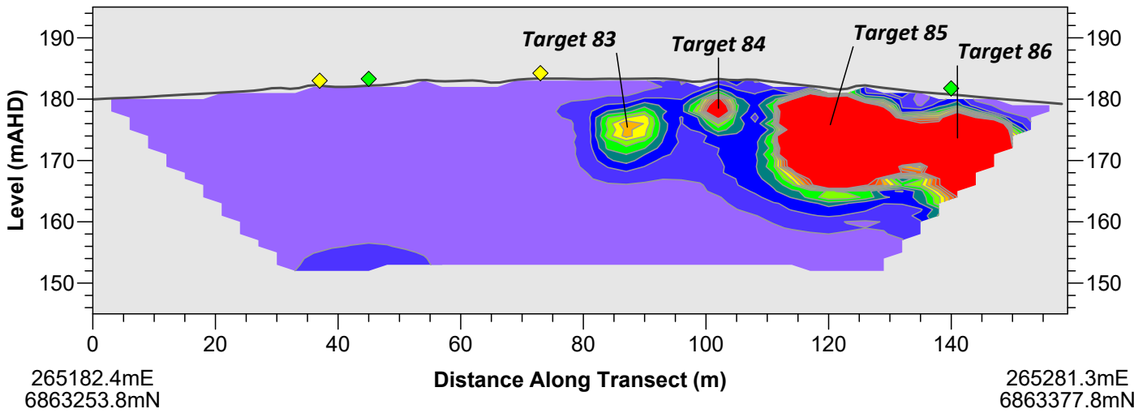
GBGGROUP
G B Geotechnics (Australia) Pty Ltd
1/11 Gympie Way Willetton WA 6155
ABN: 77 009 550 869
Telephone: 02 9890 2122
Email: info@gbgoz.com.au

GBGGROUP

GEOPHYSICAL INVESTIGATION FOR ABANDONED MINE FEATURES, SHIRE OF NORTHAMPTON WESTERN AUSTRALIA.

COMMONAGE ELECTRICAL RESISTIVITY SECTIONS

COM-21 - ELECTRICAL RESISTIVITY MODEL

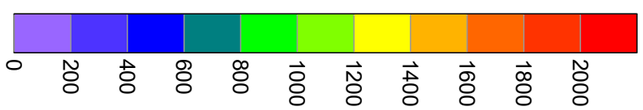


Legend

- Acquired ERT transect
- COM-1 — ERT transect ID
- Abandoned surface mine feature (WML, 2023)
- *Target 1* — Identified anomalous subsurface feature (refer to report for details)

Abandoned surface mine feature (WML)

- Deeper shafts
- Potential for deeper shafts
- Shallow workings



Electrical Resistivity (Ohm.metres)

NOTES

Drawing to be used in conjunction with Report 3091.
Map Projection GDA2020 MGA Zone 50.
Aerial image from Google Earth Pro.

CLIENT	WML CONSULTING ENGINEERS	Date	26 October 2023	Paper Size	A3
GEOPHYSICAL INVESTIGATION FOR ABANDONED MINE FEATURES COMMONAGE AND WANNERENOOKA WA		Scale	1:1000	Drawn	PJE
		Drawing	3091-13	Revision	0

