Leadville Mine Remediation Action Plan

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Leadville Mine Remediation Action Plan

Final

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Prepared for:

Legacy Mines Program, Department of Regional NSW

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Terra Tech
CONSULTING

EXECUTIVE SUMMARY

Terra Tech Consulting (TTC) was engaged by Legacy Mines Program (LMP) (The Principal) to develop a Remedial Action Plan (RAP) for the site of the former Leadville mine (The Site), located in the Warrumbungle Shire of central western New South Wales, Australia.

Due to the presence of sub-surface geohazards, identified by GHD (2023b), previous remedial designs developed by Okane, (2022) comprising the encapsulation of heavy metal impacted mine waste materials are not constructable without significant subsurface works. As a result, the remedial design presented in Okane (2021, 2022) requires amendment. The objectives of this RAP are therefore to develop a revised strategy that addresses the following aspects:

- Mitigate the potential off-site migration of heavy metals (primarily Pb) from mine waste materials. When considering potential risks to off-site receptors the remedial design was developed in accordance with the following rationale:
  - Where previous investigations indicate that there is a potential for impact to surface waters caused by the characteristics and volumes of mine and processing waste at Leadville - Remedial works should be undertaken to limit or eliminate this risk.
  - Where there are unacceptable safety risks (i.e. presence of near-surface underground workings, remediation plans should aim to achieve Acceptable Risk and Tolerable / As Low As Reasonably Practicable (ALARP) outcomes in consideration of identified safety and environmental risks.
- Isolation of areas (e.g. impacted surface water collection dams and exposed mine waste) in which heavy metal impacts pose a potentially unacceptable health risk to future site receptors.
- Isolation of areas in which heavy metal impacts (as assessed by comparison of historical datasets to the Risk Based Criteria (RBC) developed by EnRisks (2022) pose a potentially unacceptable risk to livestock to allow for grazing to occur across the balance of the site.

Accordingly, this RAP includes remedial measures which include:

- Excavation and off-site disposal of highly impacted heavy metal impacted materials which are leachable and potentially pose a significant risk to surface waters on and off-site.
- Construction of a drainage management system to limit volumes of meteoric water interacting with Potentially Acid Forming (PAF) materials where geohazards are potentially present, thus precluding excavation and off-site disposal or encapsulation remedial approaches.
- Isolating areas with fencing to remove unacceptable health risks to future site receptors as well as address risks to livestock.

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Table 1 List of Abbreviations

Abbreviation	Definition
ABA	Acid Base Accounting
AMD	Acid and Metalliferous Drainage
ARI	Average Recurrence Interval
ASL	Above sea level
ASLP	Australian Standard Leaching Procedure
BGL	Below ground level
BOM	Bureau of Meteorology
CEMP	Construction Environmental Management Plan
COPC	Contaminants of Potential Concern
CSM	Conceptual Site Model
EPA	Environmental Protection Agency
ESP	Engineering Service Provider
INAP	International Network for Acid Prevention
LEP	Local Environmental Plan
LGA	Local Government Area
LMP	Legacy Mines Program
LTEMP	Long Term Environmental Management Plan
NAF	Not Acid Forming
NAG	Net Acid Generation
NAPP	Net Acid Producing Potential
OH&S	Occupational Health and Safety
PAF	Potentially Acid Forming
QAQC	Quality Assurance and Quality Control
RAP	Remediation Action Plan
RBC	Risk Base Criteria
RWPC	Remedial Works Principal Contractor
SAQMP	Sampling Analysis and Quality Management Plan
SBRC	Solubility Bio accessibility Research Consortium
SEPP	State Environmental Planning Policy
SoW	Scope of Works
SOHI	Statement of Heritage Impact
TCLP	Toxicity Characteristic Leaching Procedure
WHS	Workplace Health and Safety

1 INTRODUCTION

1.1 Project Overview

Terra Tech Consulting (TTC) was engaged by NSW Public Works on behalf of the Legacy Mines Program (LMP The Principal) to develop a Remedial Action Plan (RAP) for the site of the former Leadville mine (The Site), located in the Warrumbungle Shire of central western New South Wales, Australia.

Due to the presence of sub-surface geohazards identified by GHD (2023b) (Figure 1), previous remedial designs developed by Okane, (2022) comprising the encapsulation of heavy metal impacted mine waste materials are not constructable without significant subsurface works. As a result, the remedial designs presented in Okane (2022) require amendment. The objectives of this RAP are therefore to develop a revised strategy that addresses the following aspects:

- Mitigate the potential off-site migration of heavy metals (primarily Pb) from mine waste materials.
- Isolation and on-going management of areas (e.g. impacted surface water collection dams and surface soils/sediment) in which heavy metal impacts pose a potentially unacceptable health risk to future site receptors and livestock (where allowed to graze for a maximum of 2 months per year on site).

The remedial strategies presented herein, have been developed on the basis of previous investigations (Okane, 2021) and in collaboration with The Principal and other stakeholders including NSW Crown Lands (Crown Lands) and the NSW Legacy Mines Program (LMP).

1.2 Objectives

The objective of this RAP is to document the procedures and standards to be followed in order to manage the risks posed by the identified potential contamination issues, to make the site suitable for agricultural purposes (grazing of livestock where possible) while ensuring the protection of human health and the surrounding environment.

2 SITE DETAILS AND HISTORY

2.1 Tenure and Land Use

The site is located 500 m west of the village of Leadville, NSW. Tenure of the site includes:

- A Crown Land parcel (Lot 7304 DP 1152229) (otherwise Part Reserve 750766 (7304/1152229) for the purpose of Future Public Requirements).
- The Travelling Stock Route Part Reserve 68 (7305/1152229) (Part Reserve 68 (7305/1152229) for the purpose of Travelling Stock Route).
- An adjoining water reserve (Lot 149, DP 750766) otherwise (Reserve 97441 (149/750766 for the purpose of Water Supply); and

All site tenure is identified as RU1 (primary production) in the Warrumbungle Shire Local Environmental Plan (LEP). Proposed future land uses are provided in Table 2.

Table 2 Tenure and Future Land Use by Cadastre

Cadastre	Crown Land Tenure	Intended Future Land Use
Lot 7304 DP 1152229	Future Public Requirements Part Reserve 750766	Land management activities.
Lot 7305 DP 1152229	Travelling Stock Route Part Reserve 68	Land management activities and limited grazing.[1]
Lot 7303 DP 1152229	Travelling Stock Route Part Reserve 47657	Land management activities and limited grazing.[1]
Lot 149 DP 750766	Water Supply Reserve 97441	Water used by RFS during emergency response.

A site overview including relevant tenure is included in Figure 1.

[1] Limited grazing assumes individual cattle would not graze the TSR within the project area for more than 2 months per annum.

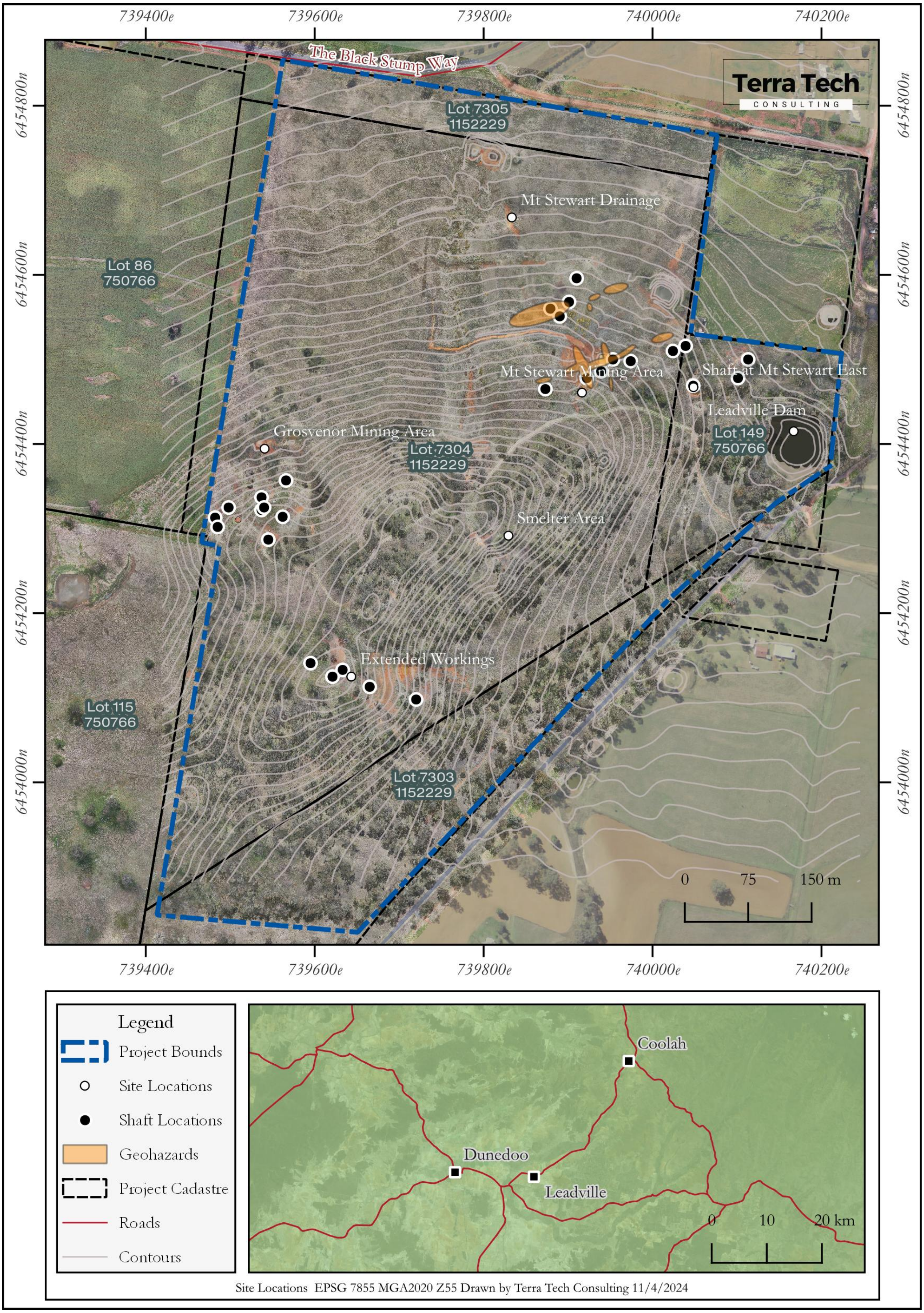

Figure 1 Site Location and Cadastre

2.2 Regional Landscape Topography, Setting and Access

The landscape surrounding the area consists of rolling hills and low rises, ranging from 420 to 530 metres in elevation. These features exhibit gently sloping inclines of less than 15%, with intermittent drainage lines spaced between 300 to 1000 metres apart. The terrain is interspersed with agricultural pastures, rural properties, and woodland patches.

A detailed survey was undertaken by TTC in November 2023. Elevations within the surveyed area range from 420 to 465 metres Above Sea Level.

Surface drainage within the Leadville Mine site is transient, following the natural topography. The primary flow directs northward from the mine workings and infrastructure toward the stock dams present in the area.

Access to the former mining area is facilitated via Garland Street, also known as Sir Ivan Doherty Drive. An existing unsealed earthen track, approximately 3 metres wide, provides passage throughout the precinct. The track and grassy terrain currently require no vegetation clearance for use, although occasional overhanging branches may need trimming.

2.3 Hydrology

Surface drainage at the Leadville site is ephemeral, shaped by the terrain, primarily flowing northward from the mining activity and infrastructure toward stock dams. These dams exhibit variable low pH (acidic) conditions with elevated levels of metals at one location (LVD1 Figure 4). The expanded mining operations south of the hill's peak drain in a southeastern direction.

Three groundwater bores are positioned within a kilometre of the site:

- GW800847 is situated on private land westward near Black Stump Way,
- GW010685 is located in Leadville township and serves as the source for the town's water supply.
- GW2 which was installed in 2020 as part of Okane's site investigation works.

2.4 Environmental Setting

The site's vegetation has been mapped by OEH (2012) and Lesryk (2021) including the subject site. This mapping identifies three distinct map units, which can be likened to plant community types (PCTs) within the study area:

- Map Unit 180 comprises Plainsgrass, Purple wiregrass, and Wallaby Grass grassland on basalt soils of the Merriwa plateau.
- Map Unit 175 represents White Box grassy woodland on basalt soils found in the upper Hunter and Liverpool Plains.
- Map Unit 176 encompasses Yellow Box and Rough-barked Apple grassy woodland prevalent in the upper Hunter and Liverpool Plains.

However, during field investigations conducted by Lesryk (2021), certain discrepancies between OEH mapping and field mapping were observed in the mapped data:

- Map Unit 180 appeared less extensive on the ground, with some areas devoid of vegetation or degraded to an extent where less than 50% of the ground cover comprised native species.
- The wooded region designated as Map Unit 180 around Grosvenor Dam actually aligned more with Map Unit 175.
- Vegetation on the lower slopes adjacent to the drainage line along the eastern boundary and near the dam likely resembled Map Unit 176 rather than Map Unit 175. Unfortunately, these areas, along with the region marked as Map Unit 176 in the southwestern part of the site, were not surveyed as they lie beyond the proposed work area.

Based on field mapping, a Statement of Environmental Effects (SEE) was prepared to assess environment impacts of works proposed by Okane (2021). This document provides a summary of:

- Vegetation communities and fauna habitats present at the Site.
- An assessment of the potential for significant impacts to matters listed within:
    - *Biodiversity Conservation Act 2016*
    - *Environment Protection and Biodiversity Conservation Act 1999.*
    - *State – State Environment Planning Policy (Koala Habitat Protection) 2021*.

The SEE concluded that no significant impact to matters listed within the legislation above was anticipated as a result of the works described in Okane (2021).

Figure 2 provides an overview of mapped vegetation communities within the Site.

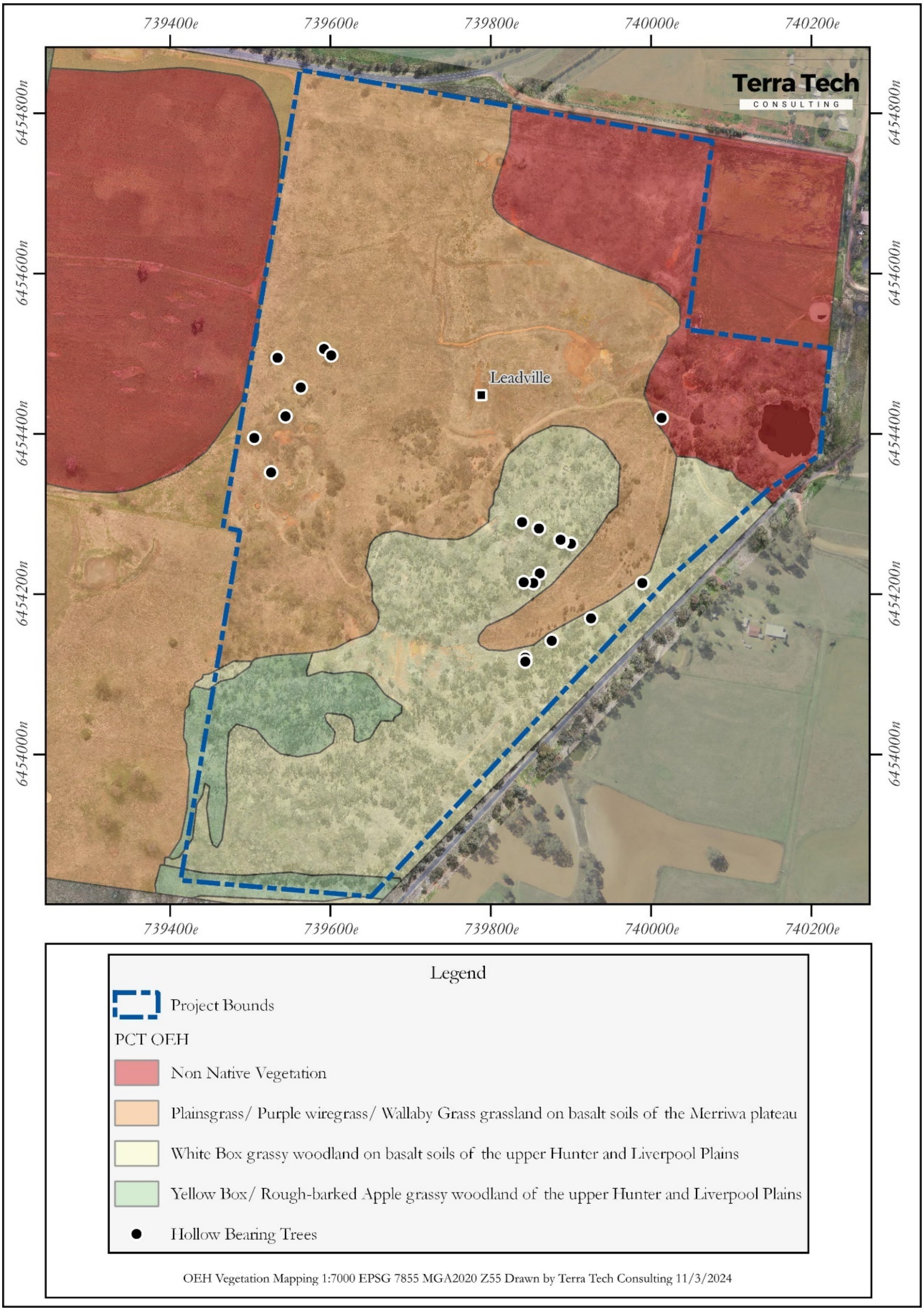

Figure 2 OEH Mapped Vegetation

2.5 Historical Operations and Site Layout

Underground mining operations were undertaken at the Site periodically from the late 1800s to the 1950s, extracting commodities such as Pb-Ag, Cu, Zn, and pyrite concentrates. The site encompasses multiple small groups of underground workings situated at Mount Stewart, Grosvenor, and Extended Workings, with processing occurring at a Smelting site located in the Southeast of the Site. (Okane, 2022).