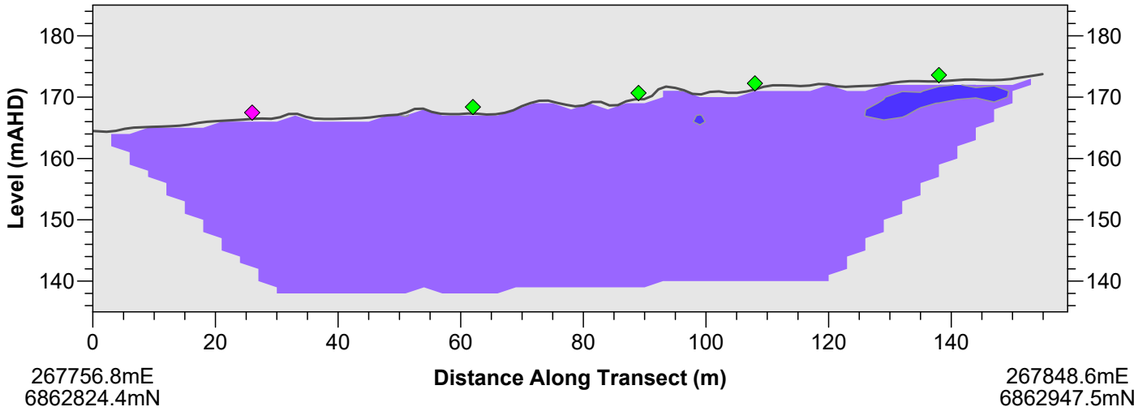
GBGGROUP
G B Geotechnics (Australia) Pty Ltd
1/11 Gympie Way Willetton WA 6155
ABN: 77 009 550 869
Telephone: 02 9890 2122
Email: info@gbgoz.com.au

GBGGROUP

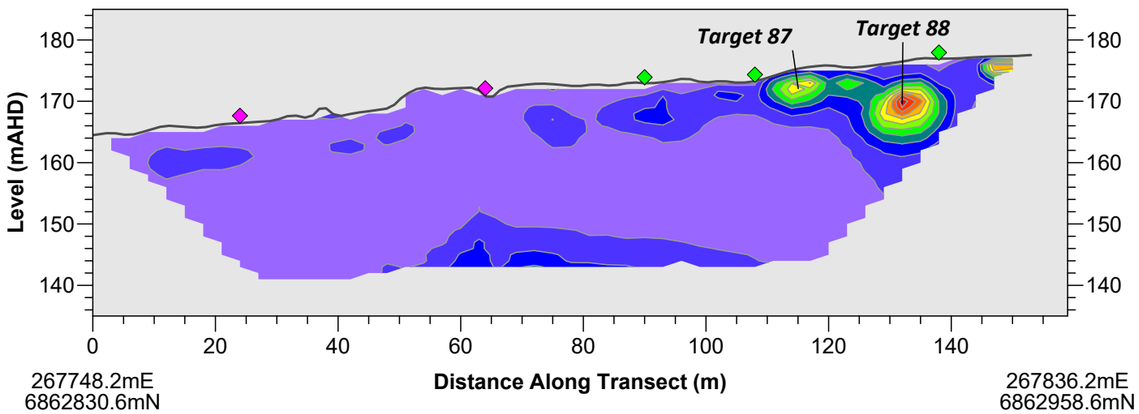
GEOPHYSICAL INVESTIGATION FOR ABANDONED MINE FEATURES, SHIRE OF NORTHAMPTON WESTERN AUSTRALIA.

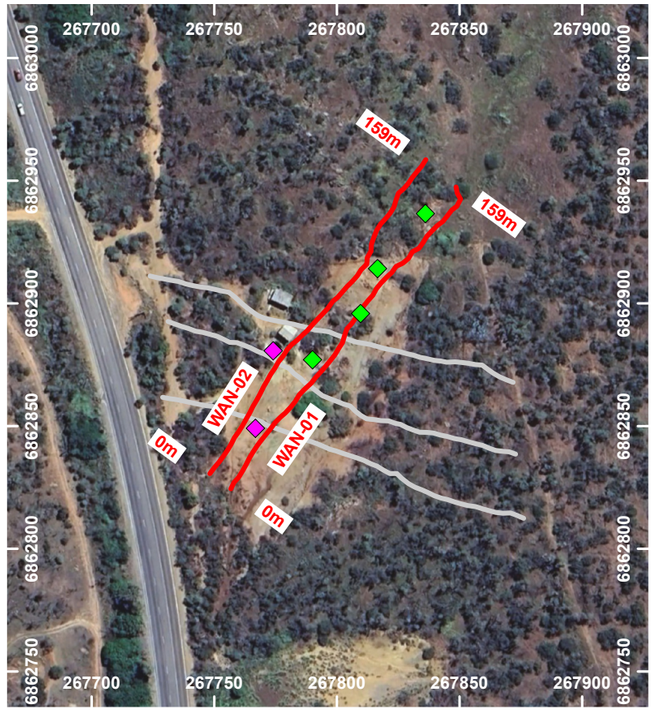
WANNERENOOKA ELECTRICAL RESISTIVITY SECTIONS

WAN-01 - ELECTRICAL RESISTIVITY MODEL



WAN-02 - ELECTRICAL RESISTIVITY MODEL





Legend

- Acquired ERT transect
- **WAN-1** ERT transect ID
- Abandoned surface mine feature (WML, 2023)
- ***Target 1*** Identified anomalous subsurface feature (refer to report for details)