Table 3 provides a summary of activities since commencement of operation to the present. An interpretative report was developed by GHD (2023b) based on historical mining records and provides details on the characteristics and locations of various relict mining infrastructure which persist on site.

Table 3 Summary of Historical Mining Activities

Year	Activity Type	Activity
1888	Mining	Mine opened as Pb-Ag operation
1892-1893	Mining	Water-jacketed furnace (smelter) erected. Total of 15,000 tons of ore treated, yielding 292,03 oz Ag and 1539 tons of lead
1894	Mining	Resumption of mining for 2 months. Voluntary liquidation after ore changed from carbonates to sulfides.
1918-1920	Mining	1674 tons of pyrite sold to acid and superphosphate manufacturers; 2400 tons of Ag and Pb ore mined.
1921	Mining	Sporadic operation with increasing investment in mine infrastructure
1925	Mining	All work suspended on site.
1932-1937	Mining	30,000 tons of pyritic ore, 419 tons of Ag-Pb ore produced (Mount Stewart Syndicate)
1937	Mining	Zinc ore mined
1950-1951	Mining	50 tons of Ag-Pb ore produced (Leadville Mining Company Pty. Ltd.)

2.6 Climate

Figure 3 presents a summary of climate data spanning the past 107 years at Dunedoo Post Office (Bureau of Meteorology Station 064009). Based on the available climate data, the Köppen Geiger classification indicates that the site falls under the category of Warm temperate (Cfa). This information has been considered in the development of remedial designs and nomination of design storms at Leadville.

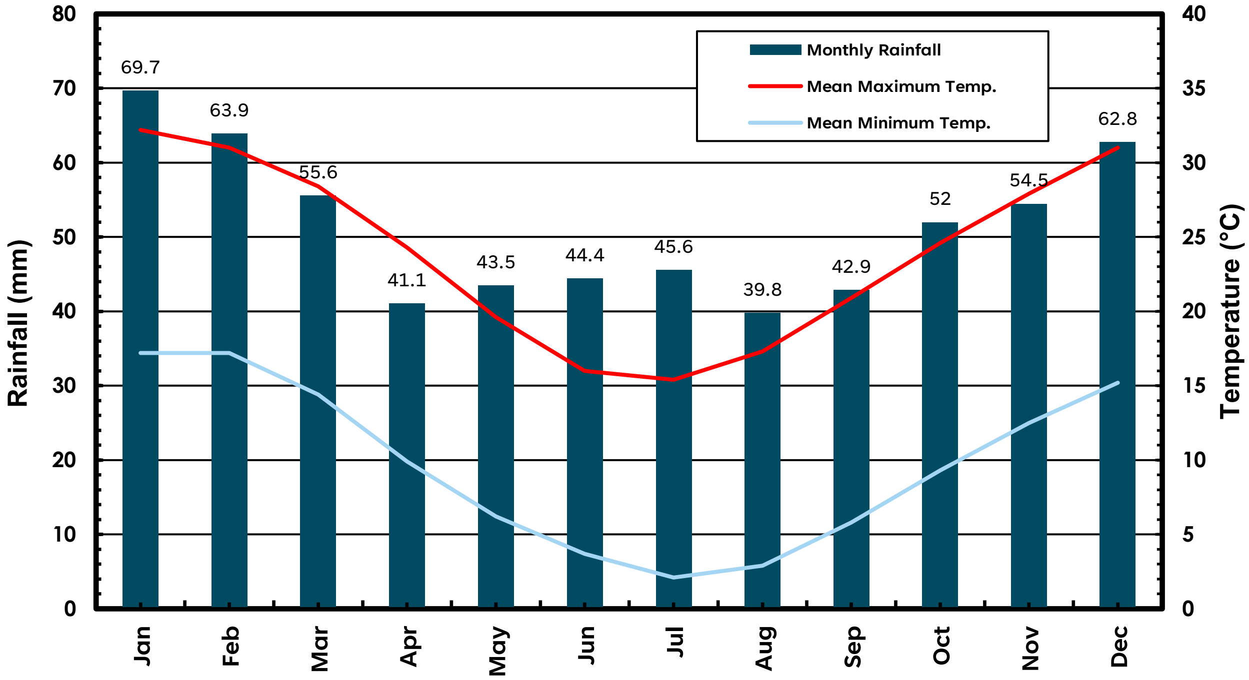

Figure 3 Climate Statistics for Dunedoo Post Office

2.7 Heritage Significance

The Leadville site is a registered historic site registered on the Warrumbungle LEP 2013 as a place of Local Heritage Significance. The site includes *in-situ* relict mine infrastructure at the site including mine shafts, building footings and processing relicts including slag, smelter locations, tanks and drains.

A detailed description of historical mining operations and their relevant locations is provided in the Hazard Assessment Report, GHD (2023b). The heritage significance of various relict features located at the site is described in *Statement of Heritage Impact,* Everick (2022). A Photographic Archival Report (PAR) was undertaken by Everick (2022) and provides detailed recordings of site features for the purpose of archival records.

A desktop search for registered Aboriginal Cultural Heritage (ACH) items and places was undertaken by Lesryk (2022). Three modified trees were identified on Lot 86 DP750766, however are outside the project area and not anticipated to be impacted by the works described herein.

3 PREVIOUS SITE INVESTIGATIONS

3.1 Historical Investigations and Remedial Work

Fredrickson, (1993) established that acid and metalliferous drainage (AMD) from the oxidation of sulfidic ore had led to sediment contamination in drainage lines and water within existing stock dams at The Site. The estimated volume of contaminated waste material stood at 10,000 m^3 before remedial action was initiated (El-Chamy, 1993). Remediation efforts conducted in 1995 encompassed various measures such as shaft filling, drainage enhancements, consolidation, waste dump compaction, chemical treatment of acidic soil through lime dosing, revegetation, and fencing (Land & Water Conservation, 1996).

Subsequent water quality assessments in 1996 and 2000 at the stock dams (LVD3 and LVD4 Figure 4) indicated that the water remained unsuitable for both stock consumption and irrigation. Analysis of sediment and water samples taken on-site by LMP in 2015 revealed persistent elevated levels of Pb, As, Cu, and Zn in sediment and water across multiple locations, including recently active stock dams.

Additional remediation and safety measures were executed in 2016. These actions involved backfilling or fencing of mine shafts and initiatives to mitigate soil erosion and runoff contamination (Soil Conservation Service, 2016). As part of these efforts, two new sediment dams were constructed to intercept runoff from Mt Stewart. Furthermore, grazing activities for livestock were prohibited at the site. Although no as built or final remedial reports from this period were available (solely photo records and memoranda), based on site observations, it is assumed that areas identified as Mt Stewart Drainage (See Figure 4) underwent remedial procedures during this phase.

For detailed reference information regarding the activities undertaken at the site and associated documents, Table 4 provides a comprehensive summary.

Table 4 Summary of Site Activities to Present

Year	Activity Type	Activity	Reference
1993	Rehabilitation / Sampling	Preliminary environmental investigation	Fredrickson, (1993) Preliminary Environmental Investigation at derelict mine site, Leadville NSW.
1995	Rehabilitation / Sampling	Water quality samples taken at two stock dams highly acidic with moderate concentrations of Contaminants of Concern (COC). Rehabilitation work on securing shafts and earthworks on contaminated areas/dump sites	
1999	Rehabilitation/Sampling	Water quality samples taken from dams and depression, highly acidic with moderate concentrations of COC.	Fredrickson, (1999) Follow up inspection and water sampling after rehabilitation works.
2019-2020	Rehabilitation/Sampling	Elevated blood Pb in cattle that grazed on site (unauthorised access). FP-XRF surveys, soil and water sampling	LMP (2019) Soil and water sampling -
2020-2022	Development of RAP by Okane	A RAP was prepared by Okane Consultants between 2020-2022 (Okane, 2022). Work included soil, water (including groundwater) and leachate sampling, Acid Base Accounting (ABA), development of Risk Based Criteria based on land use and bio accessibility of COC.	Okane, (2020) Leadville SAQMP. Okane (2021) Leadville RAP Rev A. Okane (2022) Leadville RAP Rev B. EnRisks (2022) Risk Based Criteria for Leadville Mine.
2022-2023	Remedial works planning	Legacy Mines Program planned remedial works on the basis of the Okane, (2022). During the development of technical oversight plans, GHD (2023a) identified a number of underground workings at Mt Stewart which presented subsidence risks and raised the need to review the remediation strategy.	GHD (2023b) Hazard Assessment Report GHD (2023a) Geophysical Interpretive Report

3.2 Okane Consultants Investigations and RAP

Okane, (2020) developed a Sampling Analysis and Quality Management Plan (SAQMP) to guide field investigations which were aimed at:

- Characterisation of potential contamination sources identified during field activities.
- Determining spatial extents and volumes of contaminated media at the site.
- Gathering further site-specific data to inform development of risk-based criteria.
- Characterising potential borrow materials for use in remedial works.
- Assessing potential for offsite migration to groundwater resources.
- Assess surface water quality.

Based on a background review of existing data (LMP, 2019) which indicated AMD process where ongoing at the site, Okane undertook a range of targeted activities including:

- Acid Based Accounting (to determine risk of acid mine drainage processes for each material type encountered) and further guide field investigations (An overview of these results, which were considered in developing remedial strategies presented in this RAP are presented in Figure 5.
- Further XRF surface screening based on field observations and site mapping (shown in Figure 4)
- Targeted test pitting at former processing areas, mine areas and disturbance areas (areas subject to previous remedial works) (shown in Figure 4)
- Geochemical assessment of contaminated media including via ICP-AES (used to calibrate XRF results), ASLP (to determine contaminant mobility).
- Surface water monitoring across the site (summarised in Section 3.2.5)
- Geotechnical assessment of potential borrows materials at the Site (Details provided in Section 6.1.4)
- Collection of bio accessibility samples to inform the development of RBC based on potential for uptake by receptors under current land use scenarios. (Summarised in Section 3.2.1 for each contamination domain.)
- Advancement and installation of a groundwater monitoring bore (LVGW2) to assess groundwater quality. (Shown in Figure 4 and discussed in Section 3.2.5).

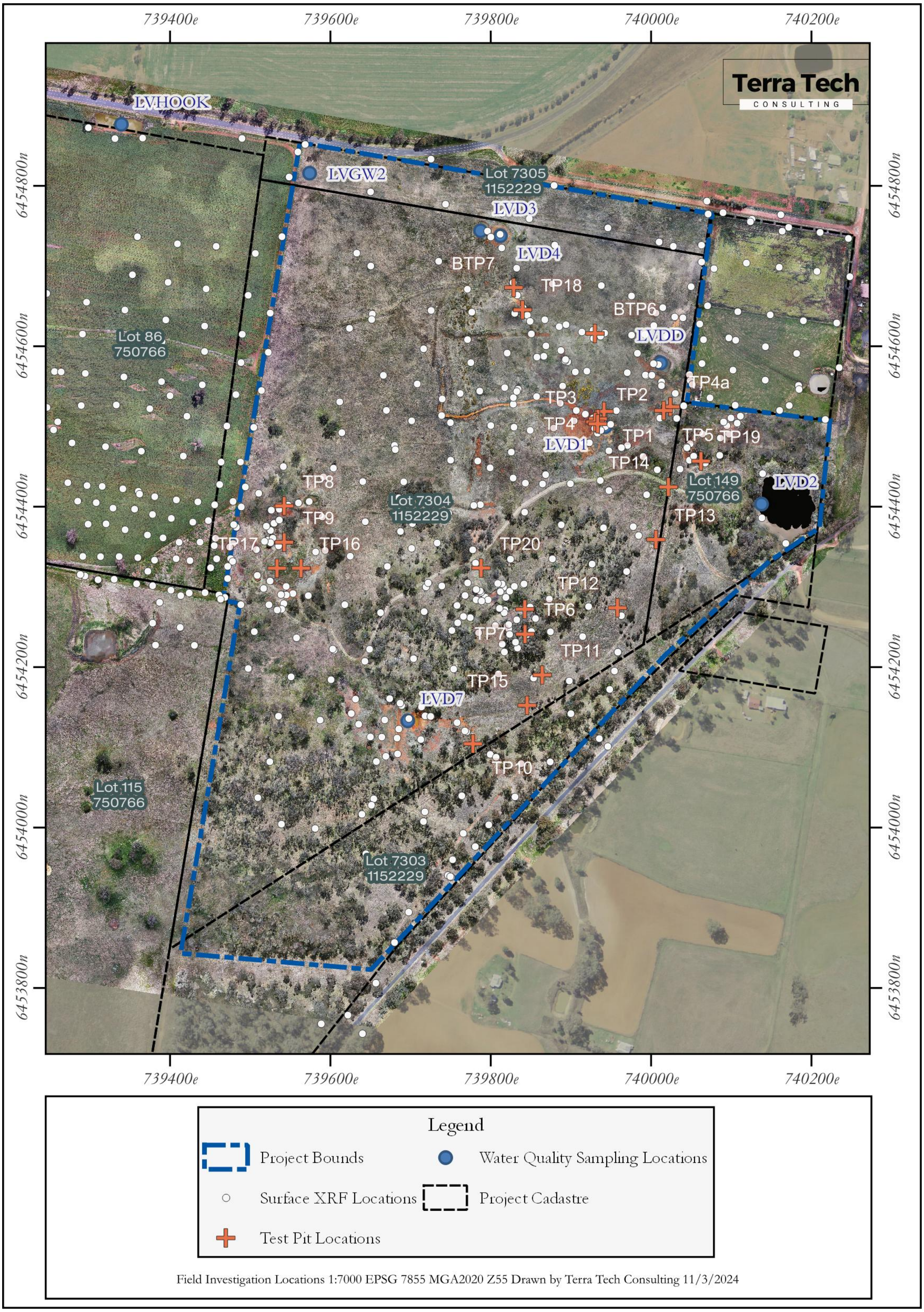

Figure 4 Locations of Okane field investigations.

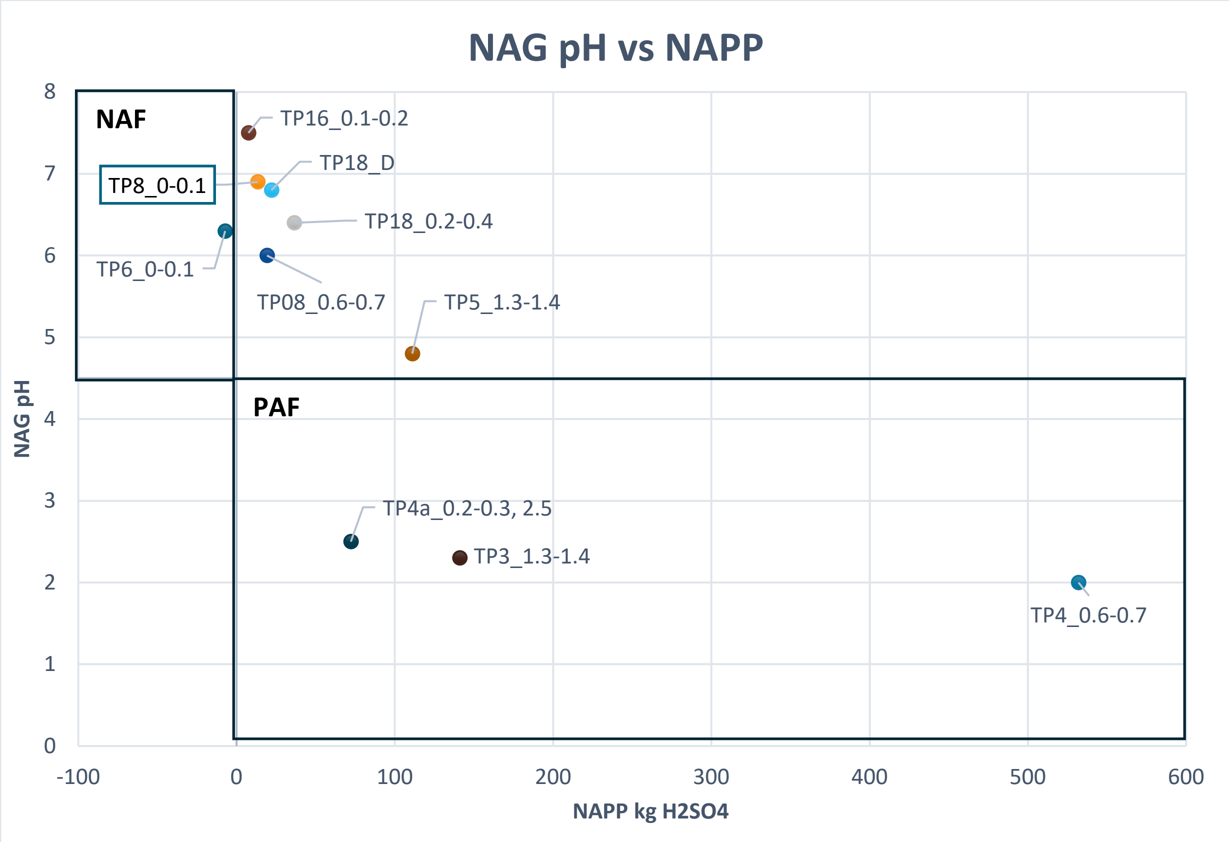

Figure 5 NAG pH Vs NAPP as indicator for AMD Risk at Leadville (Okane, 2022)

Detailed information collected during field investigations is included in the RAP developed by Okane (2021, 2022) with several interactions due to review by the NSW EPA, Crown Lands and the Legacy Mines Department.

Here we summarise key data from this work which has been relied upon to assess risk to offsite receptors based on physical characteristics of waste or contaminated media. It should be noted that Okane, (2022) relied upon XRF and paired 4 acid-digest as the primary tool for assessment of metals in soils. Supplemented with ABA data to determine AMD risk, these data are considered useful for identifying contamination domains and characterising the potential mobility mechanisms for COC which need to be addressed to control risk to offsite receptors.

3.2.1 Grosvenor

Test pitting was undertaken across the Grosvenor area where calibrated handheld XRF was used to guide characterisation and sampling activities. In addition to detailed down-pit XRF (presented in logs and Appendices in Okane (2021)) geochemical analysis was undertaken to assess the risk posed by Potentially Acid Forming (PAF) materials. Geochemical analysis also included bio-accessibility assessments and an assessment of leachable metals by ICP-MS.

On this basis, waste materials at Grosvenor are characterised by either:

- Being associated with naturally mineralised outcrops of mineralised ironstone (including scree and detritus) which is not PAF but high in metals (Pb, Zn, Mn, Fe) (TP16 in Table 5 and Table 6).

- Being associated with fine (silt sized) fraction materials which occur in the Western side of Grosvenor dam (separated from the Eastern dam by a bund – with the Eastern side not showing obvious signs of contamination. The material in the Western side of Grosvenor dam fills the dam depression and extends to 500 mm below ground surface. The material is not PAF but has high levels of total and leachable Pb (TP8 in Table 5 and Table 6).

Table 5 Water Leachable Metals by ICP-MS (Grosvenor)

Sample #	Location	Description	Pb ppm	Zn ppm	Mn ppm	As ppm	Cd ppm
TP8-0-0.1	Grosvenor Dam	Clayey Silt	11.9	2.43	0.392	0.205	0.0108
TP16-0.1-0.2	Grosvenor	Silt IS Fragments	0.821	4.24	2.21	0.006	0.0657
TP8-0.6-0.7	Grosvenor Dam	Clayey Silt	0.782	1.46	1.25	0.001	0.0848

Table 6 Total Metals by 4 Acid Digest

Sample #	Location	Pb %	Zn ppm	Mn ppm	As ppm	Cd ppm
TP8-0-0.1	Grosvenor Dam	4.8	6100	4330	1130	24.5
TP16-0.1-0.2	Grosvenor	1.29	8070	31100	707	55.9
TP8-0.6-0.7	Grosvenor Dam	1.23	2550	2960	243	8.23

Figure 6 Naturally Mineralised Surface Outcrops at Grosvenor and Silty Contaminated Material in Grosvenor Dam

3.2.2 Mt Stewart

Test pitting conducted across the Mt Stewart area where calibrated handheld XRF was used to guide characterisation and sampling activities. In addition to detailed down-pit XRF (presented in logs and Appendices in Okane (2021)) geochemical analysis was undertaken to assess the risk posed by PAF materials. Geochemical analysis also included bio-accessibility assessments, sampling of standing water in a depression at the Main Shaft and an assessment of leachable metals by ICP-MS.

On this basis, waste materials at Mt Stewart are characterised are having ongoing AMD potential as indicated by Net Acid Producing (NAP) results, readily mobilised acidity and dissolved metals. Without remedial works, ongoing oxidation of S is interpreted to continue, impacting runoff water quality with acidification and association dissolution and mobilisation of metals.

Table 7 Metals by 4 Acid Digest (Mt Stewart)

Sample #	Location	Pb %	Zn ppm	Mn ppm	As ppm	Cd ppm
TP3-0.0-0.1	Mt Stewart	1.47	3290	735	367	11.85
TP3-1.3-1.4	Mt Stewart	0.678	15350	3860	482	83
TP4-0.6-0.7	Mt Stewart	2.8	3400	1500	486	17.75
TP4a-0.2-0.3	Mt Stewart	1.075	2810	1280	1040	5.68

Table 8 Water Leachable Metals by ICP-MS (Mt Stewart)

Sample #	Location	Description	Pb ppm	Zn ppm	Mn ppm	As ppm	Cd ppm
TP3-0.0-0.1	Mt Stewart	Sulfidic Waste	0.569	23.9	6.63	0.034	0.155
TP3-1.3-1.4	Mt Stewart	Sulfidic Waste	3.8	9.32	7.25	0.007	0.0664
TP4-0.6-0.7	Mt Stewart	Sulfidic Waste	0.492	64.7	15.2	1.5	0.368
TP4a-0.2-0.3	Mt Stewart	Sulfidic Waste	3.2	22.8	9.02	0.016	0.135
TP5-1.3-1.4	Mt Stewart East	Slag like materials	2.6	119	59.3	0.016	1.14

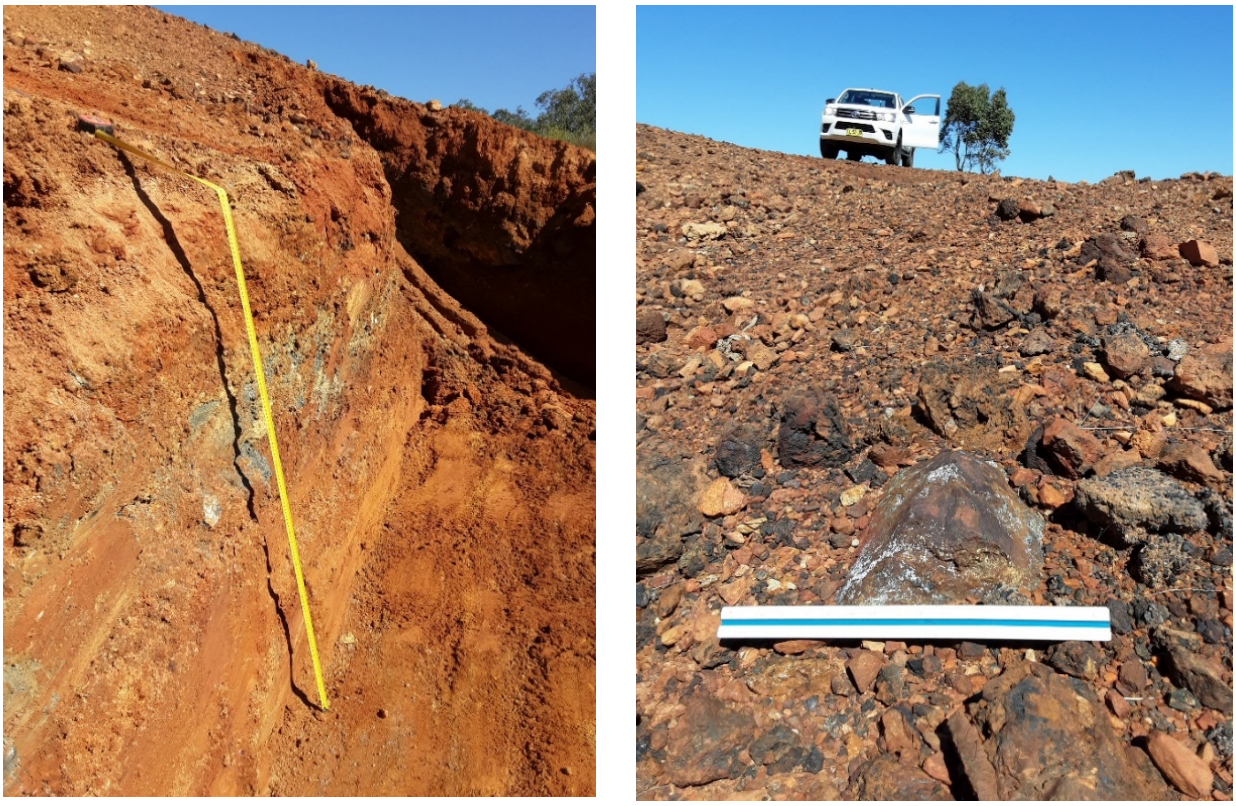

Figure 7 Test Pitting at Mt Stewart and surface photograph of salts on scree at Mt Stewart

3.2.3 Mt Stewart Drainage

Test pitting was conducted across the Mt Stewart Drainage area (TP18, BTP7, BTP6) where calibrated handheld XRF was used to guide characterisation and sampling activities. In addition to detailed down-pit XRF (presented in logs and Appendices in Okane (2021)) geochemical analysis was undertaken to assess the risk posed by Potentially Acid Forming (PAF) materials. Geochemical analysis also included bio-accessibility assessments, and an assessment of leachable metals by ICP-MS.

On this basis, waste materials at Mt Stewart Drainage Materials are characterised by the presence of surface scaring where areas lacking vegetation also indicate high metals (Pb primarily) are present. The material is not PAF and does not have ongoing AMD potential as indicated by Net Acid Producing (NAP) results. Pb is readily mobilised under circum-neutral pH conditions as indicated by Leachate Data (Table 10).

Table 9 Metals by 4 Acid Digest (Mt Stewart Drainage)

Sample #	Location	Description	Pb ppm	Zn ppm	Mn ppm	As ppm	Cd ppm
TP18-0.2-0.4	Mt Stewart Drainage	Clayey Silt	13.5	2.14	4.07	0.006	0.0741
TP18-D	Mt Stewart Drainage	Clayey Silt	6.82	3.51	7.94	0.002	0.192

Table 10 Water Leachable Metals by ICP-MS (Mt Stewart Drainage Materials)

Sample #	Location	Description	Pb ppm	Zn ppm	Mn ppm	As ppm	Cd ppm
TP18-0.2-0.4	Mt Stewart Drainage	Clayey Silt	13.5	2.14	4.07	0.006	0.0741
TP18-D	Mt Stewart Drainage	Clayey Silt	6.82	3.51	7.94	0.002	0.192

Figure 8 Backfilled contaminated material in areas devoid of vegetation (Mt Stewart Drainage)

3.2.4 Smelting Area

Test pitting was conducted across the former Smelting location where calibrated handheld XRF was used to guide characterisation and sampling activities. In addition to detailed down-pit XRF (presented in logs and Appendices in Okane (2021)) geochemical analysis was undertaken to assess the risk posed by Potentially Acid Forming (PAF) materials. Geochemical analysis also included bio-accessibility assessments, sampling of standing water in a depression at the Main Shaft and an assessment of leachable metals by ICP-MS.

On this basis, waste materials at The Smelting are characterised as being a slag like material, in both small stockpiles and cemented surface coverings. The material is (TP6 in Figure 5), relatively high in metals however these are immobile under circumneutral pH conditions as demonstrated by leachate data (Table 11 and Table 12). The materials are not PAF.

Table 11 Total Metals by 4 Acid Digest (Smelting Area)

Sample #	Location	Pb %	Zn ppm	Mn ppm	As ppm	Cd ppm
TP6-0-0.1	Smelting Area	3.79	6250	5800	406	12.1

Table 12 Water Leachable Metals by ICP-MS (Smelting Area)

Sample #	Location	Description	Pb ppm	Zn ppm	Mn ppm	As ppm	Cd ppm
TP6-0-0.1	Smelting Area	Vitreous Slag	1.39	0.199	0.116	0.035	0.0029

Figure 9 Slag Like material at and below surface at TP7 and TP6 (Smelter Site)

3.2.5 Surface Water and Groundwater

In 2021, Okane undertook surface water sampling on standing water across the site and installed a monitoring well in the NW of the site. These locations are shown in Figure 4. Field and lab water chemistry summarised in Section 5.5 of Okane (2021) indicates that at Mt Stewart, in shallow collection depression (LVD1) the concentration of Cadmium (Cd) and Zinc (Zn) surpassed the established guidelines for recreational water use[2]. It is noteworthy that the pH measurements at LVD1 (2.42) and the acidity represented by H_2SO4 align with the anticipated impact of Acid Mine Drainage (AMD). Consequently, these values would not be deemed safe for the purposes of providing drinking water for livestock (incidental consumption) or for human recreational activities (incidental access).

[2] And for RBC Livestock drinking water.

Groundwater quality at the monitoring bore was consistent with water chemistry at bore fed dam on the adjoining property (LVHOOK), being more alkaline and with conductivity.