Abandoned surface mine feature (WML)

- Deeper shafts
- Potential for deeper shafts
- Shallow workings

NOTES

Drawing to be used in conjunction with Report 3091.
Map Projection GDA2020 MGA Zone 50.
Aerial image from Google Earth Pro.

CLIENT	WML CONSULTING ENGINEERS	Date	26 October 2023	Paper Size	A3
GEOPHYSICAL INVESTIGATION FOR ABANDONED MINE FEATURES COMMONAGE AND WANNERENOOKA WA		Scale	1:1000	Drawn	PJE
		Drawing	3091-14	Revision	0

GBGGROUP
G B Geotechnics (Australia) Pty Ltd
1/11 Gympie Way Willetton WA 6155
ABN: 77 009 550 869
Telephone: 02 9890 2122
Email: info@gbgoz.com.au

GBGGROUP

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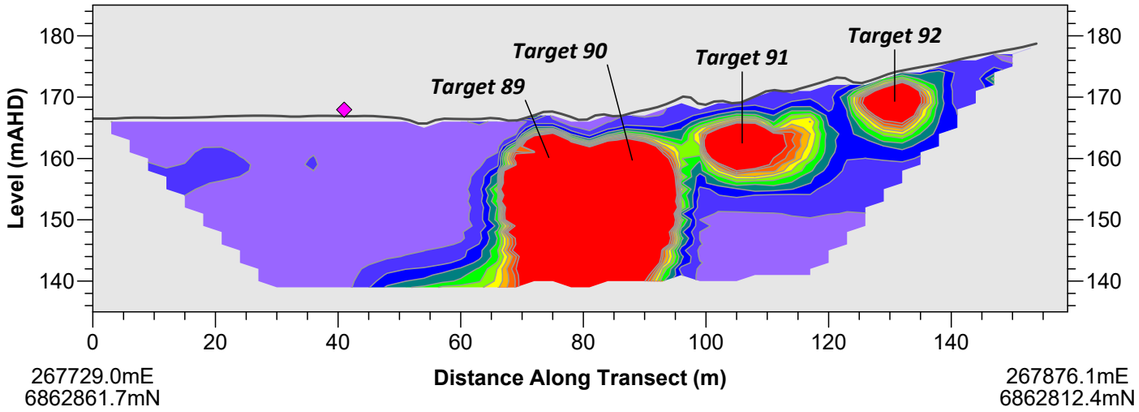
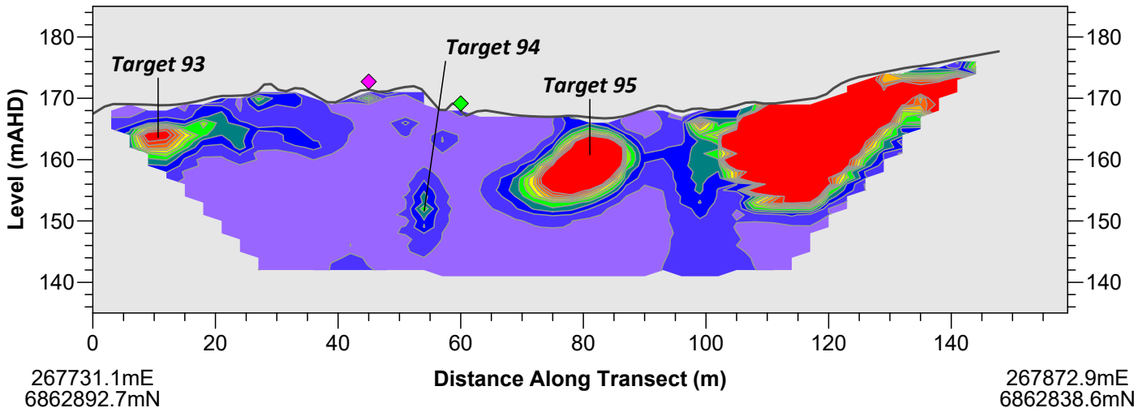
WANNERENOOKA ELECTRICAL RESISTIVITY SECTIONS