Table 13 Summary of Water Quality Results for COPC

Analyte	Unit	LVGW1	LVDD	LVD4	LVD3	LVD2	LVD1	LVD6	LVD7
pH Value	pH	7.58	6.84	5.13	4.74	6.39	2.42	6.01	5.7
Electrical Conductivity @ 25Â°C	µS/cm	10200	104	61	103	110	2660	109	116
Arsenic	mg/L	<0.001	0.002	0.002	0.008	0.008	0.066	0.006	0.002
Cadmium	mg/L	0.0064	0.0008	0.0632	0.0392	0.0002	**0.56**	0.001	0.004
Lead	mg/L	0.001	0.023	0.033	0.036	0.049	0.017	0.069	0.031
Manganese	mg/L	0.011	1.58	1.44	1.3	1.54	44.1	0.891	3.56
Nickel	mg/L	<0.001	0.002	0.011	0.01	0.002	0.164	0.005	0.006
Zinc	mg/L	0.014	0.131	2.67	1.32	0.031	**78.6**	0.088	0.592

3.3 Borrow Area Characteristics

Okane (2020) undertook an assessment of potential borrow materials at the site. Okane focused on identification of materials which may be used in subsequent engineering designs in support of the remedial strategy. TP10 – TP15 (Figure 4) were the target locations for borrow materials.

On the basis of the test pitting undertaken and geotechnical sampling which included Emersons, Atterberg limits and Particle Size Distribution the following conclusions were made about the likely hydraulic performance of the material, its suitability for use in remediation works:

- There is an area of finer fraction materials in the South of the Site (based on Test pits TP10 and TP15 and associated results. Based on particle size, saturated hydraulic conductivity (k_{sat}) was estimated using the Kozeny-Carman equation. On this basis, with compaction the material in the low permeability zone is interpreted to be capable of attaining a k_{sat} in the order of $1x10^{-7}$ cm/s and therefore is considered suitable for the construction of features requiring a higher level of control on permeability such as low permeability layers in encapsulations or dam walls and bunds. The material is not considered dispersive and exists from surface to 1 m within the area identified as low permeability. The estimated volumes available for use are approximately 10,705 m^{3}.

- The area identified as general store and release is characterised by gravelly-clay sands The material has a 45% fines content with a low plasticity. Estimated k_{sat} is in the range of $1x10^{-4}$ cm/s to $1x10^{-6}$ cm/s. The material is considered suitable for use in construction of diversion bunds. The material is not considered dispersive and exists from surface to 1 m within the area identified as low permeability in. The estimated volumes available for use are approximately 30,000 m^{3}.

A summary of PSD and Plasticity is included in Section 3.3.1. Conceptual borrow areas are shown in Figure 15. For logs of relevant test pits and geotechnical lab results, see Okane (2022).

3.3.1 Summary of Results (Okane, 2020)

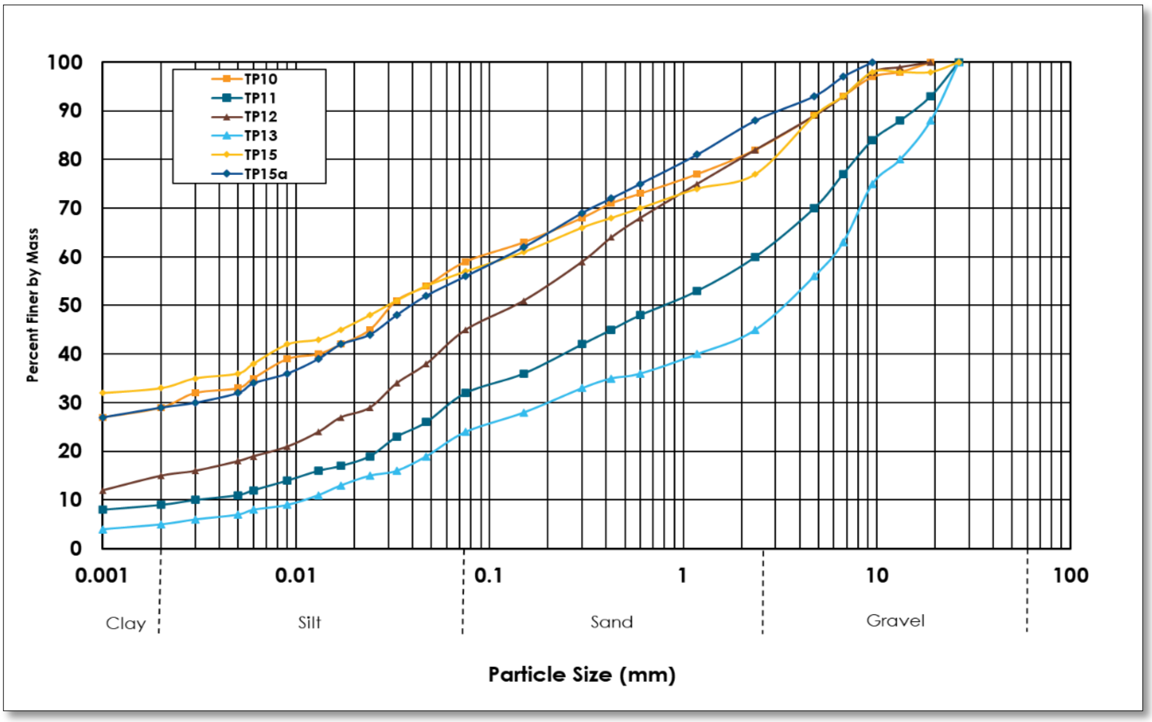

Figure 10 Particle Size Distribution – From PSD and Hydrometer

Okane (2020a)

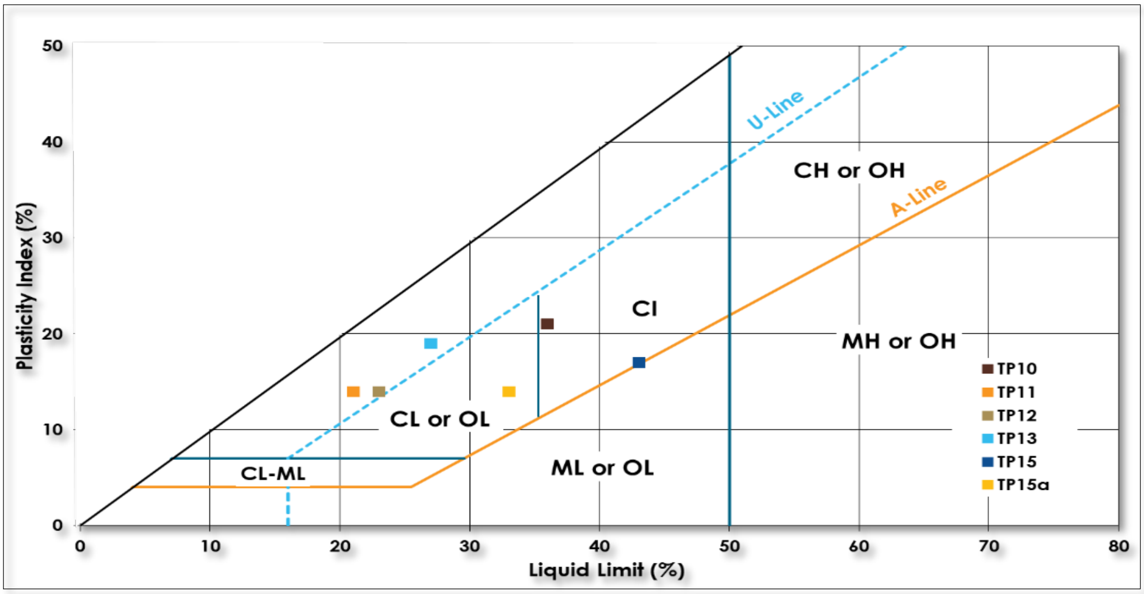

Figure 11 Cassagrande Plasticity Chart, after AS1726:2017

Okane (2020)

3.4 Terra Tech Consulting Survey

Previous Investigations and remedial plans relied upon photogrammetry without ground control points as a basis for survey data. This data was unsuitable for development of IFC documentation, and a recommendation was made within Okane, (2022) to undertake a detailed survey so IFC designs could be developed.

Therefore, as part of this SoW, a detailed survey of the site was undertaken. The survey was completed on 6th and 7th November 2023 at the Site, including:"

- The Site was surveyed using CORS RTK GPS methods and using the Dunedoo CORS base station. Position & height datum was verified locally to PM2977 & SSM1837.
- The coordinates of the survey are MGA2020 grid with a local scale factor at PM 2977 of 1.00024.
- Accuracy +/- 30 mm height, +/- 10 mm position.
- Outputs are 3D .dwg mesh surface, contour shapefile and 3D .dxf.

This data has been made available to the Principal and has been relied upon to develop the designs presented herein.

3.5 GHD Geohazards Assessment

During the planning phase for the remedial activities linked with Okane's (2022) RAP, technical oversight in 2023 involved conducting a hazard evaluation associated with proposed works near underground workings and shafts GHD (2023a). This assessment encompassed a geophysical survey and guidance on operations around historical mine workings and disused shafts.

Following interpretation of geophysical survey data (Resistivity) near-surface underground workings were identified in the Mt Stewart area (shown in Figure 1). GHD developed subsidence management measures to be implemented during works (demarcation, training, restrictions on positioning and movement of heavy plant in, and near to the identified geohazards area. Due to the complexity and residual WHS risk associated with working in and around the workings at Mt Stewart, the remedial work plans nominated in Okane, (2022) for Leadville were reviewed by the Principal, and a decision not to adopt the nominated strategy Mt Stewart (construction of an encapsulation) was taken. This decision included a review of land use goals by stakeholders, and the requirement to develop a new RAP based on these decisions.

4 CONCEPTUAL SITE MODEL

A conceptual site model (CSM) is a representation of site-related information regarding contamination sources, receptors and exposure pathways between those sources and receptors. The development of a CSM is an essential part of all site assessments and remediation action plans and provides the framework for identifying contamination sources and how potential receptors may be exposed to contamination. A detailed CSM has been presented in EnRisks (2022) and key aspects summarised below in order to define the required extent of remediation.

4.1 Sources of Contamination

The potential sources of contamination relate to the former mining activities on the site. This includes naturally elevated metals, elevated metals as a result of mining processes as well as former and ongoing acid mine drainage. The site comprises two subsided mine shafts and a denuded area comprising waste rock, tailings and overburden. The media likely to be impacted as a result of the mining activities include:

- Mining waste and overburden.
- surface soil; and
- surface water and groundwater.

The various mining domains at Leadville are shown in Figure 1 and their characteristics described in Sections 4.1.1-4.1.6 below.

4.1.1 Extended Workings

Surface XRF results at the extended workings indicate that there are dispersed, elevated metals in soil at this location. Previous remediation efforts in this area include the construction of a run-off collection dam which, based on downstream data, indicates that any mobilised metals are being contained within this domain. Grazing of livestock in this area presents an unacceptable risk.

4.1.2 Mt Stewart

The Mt Stewart area is characterised by the presence of PAF materials actively undergoing oxidation, thereby generating Acid Mine Drainage (AMD). This process has been characterized by sulfuric acid production (ABA) and the mobilization of metals such as Fe, Pb, Cd, and Zn from sulfidic compounds. Analysis of sulfide speciation reveals a substantial potential for ongoing acidity production and the presence of soluble sulfur compounds that may be released from the system upon interaction with meteoric water. (Okane, 2021).

AMD processes have resulted in surficial soil scalding spanning approximately 3,200 m^2 within the Mt Stewart Area. These processes have notably influenced the quality of standing water with extremely acidic conditions observed (LVD1 (small depression at Mt Stewart returning pH of 2.64). Concentrations of Cd in standing water (LVD1) surpass recommended recreation and livestock drinking water levels, as specified in the Risk-Based

Concentration (RBC) for the site. Furthermore, the lower pH values observed at locations LVD3 and LVD4 may signify the downstream impact of AMD emanating from this specific area.

The primary source of contamination at Mt Stewart therefore is PAF materials and the associated mobilisation of metals and acidity when this material encounters meteoric water. The volumes of leachate mobilised being dependent on the volume of water interacting with this material.

GHD (2023a) identified an area of subsidence risk due to underground workings directly below the contaminated area at Mt Stewart as shown in Figure 1.

4.1.3 Paddock Shaft Area

Sulfidic material which occurs East of Mt Stewart (Paddock shafts) include a thin veneer of similar characteristics (PAF) as those at Mt Stewart. This material is interpreted to have similar PAF potential as the sulfidic material at Mt Stewart. This material is interpreted to be relict ore material from below zone of weathering and therefore is likely to occur in a thin veneer at surface.

4.1.4 Grosvenor

The area surrounding the Grosvenor workings includes relict backfilled shafts and the remnants of the former stamper battery, which served as an ore mill. Here, gossanous ironstone outcrops are prevalent, exhibiting heightened concentrations of metals, notably Fe, Mn, and Pb. Surface XRF readings showed elevated concentrations of Pb, Mn, and As within the surface layers of naturally mineralized rocks. However, the enrichment of Mn decreases considerably with depth. Materials subjected to Acid-Base Accounting (ABA) testing did not reveal any potential for Acid Mine Drainage (AMD) formation.

Within Grosvenor Dam, total metals in the leachate suggest that Pb, particularly in the western area, would be easily mobilized (Pb in leachate up to 11.9 ppm). Notably, sediment XRF screening in the eastern portion of Grosvenor Dam did not show any signs of contamination. The considerably heightened concentrations of Pb within the Western part of Grosvenor Dam and its observed mobility pose health risks to offsite receptors (neighbouring livestock and humans through impacts to water quality).

The presence of the stamper battery upstream of the Western dam implies that ore milling activities occurred in this area, suggesting that fine ore and waste in the dam likely originated from milling activities upstream. Sediment analysis through calibrated XRF readings and 4-acid digest assays returned a value of 4.8% Lead. The material is interpreted to extend from surface to around 0.5m (see Figure 6 and Test Pit 8 – Appendix D of Okane, 2022).

4.1.5 Smelting Site

The former smelting region is characterised by surficial contaminated features including a loading wall, slag stockpiles, buried slag extending from the surface to 0.8 m depth, and a consolidated slag surface measuring 0.2 m thick. This surface extends across an area believed to have served as a loading zone for a furnace. Analysis reveals markedly heightened concentrations of Pb, Zn, and As within this material. Based on ABA analysis undertaken by Okane (2021), the material is not PAF. In addition, based on ASLP results, these elements are not readily interpreted to be easily mobilized under neutral pH conditions however present an unacceptable risk to livestock through identified uptake pathways (incidental ingestion through grazing).

4.1.6 Mt Stewart Drainage

The area North of the Mt Stewart workings exhibit multiple bare, clayey patches of land where surface XRF analyses have revealed remarkably high concentrations of Pb (up to 200,000 ppm). Disturbance history in this specific area remains inadequately documented. However, focused test pitting at TP18, BTP7, and BTP6, located within areas devoid of vegetation, where the presence of anthropogenic artifacts like pipes and scrap metal suggests potential prior remediation efforts occurred in this location involving the use of contaminated materials as backfill. (Okane, 2022)The ABA (Acid-Base Accounting) suite conducted (Section 5.4 of Okane, 2022) indicates minimal sulfur content linked with heightened Pb levels. This suggests a probable association of this material with PbO_2 and potentially $PbCO_3$ linked to skarn-type ore and waste from early mining stages and is included with other waste material. The extensively elevated Pb content was mobilized upon ASLP analysis and presents a mobilisation risk to offsite receptors via impacts to water quality.

4.2 Potential Receptors and Exposure Pathways

Table 14 presents a summary of the potential receptors and exposure pathways relevant to the proposed use of the site.

Table 14 Exposure pathways and receptors

Media / Receptor	Potentially Complete Exposure Pathways	Comment
Surface Soil / Public and recreational users on the site – adults and children and site workers undertaking remedial works.	Inhalation of dust, ingestion of soil / sediments, dermal contact with sediments	Where the public or workers may have access to the site they have the potential to come into direct contact with contamination that may be present in surface soil. Direct contact may result in ingestion and dermal contact with contamination in soil. In addition, where surface soil is dry there may be some inhalation of dust, where generated by the wind or the recreational use of open areas for activities such as dirt-bike riding (should this occur). While dust inhalation is not expected to be a significant exposure pathway it has been included in this assessment
Dams / Public and recreational users on the site – adults and children	Ingestion of surface water, dermal contact with surface water, ingestion of biota / produce	Where the public has access to the site they may also come into direct contact with sediments and surface water in the dams, where ingestion and dermal contact may occur. Mussels are known to grow in the dams and may be harvested by the public for consumption. Such intakes would only be expected to be infrequent as the dams do not support large numbers of mussels. While the consumption of mussels from the dam is not known, this assessment has considered the risks, should they be consumed. Metals are not volatile and hence there are no exposure pathways identified for the inhalation of vapours.
Surface soil, pasture and dams / Stock – cattle and sheep for meat and wool	Inhalation of dust, ingestion of soil / sediments, dermal contact with sediments, ingestion of surface water, dermal contact with surface water, ingestion of biota / produce	Stock may drink water from the dams and consume pasture grown on the site which may also include surface soil. Intakes from dust is not expected to be significant. These intakes may be of concern for the health of the cattle and sheep (should they be present), or the uptake of metals into produce that may then be consumed (as home-slaughtered meat consumption[3]). Grain crops may also be grown on the site, and the community may be exposed to contaminants taken up into grains where used in consumable products.

4.3 Extent of Required Management or Remediation

The extent of remediation has been determined by:

- Comparison of heavy metal levels (specifically As, Pb and Mn) in surface soils / sediments to the Risk based Criteria (RBC) presented in EnRisks (2022). It is noted that EnRisks (2022) states any management measures implemented to address As, Pb, Mn will also address the presence of other metals in site soils and sediments. As such, the RBC presented in Table 15 for the key heavy metals have been used to inform the extent of required management or remediation, where any exceedances of these criteria have been shown on Figure 12.

- Comparison of heavy metal levels in surface water / dams to the RBC presented in EnRisks (2022). It is noted that for LVD1 (Mt Stewart) constituents in surface water exceeded the RBC and therefore will require management in order to address potentially unacceptable risks associated with recreational exposures as well as livestock ingestion.

[3] Commercial meat is subject to assessment for contaminants prior to sale in accordance with *Australian Standard for the Hygienic Production and Transportation of Meat and Meat Products for Human Consumption AS 4696 (Australian Meat Standard)*

- Highly impacted materials that exhibit on-going leaching or AMD characteristics require remediation in order to address potential off-site migration issues and on-going source to surface water impacts. The extent of highly impacted materials that exhibit on-going leaching or AMD characteristics was informed by the presence of sulphides identified in test pitting and associated ABA test work (Okane, 2021) by Okane, summarised in Figure 5.

Table 15 RBC for Soil / Sediment.

Contaminant	RBC (mg/kg)				
	Recreational exposures	Livestock Health (cattle – assuming 2 months grazing per year)	Livestock Health (sheep– assuming 2 months grazing per year)[4]	Livestock Health (cattle – assuming 12 months grazing per year)	Livestock Health (sheep– assuming 12 months grazing per year)
As	2,000	1,200	180	200	30
Pb	6,600	3,600	440	830	110
Mn	140,000	95,000	25,000	16000	4200

[4] RBC (Sheep) for COPC are lower than cattle. Therefore, these criteria have been applied in defining the extents of grazing can occur without exposure to materials which exceed RBC.

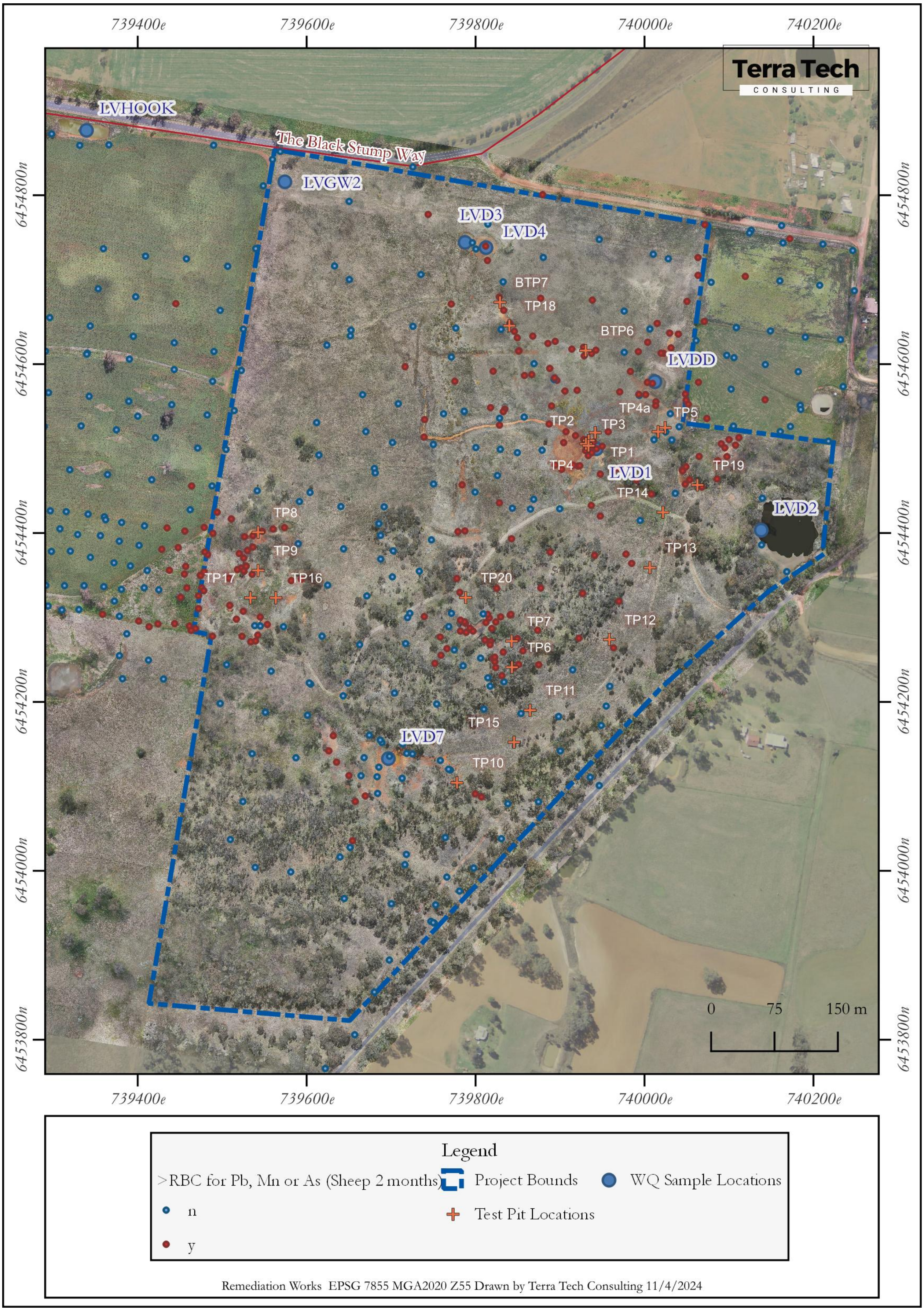

Figure 12 Exceedances of RBC for COPC

4.4 Summary of Impacts Requiring Management or Remediation

On the basis of the assessment presented in Section 4.3, Table 16 summaries the requiring management or remediation within each media at the site.

Table 16 Media requiring management or remediation.

Media	Impact	Action Required
Soil	Heavy metal impacted soils or sediment posing a potential risk to recreational users of the site or livestock.	Remediation (via isolation) or on-going management of access (Areas where limited grazing can occur).
	Highly impacted materials that exhibit on-going leaching or AMD characteristics.	Remediation (via excavation and off-site disposal or the construction of surface water diversion bunds in areas of geohazards) and on-going management
Surface Water	Heavy Metal Impact and pH (LVD1)	On-going management and control on access at source points.

5 DEVELOPMENT OF REMEDIATION STRATEGY

5.1 Site Goals

The remedial goals of the project, provided by the Principal are to develop remedial designs which:

1. *"Contain all contaminates to site and limits contaminates from leaving the site and;*
2. *"Allow grazing of livestock (Sheep and Cattle) on the remaining areas of the site in some capacity"*

In developing remedial designs which meet these goals, TTC have considered the following defining constraints which apply to the site:

- The limitations of undertaking heavy and bulk earthworks over areas proximal to geohazard risks identified in GHD, (2023a); and
- The elevated surface concentrations of COPC in soils across the site (primarily As and Pb) which exceed adopted RBC at 94% of soil sampling sites for cattle and sheep under a 12-month access scenario. As such, remedial measures have been designed to allow for livestock grazing over a maximum period of 2 months per year on site by isolating areas in which more elevated heavy metals are present.

As such, the RAP sets the remedial goals of removing the risks posed by the identified potential contamination issues, to make the site suitable for agricultural purposes (that allows livestock grazing for a period of 2 months per year) whilst addressing migration of impacts from the site.

5.2 Adopted Remediation Criteria

Previous investigations identified varying levels of heavy metal impacted materials that have been broadly categorised into the following three categories summarised below and outlined in Table 15.

1. Diffuse impact managed by institutional controls. These areas have been defined as those with elevated heavy metal impacts (with low risk of migration) in surface soils that preclude unrestricted grazing. These areas essentially comprise of all areas beyond those categorised as 2 or 3 below. Access to these areas will be restricted to minimise risk to the public and livestock will only be allowed to graze for a maximum period of 2 months per year in these areas.

2. Moderately to highly impacted materials which do not exhibit mobility of COPC (Smelter site and Grosvenor with the exclusion of Grosvenor Dam). These areas have been defined as those with heavy metal impacts that exceed the RBC protective of recreational exposures or protective of livestock when allowed to graze for a maximum period of 2 months per year. These areas are shown on Figure 14. Access to these areas will be restricted to minimise risk to the public and livestock grazing will not be permitted in these areas.

3. Highly impacted materials that exhibit on-going leaching or AMD characteristics as shown on Figure 14. These areas have been identified from previous investigations to exhibit potential for impact to surface waters and remedial works are required to address potential migration of impacts. It is noted that the

adopted remedial approach to address this category of impact will be contingent on the presence of unacceptable safety risks (i.e. presence of near-surface underground workings).

Table 17 Categories Adopted for Guiding Remedial Requirements

#	Category	Domain	Characteristics	Remediation Requirements
1	Diffuse impacted	Remaining Areas of site (excluding cat # 0, 2 and 3)	• Elevated metals in surface, no obvious signs of subsurface contamination. No obvious signs of phytotoxicity. No evidence of mobility or offsite pathways.	Limit on grazing to two months per annum (yellow area in Figure13)[5]
2	Elevated metals content with low mobility	Grosvenor and Smelter Site	• Pb Content > RBC for Pb at smelter site 6,600 mg/kg.[6] • ASLP<RBC for recreational/livestock drinking water guidelines.[7] • No AMD potential (NAG/NAPP)	Isolation (no grazing or public access) red area).
3	Elevated metals and corresponding high leachate potential or High ongoing AMD potential.	Mt Stewart, Mt Stewart Drainage, Paddock Shaft Area and Grosvenor Dam	• Pb Content > RBC for Pb at Mt Grosvenor Stewart Drainage 9800-10000 mg/kg[8] • ASLP> RBC for recreational/livestock drinking water guidelines. • Significant AMD potential (NAG/NAPP)	Offsite disposal or drainage controls *where geohazards are present.

Remedial strategies for Leadville mine were developed in consideration of:

- The characteristics of materials within domains at the site and the risk they present to receptors at the site under defined land use scenarios.
- Limitations on undertaking large scale bulk earthworks within the identified geohazards zone (See Section 3.5).
- The risk highly impacted materials present to offsite receptors (via impacts to water quality).

These domain-based strategies are summarised in Table 17.

5.3 Preferred Remedial Options

The remedial strategy developed in consultation with the Principal is:

1. Smelter site (surface soils comprise Category 2) – Leave in-situ and fence.
2. Mt Stewart (surface soils comprise Category 3) and the area contains geohazards that preclude excavation) – Drainage controls to divert unimpacted meteoric water away from the Mt Stewart source

[5] It is assumed that individual cattle would not graze the TSR more than two months per year therefore these areas are not fenced or included in the yellow area on the map.
[6] Recreational exposures for Pb based on Bioavailability of this material presented Table 22 EnRisk (2022)
[7] Recreational exposures for Pb based on Bioavailability of this material presented Table 22 EnRisk (2022)
[8] Recreational exposures for Pb based on Bioavailability of this material presented Table 22 EnRisk (2022)

point (where AMD potential was evident), collect contaminated runoff within a prescribed catchment area and fencing to prevent access.

3. Paddock Shaft Area (surface soils comprise Category 3) Strip area of sulfidic material to 200 mm, place material within Mt Stewart contaminated water catchment (estimated volumes 70m^3).[9]

4. Grosvenor general area (surface soils comprise Category 2)–Leave in-situ and fence due to location of shafts and mineralised workings.

5. Grosvenor Dam (surface soils comprise Category 3)– Excavate and send material offsite for disposal in a licenced waste disposal facility.

6. Mt Stewart Drainage (surface soils comprise Category 3) – Excavate and send material offsite for disposal in a licenced waste disposal facility.

7. Install rural fencing around areas where grazing should be managed in accordance with the prescribed limitations included in the site EMP. This would include limiting access of livestock to the site for 2 months per annum.

An overview of the adopted remedial strategies by domain are shown in Figure 13 and Figure 14. It should be noted that whilst minor exceedances of COPC occur in isolated occurrences outside prescribed restricted grazing areas, these are not considered significant. In addition, it is assumed that individual cattle would not graze in the TSR for more than 2 months per year. That is statistical analysis of the dataset was conducted in all areas proposed for grazing as provided in Appendix D. The 95% UCL of mean lead concentration was calculated at 173 mg/kg (below the grazing criterion for Sheep under a 2-month grazing scenario), the standard deviation (114 mg/kg) was less than half the criterion and the maximum concentration (73 mg/kg) was less than 250% of the criterion. As such, the extent of proposed fencing (as shown on Figure 14) will be adequately protective of livestock when allowed to graze for a maximum period of 2 months per year and any isolated exceedances of lead criterion are not considered to pose an unacceptable risk.

[9] The volume calculations presented here as estimates based on site observations undertaken during field works conducted by Okane, 2022. Validation that contaminated materials have been removed are required and are discussed in Section 6.2.2.