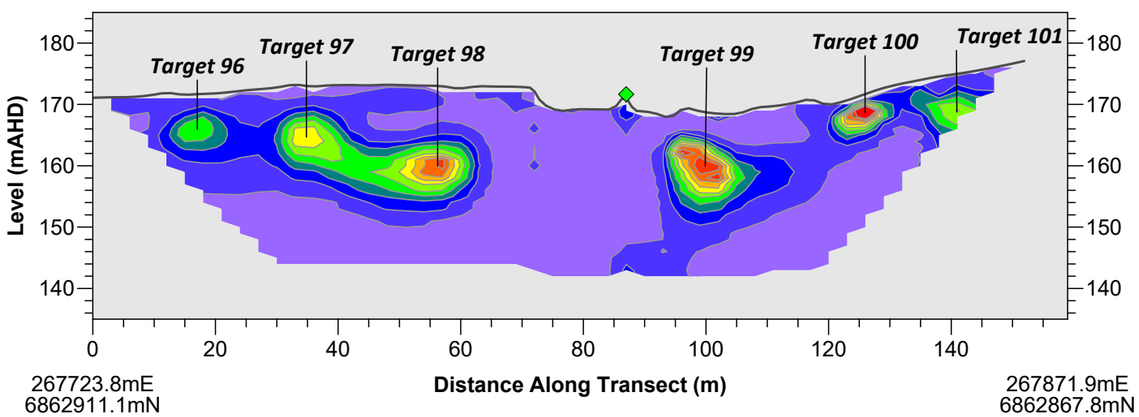
WAN-03 - ELECTRICAL RESISTIVITY MODEL

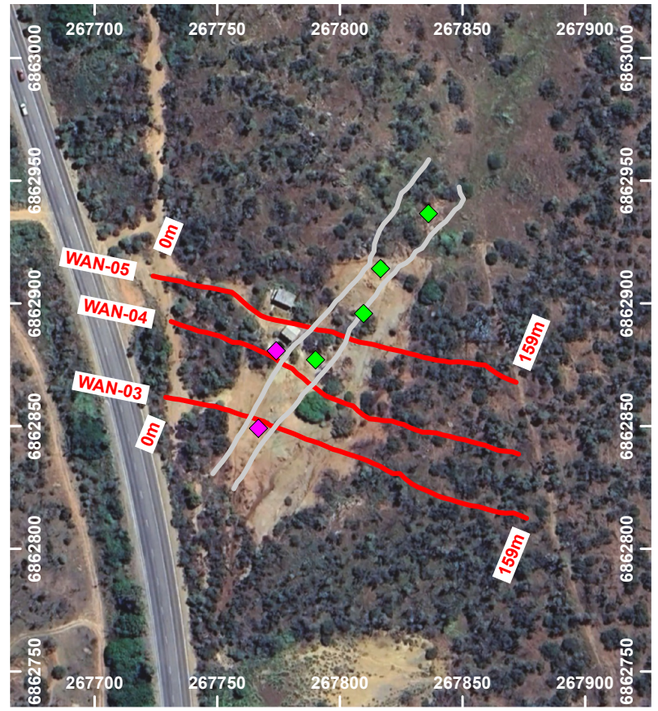


WAN-04 - ELECTRICAL RESISTIVITY MODEL



WAN-05 - ELECTRICAL RESISTIVITY MODEL





Legend

- Acquired ERT transect
- WAN-1 — ERT transect ID
- Abandoned surface mine feature (WML, 2023)
- *Target 1* — Identified anomalous subsurface feature (refer to report for details)

Abandoned surface mine feature (WML)

- Deeper shafts
- Potential for deeper shafts
- Shallow workings

NOTES

Drawing to be used in conjunction with Report 3091.
Map Projection GDA2020 MGA Zone 50.
Aerial image from Google Earth Pro.