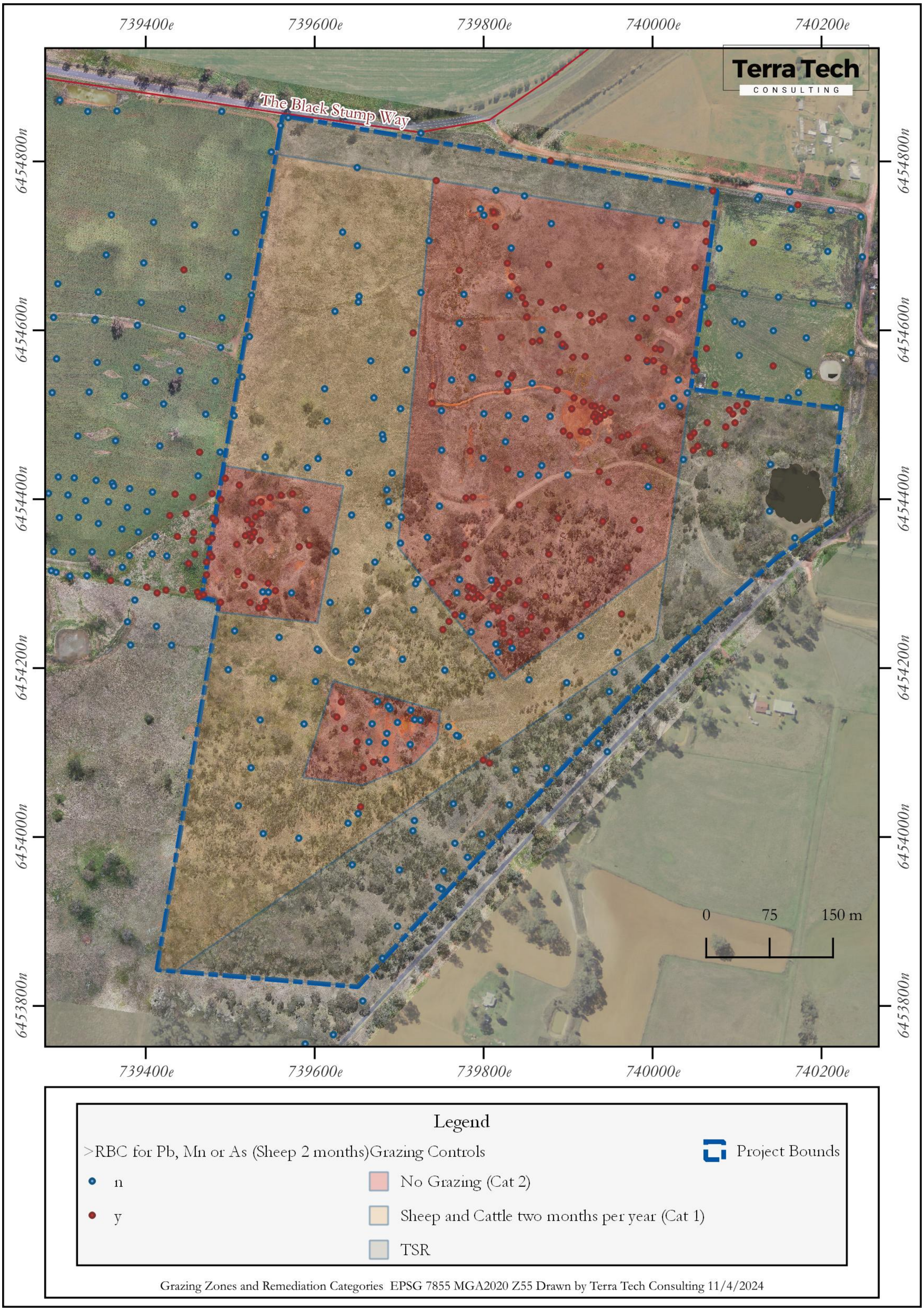

Figure 13 Remedial Extents – Grazing Restrictions

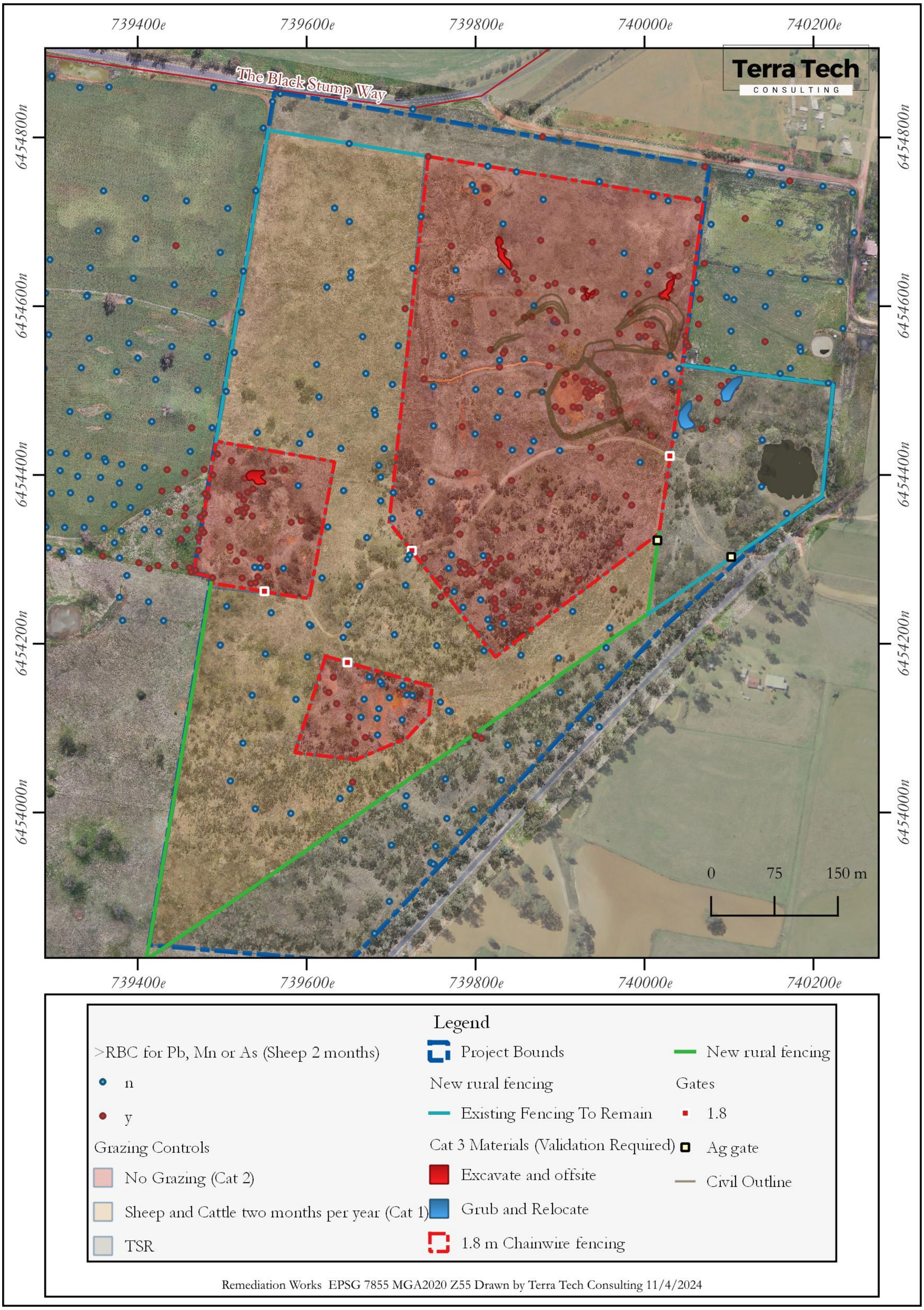

Figure 14 Remediation Extents – Fencing and Civils

5.4 Regulatory Policy of Remediation

5.4.1 State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007

The plans for remediation of the Site fall under SEPP 2007, which holds precedence over LEPs, as detailed in Part 1, Section 5 (3) of the Policy. This section asserts that in cases of inconsistency between this Policy and other environmental planning instruments, the Policy takes precedence.

Subclause 4 specifically excludes certain State Environmental Planning Policies from this rule, namely (a) *State Environmental Planning Policy (Major Projects) 2005* and (b) *State Environmental Planning Policy (Coastal Management) 2018*. Notably, the proposed mine rehabilitation area lacks coastal wetlands, littoral rainforests, or ongoing major projects.

SEPP's Clause 10(3) exempts development for minimal environmental impact on approved mine sites, petroleum production facilities, or extractive industry lands. This exemption includes demolition aligned with the Australian Standard AS 2601—2001 for structures not classified as heritage items or within heritage conservation areas. While the proposal would not be considered exempt under the SEPP, regarding Cl.6(b), development may be carried out without development consent for:

(a) rehabilitation, by or on behalf of a public authority, of an abandoned mine site

5.4.2 Other Approval Requirements

Whilst the SoW of this RAP does not include an assessment of approval requirements beyond identifying the potential eligibility of the works to be development exempt per the MPPEI SEPP (2007), it should be noted that a range of other environmental and planning legislation may apply to the works. These include:

- *Environment Protection and Biodiversity Conservation Act 1999*
- *Biodiversity Conservation Act 2016*
- *NSW Native Vegetation Act 2003*
- *NSW Heritage Act 1977* and the *Commonwealth Australian Heritage Council Act 2003*

Although a Review of Environmental Factors (REF) has been previously completed, remedial goals, their extent and nature have changed. Therefore prior to the works described herein being implemented, it is recommended that that the previous REF (Lesryk, 2022) be reviewed and revised if required to consider approval requirements for prescribed works within the context of applicable legislation and approval requirements.

6 REMEDIATION WORKS

6.1 Description of Design Methodology for Drainage Network

Scheduling and specific methodology for the construction of the drainage network should be provided by the nominated Principal Contractor. This section provides an overview of the materials required for construction of the design. Further details are included in the Drawings provided and associated Bill of Quantities (Appendix A and Appendix C). The design has been developed to ensure that all works including those conducted by heavy plant can be executed without use of heavy plant within geohazard zones. Refer to Section 7.4 for specific recommendations provided in GHD (2023a).

A series of diversion bunds will be developed to convey unimpacted water around the Mt Stewart zone. Within the geohazard zone, a separate contaminated (dirty water) catchment will be developed and the resulting flows to be routed via a network of diversion bunds to their respective containment dams for each area. Flows from clean water catchments are proposed to be routed via a network of diversion bunds and dispersed over non contaminated ground to the downstream reaches of the catchment.

The diversion bunds have been designed to convey runoff up to and including the 1% Annual Exceedance Probability (AEP) storm event. A minimum 300mm freeboard has been allowed for to account for silt up of the channel and the potential for damage from fauna over time.

The containment dams have been designed utilising continuous rainfall simulation utilising ‘MUSIC’ software. The rainfall data used in the model was sourced from the Bureau of Meteorology (BoM) for the Dunedoo Post Office rain gauge. Potential evapotranspiration data was sourced from the BoM for the Dunedoo area and was included in the model. The containment dams have been designed to empty over time via evapotranspiration after ‘frequent’ rainfall events (i.e 20% AEP storms and lower). The remaining storage volume in the Dam following ‘frequent’ rainfall events is sufficient to contain the 2% AEP design rainfall event without the dams overtopping.

For more severe rainfall events. i.e the 1% AEP rainfall event the dams may overtop via a spillway. The spillway has been designed to convey the 1% AEP flow event with rock scour protection to withstand the velocity of the flow and maintain the integrity of the dam bunds. The overtopping flow is controlled to reduce velocity of the flow to a level below the scour velocity of the downstream ground cover.

6.1.1 Overview of Construction Methodology for Drainage Network

The drainage management system including the diversion bunds, dam bunds and drainage channels are to be constructed out of borrow material soils sourced from borrow areas. The location of the drainage management system components has been placed to avoid construction work over geohazard locations. There are features which occur within the geohazard zone including bunds however placement of 3 m bunding width in this zone is achievable without placement of heavy plant on the zone via use of excavator reach from areas where geohazards do not occur in the subsurface. This will require demarcation of geohazard zones as discussed in Section 7.4.

The dam bunds are to be constructed out of low permeability soils sourced from borrow area designated as containing low permeability soil. The construction of the dam bunds are to be in accordance with the details provided on drawing C10. The toe of the dam bunds are to be protection by rip-rap scour protection underlain by non-woven geotextile.

The diversion bunds are to be constructed out of borrow materials sourced from the borrow area designated as containing ‘store and release’ materials. The construction of the diversion bunds are to be in accordance with the details provided on drawing C10. The toe of the bunds and invert of the diversion channel are to be protected by rip-rap scour protection underlain by non-woven geotextile. Concrete pits and uPVC pipes are proposed where required to drain trapped low points caused by the bund construction.

6.1.2 Scour Protection

As detailed in C01 (Appendix A) The following specifications apply to construction of contaminated catchment dam at Leadville:

- The thickness of the rip-rap protection shall be a minimum of the D50 stone size specified on the drawings. the stone shall be well graded in accordance with the table provided in drawing C01.
- Rock is to be hard, dense, durable, resistant to weathering and angular shape.
- It shall be free from overburden spoil, shale and organic matter. rock that is laminated, fractured, porous or otherwise physically weak is unacceptable.
- The properties of the rock shall be in accordance with AS2758.6 specification. For erosion control to the satisfaction of the principal’s representative.
- An approximate guide to stone shape is that breadth or thickness of a single stone should be not less than one-third its length. round material can be used as rip rap provided it is not placed on slopes greater than 3h:1v.
- Geotextile under rock filled mattress and rip-rap to be in accordance with TFNSW specification R63.
- Rocks and boulders to have total unit weight of 21 to 27kn/m3.
- All riprap specified on the drawings are placed rocks.

6.1.3 Dam Construction

As detailed in C01 (Appendix A) The following specifications apply to construction of contaminated catchment dam at Leadville:

- The base of the embankment should be stripped of all topsoil, silt, loose material, vegetable matter, and then scarified over its whole area.
- Topsoil is to be stripped to be a minimum 200mm to expose sub-grade and stockpiled in an appropriate location to be managed by the contractor.

- All fill material for the embankment should be placed in layers (or lifts) no greater than 150mm thick.
- The largest size particle should not be greater than 1/3rd the height of the lift, that is, 50mm.
- Each layer should be thoroughly compacted before the next layer is placed. A minimum of 6 passes to achieve the required compaction effort is generally required by a suitable machine (see below).
- The compaction effort achieved should be on average 98% standard maximum dry density (MDD) (non-structural fill) as in context to modified MDD (structural fill) as per Australian standard: AS1289.0-2000 methods of testing soils for engineering purposes.
- The minimum compaction effort should be 95% standard MDD. The moisture content should be in the range of –1% to + 3% of optimum moisture content (OMC). if the material is too dry, water should be added. if the material is too wet it should be spread and mixed.
- Prepare the site under the embankment by ripping a minimum of 100mm to ensure bond between existing substrate and compacted fill. before each additional 150mm lift is added to the embankment, the preceding lift should be scarified to ensure that the two lifts are properly joined so that no natural paths for seepage are present that may result in dam failure.
- Maintain cut-off trench free of water.

6.1.4 Earthworks Specifications

As detailed in C01 (Appendix A) the following specifications apply to earthworks to be conducted during the remedial works prescribed in this RAP:

- Earthworks to be in accordance with AS3798, the referenced current Australian standards.
- Spoil to be reinstated on-site as per drawing spec.
- All topsoil fill to be taken from borrow area (store and release) on-site.
- Stripping of topsoil and vegetation should only be completed within the remediation work extent. vegetation should be pushed over (not chipped) and dragged (in manageable portions to a location on-site which does not impede safe ingress / egress or works. re-use cleared vegetation on re-vegetated areas as appropriate.
- All fill should be placed and compacted under level 1 supervision as specified in AS3798. the contractor to provide level 1 certification upon completion of earthworks.
- Topsoil to be excavated minimum 200mm to expose sub-grade & stockpiled.
- Sub-grade to be compacted and tested as specified. any soft or weak areas detected are to be excavated and replaced by compacted fill as per specification.

- Tests shall be undertaken on any proposed fill materials to ensure that they do not have a high dispersion potential as defined by the emerson crumb/dispersion tests (AS1289 C8-1980).
- All earthworks shall be tested and certified by a NATA. registered laboratory. all test certificates, accompanied by an overall site plan, clearly indicating the location of each test and fill areas etc., and the laboratory certificate covering the whole of the area tested are to be forwarded to the design representative upon completion.
- Unsuitable materials (e.g. loose rock or soft soil, roots or other organic materials) must be removed and replaced by approved engineered fill or as approved by the principal.
- Backfill materials should be free from any organic, plastic, metal, rubber or any other synthetic material, inorganic contaminants, dangerous or toxic material or material susceptible to combustion. materials should consist of naturally occurring or processed materials that are capable of being compacted in accordance with AS3798.
- Fill is to be sourced from identified areas. no fill is to be imported without notifying the principals representative for approval.
- Fill to be compacted to achieve a compaction (standard compactive effort) when tested in accordance with AS1289.5.1.1.
- In areas to be filled where the slope of the natural surface exceeds 1(v):4(h), benches are to be cut to prevent slipping of the placed fill material.
- All batters are to be scarified to a depth of 50mm to assist with adhesion of top soil to batter face.
- Provide minimum 100mm and maximum 200mm topsoil to all filled areas and all other areas disturbed during construction. topsoiled areas to be stabilised with seed as per specification after topsoiling and is to be watered to ensure germination.

6.1.5 Management of Borrow Materials

The fill material required for the construction of the drainage network and the remediation of excavated areas are proposed to be sourced from borrow areas (Figure 15). The methodology for the excavation of borrowed material is as follows:

- Strip surface by 200mm to remove topsoil and vegetation. Stockpile adjacent to borrow areas for reinstatement after completion of excavation.
- Excavate required borrow material volume and type up to a maximum depth of 1.5m from existing levels.
- Shape bulk earthworks levels to ensure free flow of water off the surface and safe batters back to existing levels.