CLIENT	WML CONSULTING ENGINEERS	Date	26 October 2023	Paper Size	A3
GEOPHYSICAL INVESTIGATION FOR ABANDONED MINE FEATURES COMMONAGE AND WANNERENOOKA WA		Scale	1:1000	Drawn	PJE
		Drawing	3091-15	Revision	0

GBGGROUP
G B Geotechnics (Australia) Pty Ltd
1/11 Gympie Way Willetton WA 6155
ABN: 77 009 550 869
Telephone: 02 9890 2122
Email: info@gbgoz.com.au

APPENDIX C –GROUND PENETRATING RADAR MAPS

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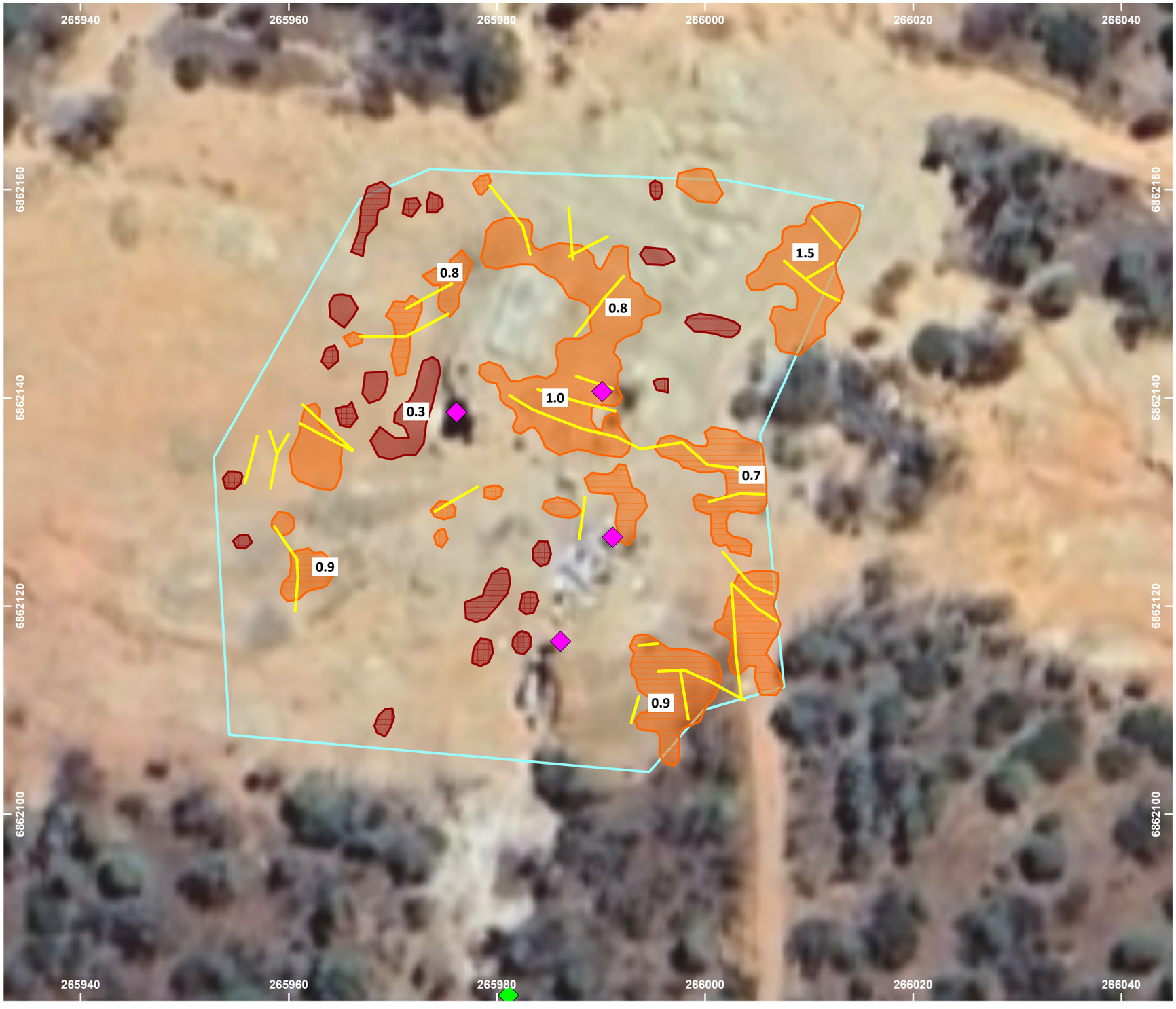
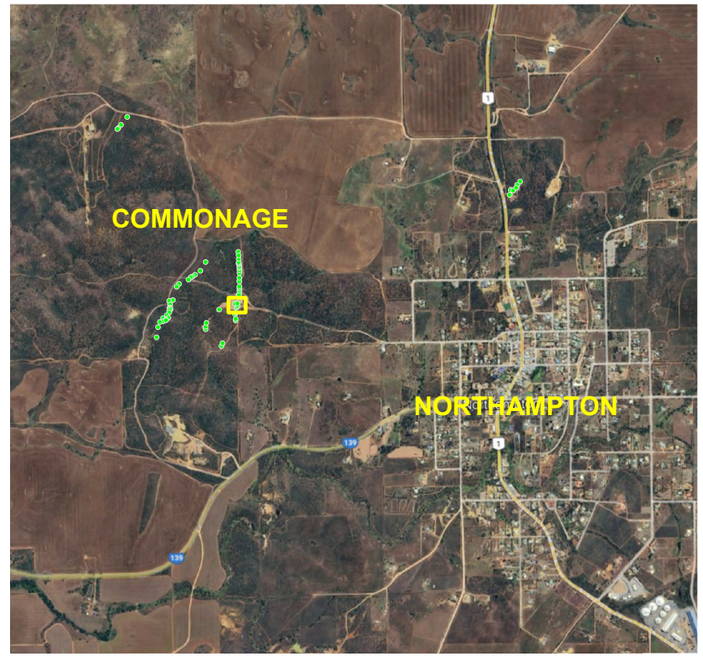
GEOPHYSICAL INVESTIGATION FOR ABANDONED MINE FEATURES, SHIRE OF NORTHAMPTON WESTERN AUSTRALIA.

COMMONAGE EAST GPR INTERPRETATION





Legend

- Potential shallow mine workings
- Worked ground with low potential for voiding of subsurface material
- Worked ground with high potential for voiding of subsurface material
- **0.5** Depth to feature (mBGL)
- GPR investigation area

Abandoned surface mine feature (WML)

- Deeper shafts
- Potential for deeper shafts
- Shallow workings

NOTES

Drawing to be used in conjunction with Report 3091.
Map Projection GDA2020 MGA Zone 50.
Aerial image from Google Earth Pro.

0 5 10 15 20
Distance (metres)

N

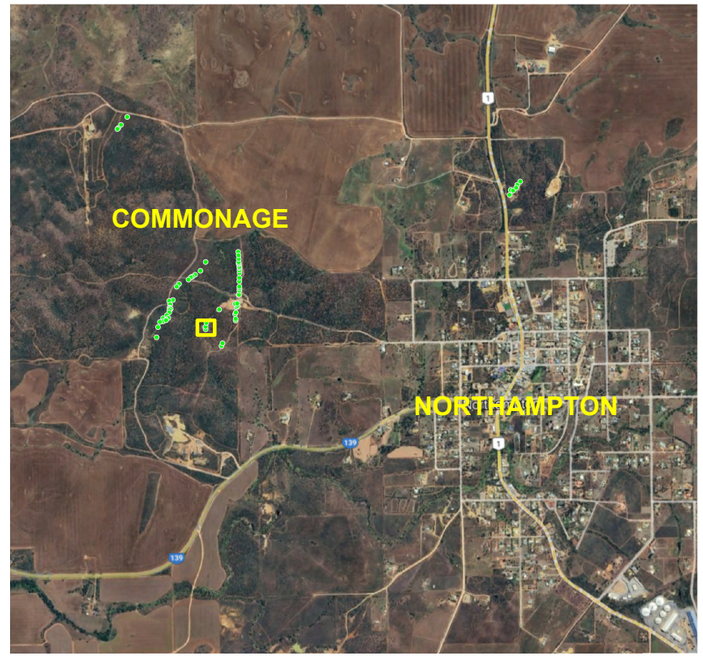
CLIENT	WML CONSULTING ENGINEERS	Date	26 September 2023	Paper Size	A3
	GEOPHYSICAL INVESTIGATION FOR ABANDONED MINE FEATURES COMMONAGE AND WANNERENOOKA WA	Scale	1:400	Drawn	AHWS
		Drawing	3091-16	Revision	0