- Reinstate stripped topsoil material in an even layer over the disturbed area and apply seed mix as prescribed in Table 18. Apply granular fertiliser to the disturbed area at the rates prescribed in Section 6.2.

Refer to Appendix A for earthworks designs.

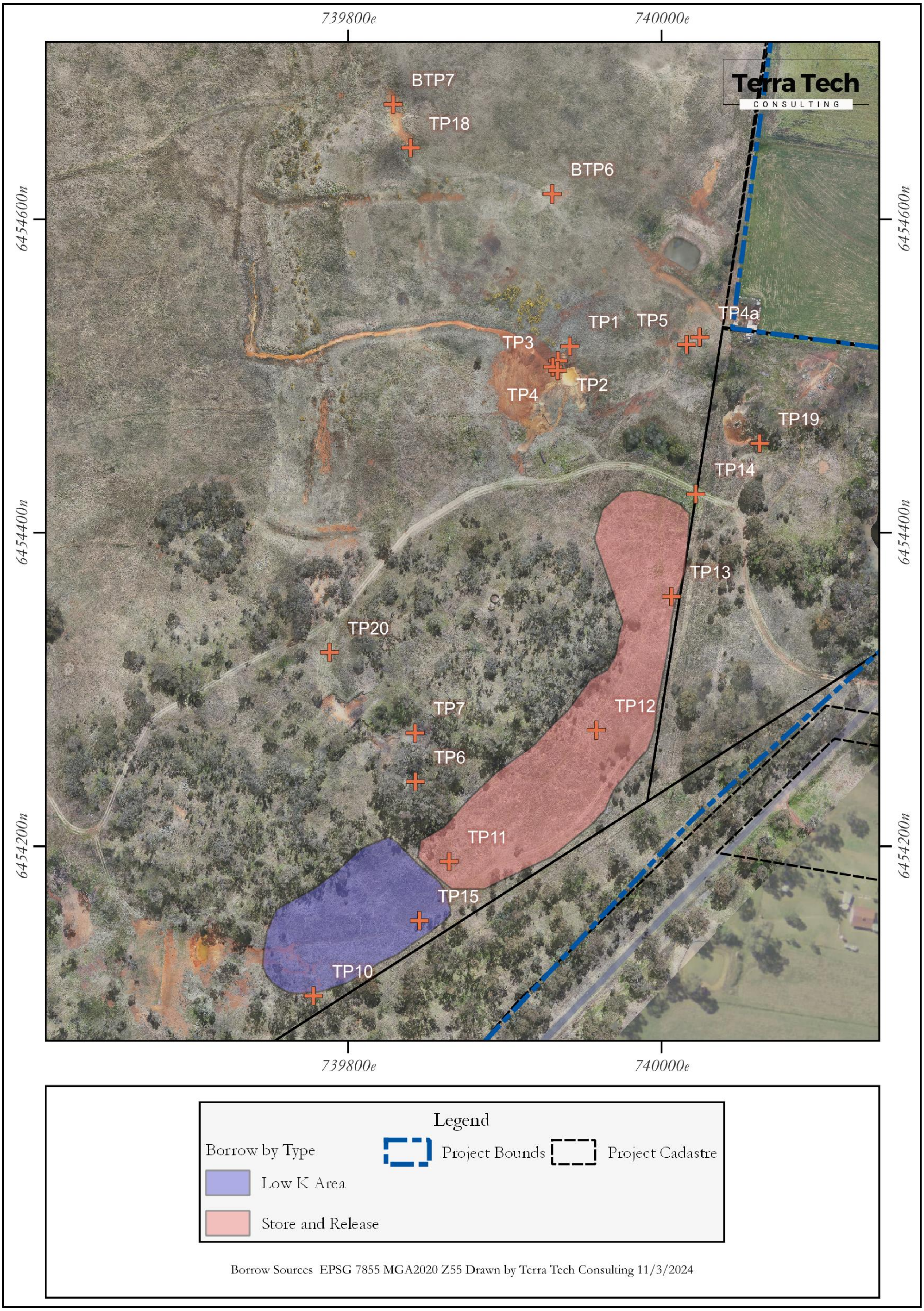

Figure 15 Borrow Areas by Type

6.2 Excavation and disposal of contaminated material

The remedial extents for excavation and offsite disposal are defined in Figure 16 and provided as .DXF for reference by the Remedial Works Principal Contractor'. The required methodology is as follows:

- Remove material to the depths and volumes prescribed for each location.
- Characterise the waste according to relevant state waste classifications (EPA, 2014) for NSW or DES, 2021)[10] prior to acceptance at licenced waste facility. (See Section 6.2.1)
- Dispose to a licenced waste disposal facility in accordance with applicable legislative requirements for transport and disposal of waste in nominated jurisdiction.
- Reinstate the void with borrow material sourced from the borrow area (Shown in Figure 15)
- Traffic compact and rip reinstated areas to surrounding surface RL.
- Apply the seed mix prescribed in Table 18 to the area disturbed. Seed should be mixed with a sand broadcast medium at a rate of 2.1 kg seed mix /250 kg and the mixture applied at a rate of 252 kg (sand and seed mixed) per Ha.
- Apply granular fertiliser to the disturbed area at the following rates (DPI, 2005)
    - Nitrogen (N): Around 40-60 kg/ha
    - Phosphorus (P): Approximately 20-30 kg/ha.

Table 18 Seed Mix for Revegetation of Excavated Areas

Species	Rate g/Ha
Any combination of the following species to 20 %: *Acacia buxifolia* *Acacia implexa* *Acacia paradoxa* *Acacia decora* *Acacia implexa*	100 g/ha
Any combination of the following species to 30 %: *Poa sieberiana* *Themeda australis* Rytidosperma spp Austrostipa spp. Austrodanthonia spp Aristida ramosa Aristida personata Cymbopogon refractus,	2000 g/ha

[10] As defined by Schedule 9 of the Environment Protection Regulation (QLD) 2019

6.2.1 Indicative Waste Classification for Materials to be Removed Offsite

During development of conceptual designs for consideration by the Principal TTC compared existing total metals and leachate data[11] against NSW Waste Classification Guidelines. Indicative classification has been provided in Table 19. The remedial works Principal Contractor will be responsible for classification of waste in accordance with the requirements of the licenced waste disposal centre which is designed and approved to accept relevant waste.

Table 19 Indicative Waste Classification Guidance for material to be disposed of offsite.

Domain	Max total Pb (mg/kg)	Max Pb (TCLP) (mg/L)	Max total As (mg/kg)	Max As (TCLP) (mg/L)	Max total Cd (mg/kg)	Max Cd (TCLP) (mg/L)
Mt Stewart Drainage	51800	13.5	541	0.006	15.1	0.192
Grosvenor Dam	48000	11.9	1130	0.205	24.5	0.0848
SCC1/TCLP 1	1500	5	500	5	100	1
SCC2/TCLP 2	6000	20	2000	20	400	4
Mt Stewart Drainage	Indicative Waste Classification per NSW EPA (2014) - Hazardous Waste					
Grosvenor Dam	Indicative Waste Classification per NSW EPA (2014) - Hazardous Waste					

6.2.2 Volumes and Location of Contaminated Materials to be Removed.

Figure 16 provides a plan view of required excavation extents. Each of the areas designated for offsite disposal should be excavated to the prescribed volumes and disposed of to a licenced waste disposal facility, material to be excavated should include heterogenous of fill material. Excavations should be ceased at the natural-fill boundary. These locations include:

Grosvenor Dam:

Excavate 44.5 m^3 to 0.5m within the prescribed boundary and transport material offsite for disposal in a licenced waste disposal facility.

Mt Stewart Drainage:

MTS1: – Excavate 196 m^3 to 0.9 m within the prescribed boundary and transport material offsite for disposal in a licenced waste disposal facility.

MTS2: – Excavate 58.4 m^3 to 1 m within the prescribed boundary and transport material offsite for disposal in a licenced waste disposal facility.

[11] Noting the leachate methodology Okane adopted does not comply with the requirements for TCLP as prescribed in EPA (2014) and is considered indicative

MTS4: – Excavate 44.5 m^3 to 0.3m within the prescribed boundary and transport material offsite for disposal in a licenced waste disposal facility.[12]

Paddock Shaft:

Strip area of sulfidic material to 200 mm (150m^3), place material within Mt Stewart contaminated water catchment.[13]

[12] MTS3 will remain in situ – this material is within the contaminated water catchment and is not interpreted to extend as fill below surface.
[13] Provided the area can be validated in accordance with the guidance set out in Section 8 of this document no ongoing management or grazing restriction in this area is required.

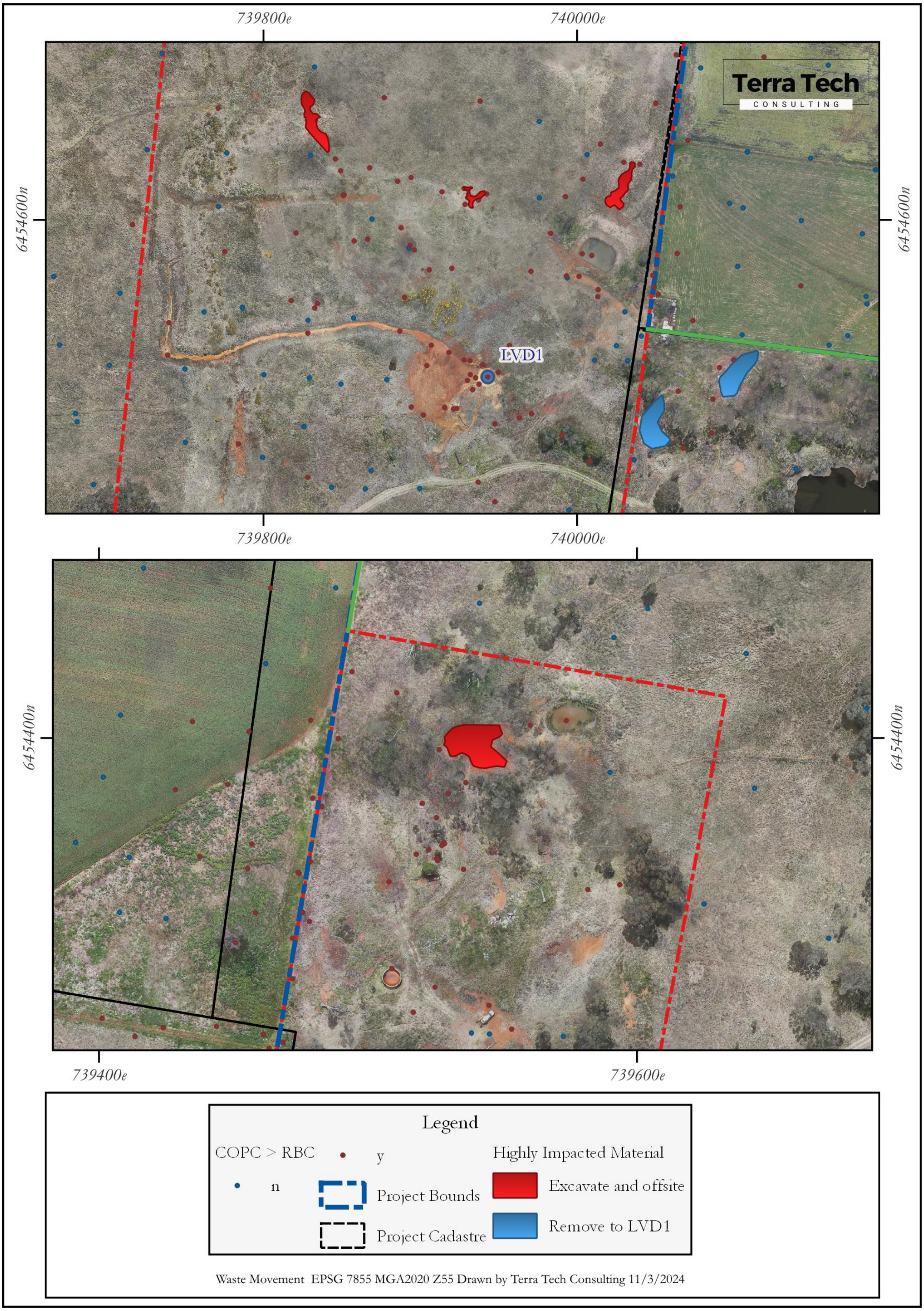

Figure 16 Locations where excavation and/or offsite disposal is required.

6.2.3 Materials Classification, Excavation and Offsite Disposal

Prior to disposal at a licenced waste disposal facility, waste must be classified according to the relevant state waste classification guidance. Relevant guidance may include:

- *Schedule 9 of the QLD Environmental Protection Regulation 2019.*
- EPA Waste Classification Guidelines (EPA, 2014*)* in accordance with Schedule 1 of the *Protection of the Environment Operations Act 1997 (POEO Act):*

6.3 Fencing

Fencing of the site is prescribed as an effective deterrent from access by third parties and incidental access and uptake by livestock and other fauna which may be consumed by humans. The nominated alignment is shown in Figure 14. Gates on the fencing are prescribed for access by land managers as needed, specifications are shown in C01.

7 REMEDIATION MANAGEMENT

7.1 Environmental Management Plan

Since this RAP proposes on-site containment of contamination, it necessitates the development of an Environmental Management Plan (EMP) specific to the site. This plan should outline its objectives and cover:

- Details regarding the remaining contamination on-site and its nature and location.
- Strategies for long-term site management ensuring continual protection of human health and the surrounding environment, both on and off the site. This would include monitoring of erosion, water quality and any evidence of phytotoxicity caused by contamination.
- Clear mechanisms for monitoring enforcement.
- Additionally, the environmental management plan should demonstrate its feasibility for long-term implementation and acknowledge the potential consequences of inadequate execution during its formulation. It must provide comprehensive details and clarity about the site and necessary actions, making it easily comprehensible as a standalone document (NSWEPA, 2020).: The EMP would also include measures for monitoring performance of the adopted remedial strategies in relation to achieving land use goals.
- Monitoring of the integrity of drainage features.
- Monitoring of the integrity of fencing and access controls.

7.1.1 Long term performance monitoring

The catchment dams have been designed to withstand and accommodate a 1:50 year ARI for 168 hours. Where the dam overtops under a severe storm scenario (> 1: 50 years) there is potential for contaminated water (although significantly diluted) to overtop and deposit contaminated sediment north of the dam wall on Lot 7304 DP 1152229 In addition, an event of this magnitude may cause minor erosion to the bunds. It is recommended that that a monitoring plan for competence of the drainage system and intermittent monitoring of surface sediment North of the dam be developed and implemented during other site management works including fire control measures and routine maintenance.

7.2 Construction Environmental Management

A Construction Environmental Management Plan (CEMP) for the remediation works will be required to ensure site works comply with relevant environmental legislation and mitigate potential impacts to offsite receptors. It will be the responsibility of the Remedial Works Principal Contractor to provide, install, monitor and maintain the environmental control measures established onsite. Inclusions for the CEMP should include, but not limited to:

- Protocols for handling contaminated waste (category 3).
- Soil management procedures such as limiting the height of topsoil stockpiles.

- Characterisation of imported and exported materials.
- Approved hours of work.
- Traffic management measures to be implemented to ensure safe operation of plant and ingress and egress from the site.
- Dust, Noise and Water Quality management measures to ensure compliance with relevant environmental legislation applicable to construction sites in NSW.
- Erosion and sediment control measures to eliminate the potential for offsite migration of material during construction.
- Management protocols measures designed to protect native vegetation and heritage features.

7.3 Management of Heritage Items

Should any items potentially tied to European or Aboriginal cultural heritage be discovered during the project, a precise protocol for unexpected archaeological findings needs immediate implementation. All operations within this area must cease, and a certified archaeologist must be engaged to conduct a thorough assessment. If this assessment identifies the exposed remains as 'relics,' as defined by the *NSW Heritage Act 1977*, prompt notification to the Heritage Division of the Department of Primary Industries and Environment is necessary, in accordance with Section 146 of the *Heritage Act.*

7.4 Works Near Geohazards

GHD (2023a) identified the presence of a number of relict mining features including underground workings which present a risk to safe surface operations. The RAP presented herein has been designed in consideration of these hazards, which are presented in Table 20. These locations should be demarcated and avoided during works.