GBGGROUP
G B Geotechnics (Australia) Pty Ltd
1/11 Gympie Way Willetton WA 6155
ABN: 77 009 550 869
Telephone: 02 9890 2122
Email: info@gbgoz.com.au

GBGGROUP

GEOPHYSICAL INVESTIGATION FOR ABANDONED MINE FEATURES, SHIRE OF NORTHAMPTON WESTERN AUSTRALIA.

COMMONAGE SOUTH GPR INTERPRETATION



Legend

- Potential shallow mine workings
- Worked ground with low potential for voiding of subsurface material
- Worked ground with high potential for voiding of subsurface material
- **0.5** Depth to feature (mBGL)
- GPR investigation area

Abandoned surface mine feature (WML)

- Deeper shafts
- Potential for deeper shafts
- Shallow workings

NOTES

Drawing to be used in conjunction with Report 3091.
Map Projection GDA2020 MGA Zone 50.
Aerial image from Google Earth Pro.

0 5 10 15 20
Distance (metres)

N

CLIENT	WML CONSULTING ENGINEERS	Date	26 September 2023	Paper Size	A3
	GEOPHYSICAL INVESTIGATION FOR ABANDONED MINE FEATURES COMMONAGE AND WANNERENOOKA WA	Scale	1:400	Drawn	AHWS
		Drawing	3091-17	Revision	0

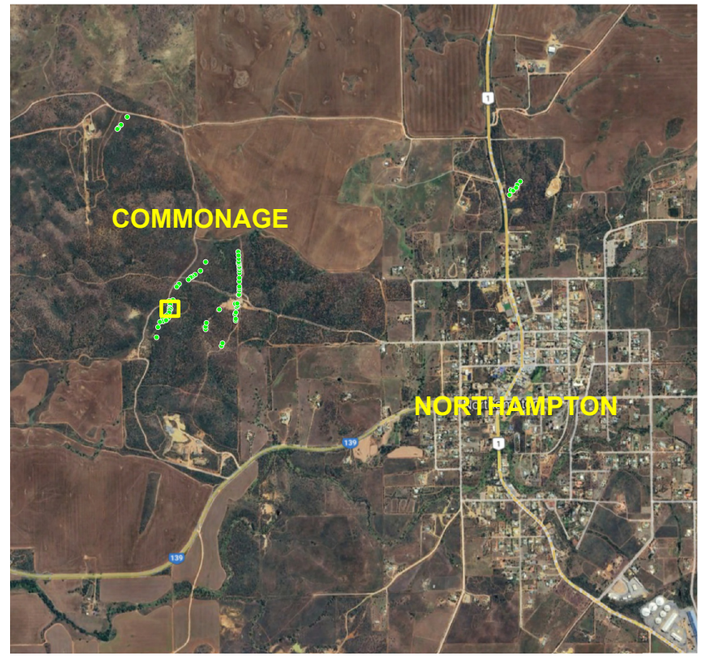
GBGGROUP

G B Geotechnics (Australia) Pty Ltd
1/11 Gympie Way Willetton WA 6155
ABN: 77 009 550 869
Telephone: 02 9890 2122
Email: info@gbgoz.com.au

GBGGROUP

GEOPHYSICAL INVESTIGATION FOR ABANDONED MINE FEATURES, SHIRE OF NORTHAMPTON WESTERN AUSTRALIA.

COMMONAGE WEST GPR INTERPRETATION



Legend

- Potential shallow mine workings
- Worked ground with low potential for voiding of subsurface material
- Worked ground with high potential for voiding of subsurface material
- **0.5** Depth to feature (mBGL)
- GPR investigation area

Abandoned surface mine feature (WML)

- Deeper shafts
- Potential for deeper shafts
- Shallow workings

NOTES

Drawing to be used in conjunction with Report 3091.
Map Projection GDA2020 MGA Zone 50.
Aerial image from Google Earth Pro.

0 5 10 15 20
Distance (metres)

N

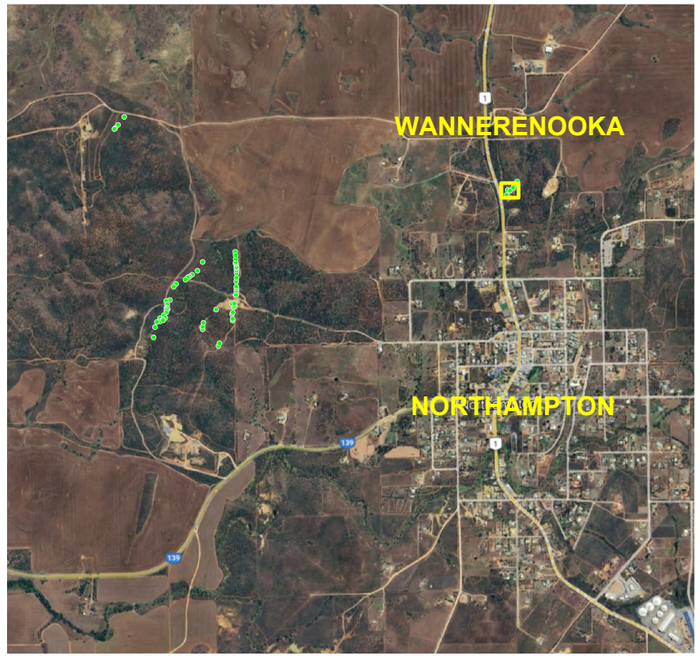
CLIENT	WML CONSULTING ENGINEERS	Date	26 September 2023	Paper Size	A3
	GEOPHYSICAL INVESTIGATION FOR ABANDONED MINE FEATURES COMMONAGE AND WANNERENOOKA WA	Scale	1:400	Drawn	AHWS
		Drawing	3091-18	Revision	0

GBGGROUP
G B Geotechnics (Australia) Pty Ltd
1/11 Gympie Way Willetton WA 6155
ABN: 77 009 550 869
Telephone: 02 9890 2122
Email: info@gbgoz.com.au

GBGGROUP

GEOPHYSICAL INVESTIGATION FOR ABANDONED MINE FEATURES, SHIRE OF NORTHAMPTON WESTERN AUSTRALIA.

WANNERENOOKA GPR INTERPRETATION



Legend

- Potential shallow mine workings
- Worked ground with low potential for voiding of subsurface material
- Worked ground with high potential for voiding of subsurface material
- **0.5** Depth to feature (mBGL)
- GPR investigation area

Abandoned surface mine feature (WML)

- Deeper shafts
- Potential for deeper shafts
- Shallow workings

NOTES

Drawing to be used in conjunction with Report 3091.
Map Projection GDA2020 MGA Zone 50.
Aerial image from Google Earth Pro.

0 5 10 15 20
Distance (metres)

N

CLIENT	WML CONSULTING ENGINEERS	Date	26 September 2023	Paper Size	A3
	GEOPHYSICAL INVESTIGATION FOR ABANDONED MINE FEATURES COMMONAGE AND WANNERENOOKA WA	Scale	1:400	Drawn	AHWS
		Drawing	3091-19	Revision	0

GBGGROUP
G B Geotechnics (Australia) Pty Ltd
1/11 Gympie Way Willetton WA 6155
ABN: 77 009 550 869
Telephone: 02 9890 2122
Email: info@gbgoz.com.au