In addition to shaft, underground workings and associated subsidence risk zones were identified by GHD (2023b) – shown in Figure 1. For full details of the areas of potential subsidence and geohazard risk, refer to GHD (2023b).

In accordance with the advice presented by GHD, the following measures should be implemented by the Remedial Works Principal Contractor when engaged in undertakings at site:

- **Risk assessment and risk mitigation advice: "***The PWC is advised to retain the services of a Geotechnical Engineer or Engineering Geologist experienced in mine subsidence and risk assessment to assist with documentation prior to commencement, risk assessments, risk mitigation measures as well as assisting with identifying and responding to changes in site conditions."*
- **Training, induction and awareness "***People entering the work site must be inducted and made aware of hazards. Incorporating explanation of mine subsidence hazards and their locations into site inductions and daily pre-work meetings is recommended. More detailed and up to date information should be*

provided in active work areas. Training should include how to recognise and report subsidence. Showing people the locations of hazards, in person, is recommended rather than relying on maps or photos.

- **Delineation of hazard zones (fencing) and administrative controls "***The hazards zones presented in the figures in Appendix A (or amendments of them approved by LMP) should be delineated with flagging and/or fencing with signage. Access into these areas should be restricted with administrative controls such as, but not limited to:*

    - *At least daily pre-work inspection and clearance.*
    - *Change identification and reporting protocols.*
    - *No working alone.*
    - *Supervision by suitable experienced personnel*
    - *Restrictions on people on foot*
    - *Restrictions on light vehicle access and speed*
    - *Restrictions on plant and heavy vehicles*
    - *Restrictions on equipment and material storage*
    - *Restrictions on activities (e.g. no crane lifts, no excavation, no water storage)*
    - *Limiting duration spent within hazard zones.*
    - *Cessation of work during or immediately preceding heavy rainfall and poor visibility*

    Where site personnel change, knowledge on recent observations and hazard controls should be transferred. The delineation of hazard zones should be based on the actual observable feature where it is visible rather than locations scaled off plans or coordinates taken from spatial databases or this report. Where not visible, the coordinates extracted from this report can be used.Flagging fencing should surround the hazard zone with the addition of at least a 1 m wide buffer. For example, fencing around a 3 m diameter hazard zone would be at least 5 m in diameter.

Table 20 Identified Shaft Locations

Area	Shaft label	Easting (m)	Northing (m)	Estimated accuracy (m)[1]
Mount Stewart Western Lode	Western Shaft	739879	6454560	± 4.0
	Shaft to 90' level	739890	6454551	± 1.5
	Shaft to 50' level	739901	6454568	± 1.5
	unnamed shaft to north	739910	6454596	± 4.0
Mount Stewart Main/ Lode	No.1 South Shaft	739873	6454465	± 4.0
	Engine Shaft	739922	6454478	± 1.5
	No.1 Shaft	739939	6454486	± 4.0
	No.2 Shaft	739974	6454498	± 4.0
	No.3 Shaft	740024	6454510	± 4.0
	No.4 Shaft	740039	6454516	± 4.0
	No.2 Rise (surface)	739953	6454500	± 4.0
Mount Stewart Paddock Lode	No.1 Paddock Shaft	740101	6454478	± 1.5
	No.2 Paddock Shaft	740113	6454500	± 4.0
	No.3 Paddock Shaft	740048	6454469	± 1.5
Grosvenor	Rabbit Shaft	739482	6454313	± 4.0
	Wheat Shaft	739498	6454325	± 4.0
	No.1 Shaft	739537	6454337	± 4.0
	No.2 Shaft	739562	6454314	± 4.0
	No.3 Shaft	739545	6454287	± 1.5
	No.4 Shaft	739485	6454302	± 1.5
	No.5 Shaft	739566	6454357	± 1.5
	#103	739537	6454322	± 1.5
	#104	739540	6454325	± 1.5
Extended	Western Shaft	739595	6454141	± 4.0
	Copper Shaft	739633	6454133	± 1.5
	Blind Shaft	739621	6454125	± 1.5
	Engine Shaft	739665	6454113	± 1.5
	Marshall’s Shaft	739720	6454098	± 1.5

7.5 Other Safety Considerations

The SoW has not included the development of Workplace Health and Safety protocol in regard to undertaking the works prescribed in the RAP. The Leadville site contains elevated levels of heavy metals which may exceed the relevant exposure standard. The ESP must prepare appropriate WHS controls in accordance with state and federal legislation to be protective of workers and the community. The advice provided herein is general in nature, the specific requirements of WHS plans should be developed in consideration of relevant legislation and guidance.

7.5.1 General Considerations

A workplace health and safety (WHS) plan is an essential part of all remediation projects to manage the health and safety of all personnel working on or visiting the site. A detailed WHS plan will be prepared by the ESP for the works prior to the commencement of any site activity. The WHS plan is to be developed in accordance with the relevant regulatory guidelines.

The purpose of the plan is to provide all relevant health and safety information for all personnel undertaking work at the site and to provide and maintain safety standards and practices which offer the highest practical degree of personal protection to the on-site workers, based on current knowledge. The plan will recognise the legislative obligations of the Remedial Works Principal Contractor.

All personnel must read the plan and confirm acceptance of its requirements prior to commencing work at the site. The information provided by the plan shall include:

- Induction requirements;
- Assignment of responsibilities;
- A discussion of site conditions;
- Details of the work;
- Identification of on-site and off-site hazards;
- Assessment of the potential risks associated with identified hazards;
- Procedures to eliminate, or if not possible, control the potential risks;
- Establishment of personnel protection standards and mandatory safety practices and procedures;
- Establishment of WHS monitoring protocols;
- Training and responsibilities of emergency team members;
- Evacuation procedures and emergency drills;
- Emergency information;
- Incident reporting;
- Provision for contingencies that may arise while operations are being conducted during the project; and
- Procedures to ensure that the Remedial Works Principal Contractor consults with, co-operates with, and co-ordinates its activities with the Principal (and with any other person or entity having concurrent health and safety duties arising out of the remediation works)

8 SITE VALIDATION

8.1 Data Quality Objectives

Data quality objectives (DQOs) have been developed for site validation to confirm remediation meets the required objective.

8.1.1 State the Problem

The site is proposed to be used for agricultural purposes (grazing of livestock for a maximum period of 2 months per year). Previous investigations have identified environmental impacts at the site require remediation in order to address potential unacceptable risks to future site receptors and address off-site migration of impacts (refer to Section 4). As such, a set of environmental data are required to verify that remediation works as documented in Section 6 have been implemented in a manner which causes potential risks associated with contaminated site media to reduce to low and acceptable levels.

8.1.2 Identify the Decision

The following decisions will need to be satisfied through the course of the remediation works:

- Have contaminated soils been remediated to a level that mitigates the potential for off-site migration of contamination to the extent practicable?
- Have contaminated soils been remediated (via isolation) to remove unacceptable health risks to future site receptors and allow for grazing across the balance of the site for a maximum period of 2 months per year?
- Were the impacted/surplus materials classified and disposed off-site to a facility licensed to accept the classified waste?
- Has all material imported to site as part of remediation activities been demonstrated as suitable for use?
- Is the site suitable for the proposed use subject to ongoing implementation of the LTEMP?

8.1.3 Identify Inputs to the Decision

The inputs to the decisions are:

- Previous investigation results as discussed in Section 3;
- The proposed land use and site features;
- Field observations in relation to inspection of all excavation bases, walls, stockpiles and final site surfaces for signs of potential contamination;
- Environmental data as collected from the validation of remedial excavations;
- Material characterisation data obtained during assessment of surplus material prior to off-site disposal;

- Disposal dockets and relevant documents in relation to appropriate disposal of material (if required) to be removed from site as part of the remediation works (landfill dockets, beneficial reuse / recycling dockets, trade waste disposal, etc.);
- Material characterisation data (including field observations, sampling and analytical data) obtained during assessment of material proposed to be imported to the site;
- Survey information on the height and lateral extent of the drainage features and areas of containment;
- Relevant guideline criteria for validation and waste classification;
- Management measures documented within a Long term Environmental Management Plan (LTEMP) to be prepared for the site following remediation to ensure the site remains suitable for the proposed use; and
- Data quality indicators (DQIs) as assessed by quality assurance / quality control (QA/QC).

8.1.4 Define the Study Boundaries

The validation study boundaries are restricted to the lateral extent of the site as shown on Figure 1. The vertical extent of the validation study is anticipated to be restricted to soils extending to the maximum depth of disturbance as part of remediation.

Ultimately the study boundaries will comprise the lateral and vertical extent of the site successfully validated in accordance with the requirements of this plan. The temporal limits of the assessment will comprise the duration of the remedial works and validation program.

8.1.5 Develop a Decision Rule

The decision rules adopted to answer the decisions identified in Section 8.1.2 are summarised following:

- *Have contaminated soils been remediated to a level that mitigates the potential for off-site migration of contamination to the extent practicable?*

  At the completion of remediation works, highly impacted soils (identified as Category 3 in Section 6) will have been remediated via excavation and off-site disposal or via the construction of surface water diversion bunds (in areas of geohazards). In instances of off-site disposal, soil samples collected from the base of remedial excavations and where the validation results meet the adopted validation criteria, then the answer is Yes. In instances of surface water diversions, if site observations (inspections and photographs) and site surveys are available to demonstrate that they have been appropriately installed in accordance with this RAP, then the answer is Yes.

  If there is uncertainty as to the above, then the answer is No.

- *Have contaminated soils been remediated (via isolation) to remove unacceptable health risks to future site receptors and allow for grazing across the balance of the site for a maximum period of 2 months per year?*

At the completion of remediation works, fencing will have been installed to restrict access to areas (containing impacted media identified as Category 2 in Section 6). If site observations (inspections and photographs) and site surveys are available to demonstrate that fencing has been appropriately installed in accordance with this RAP, then the answer is Yes.

If there is uncertainty as to whether these measures have been installed where required at the site, then the answer is No.

- *Were the impacted/surplus materials classified and disposed off-site to a facility licensed to accept the classified waste?*

  Soil analytical data will be compared against EPA (2014) criteria. Statistical analysis (comprising a review of 95% UCL of the mean, standard deviation and maximum values of dataset) of the data in accordance with relevant guidance documents will be undertaken, where appropriate, to facilitate the decisions (as detailed above). Documentation from the operation receiving the material including the dates, tonnage and classification of the accepted material will be required to facilitate the decision. If the statistical criteria stated above are satisfied, the decision is Yes, and if receipts are provided recording the disposal of material to an off-site licensed facility, the decision is Yes. If the material exceeds the criteria, and no disposal receipts are provided, the answer is No.

- *Has all material imported to site as part of remediation activities been demonstrated as suitable for use?*

  Analytical data sets and inspection data will be reviewed for each proposed material type/source against established definitions for acceptable material (i.e. VENM, resource recovery exemptions, etc) and EPA endorsed criteria as established in the RAP as validation criteria. If the complete data set for the applicable material meet the requirements relevant to the material type, the answer to the decision is Yes and material may be imported to site. If the data set exceeds the adopted criterion, the answer to the decision is No and the material cannot be imported to site for use in development activities.

- Is the site suitable for the proposed use subject to ongoing implementation of the LTEMP?

  If the answer to all the previous decision rules is Yes, then the answer to the decision is also Yes. Otherwise, the answer to the decision is No. In this instance further remediation/ management actions will require to be implemented and appropriately documented such that a future review of the above decisions may result in a different decision outcome.

8.1.6 Specify the Limits on Decision Error

This step is to establish the decision maker's tolerable limits on decision errors, which are used to establish performance goals for limiting uncertainty in the data. Data generated during this project must be appropriate to allow decisions to be made with confidence.

Specific limits for this project have been adopted in accordance with the appropriate guidance from the NSW EPA, NEPC (2013) and appropriate indicators of data quality (DQIs used to assess quality assurance / quality control)/

To assess the usability of the data prior to making decisions, the data will be assessed against pre-determined DQI) established for the project as discussed below in relation to precision, accuracy, representativeness, comparability and completeness (PARCC parametres). The acceptable limit on decision error is 95% compliance with DQIs.

The DQIs and data assessment criteria are summarised following:

- **Precision** - measures the reproducibility of measurements under a given set of conditions. The precision of the laboratory data and sampling techniques is assessed by calculating the Relative Percent Difference (RPD) of duplicate samples.
- **Accuracy** - measures the bias in a measurement system. The accuracy of the laboratory data that are generated during this study is a measure of the closeness of the analytical results obtained by a method to the 'true' value. Accuracy is assessed by reference to the analytical results of laboratory control samples, laboratory spikes and analyses against reference standards.
- **Representativeness** – expresses the degree which sample data accurately and precisely represent a characteristic of a population or an environmental condition. Representativeness is achieved by collecting samples on a representative basis across the site, and by using an adequate number of sample locations to characterise the site to the required accuracy.
- **Comparability** - expresses the confidence with which one data set can be compared with another. This is achieved through maintaining a level of consistency in techniques used to collect samples; ensuring analysing laboratories use consistent analysis techniques and reporting methods.
- **Completeness** – is defined as the percentage of measurements made which are judged to be valid measurements. The completeness goal is set at there being sufficient valid data generated during the study.
- **Sensitivity** – expresses the appropriateness of the chosen field and laboratory methods, including the limits of reporting, in producing reliable data in relation to the adopted site assessment criteria.

8.1.7 Validation Inspections and Sampling

The validation inspections, sampling and analysis required for remediation areas are summarised in Table 21 below.

Table 21 Validation Inspection and Sampling Program

Item	**RAP Sampling Density**			**Analytical Suite**
Source Removal Excavation Validation				
	Excavation Floors	Excavation Walls	Materials	
Excavations formed to remove Category 3 Materials	1 / 100 m^2 (10 m grid)	1 / 10 m (from each distinct horizon or material type or 1 m vertical soil profile)	N/A	Total heavy metals and ASLP heavy metals
Materials Importation				
Imported VENM	Minimum of 3 samples per source site / material type to 500 m^3 then 1 sample per 500 m^3 thereafter			TRH/BTEX PAH Heavy Metals OCP/PCBs Asbestos (500 ml)
Quarry VENM Materials (e.g. blue metal, sandstone, shale)	Confirmation that the material is quarried rock (VENM) prior to importation, and visual confirmation.			Site Inspection required.

Item	RAP Sampling Density	Analytical Suite
Material subject to a NSW EPA Resource Recovery Order/Exemption	Confirmation by the supplier that the material meets the terms of the order. Then environmental consultant sampling at a minimum of 3 samples per source site / material type to 500 m^3 then 1 sample per 500 m^3 thereafter, prior to importation	TRH/BTEX PAH Heavy Metals OCP/PCBs Asbestos (500 ml)
Export of Materials		
Surplus waste materials for off-site disposal are to be classified in accordance with EPA (2014).	Stockpiled materials for off-site disposal require a minimum of 5 samples (up to 75 m^3) or a sample density of 1/25 m^3 to 200 m^3 (whichever is greater) Decreased sampling frequency to be justified on basis of stockpile homogeneity and risk of contaminants present.	Heavy metals and TCLP heavy metals

8.2 Validation Criteria

8.2.1 Site-won Materials

Risk-based validation criteria as derived in EnRisks (2022) for each of the constituent's requiring remediation in soil are summarised in Table 22.

Table 22 Summary of Risk Based Soil Criteria for Site Remediation

Contaminant	RBC (mg/kg)				
	Recreational exposures	Livestock Health (cattle – assuming 2 months grazing per year)	Livestock Health (sheep– assuming 2 months grazing per year)[14]	Livestock Health (cattle – assuming 12 months grazing per year)	Livestock Health (sheep– assuming 12 months grazing per year)
As	2,000	1,200	180	200	30
Pb	6,600	3,600	440	830	110
Mn	140,000	95,000	25,000	16000	4200

The site will be required to be validated as suitable for commercial / industrial land use pursuant to the NEPC (2013). With consideration of the preferred remediation approach (see Section 5), there have been no identified impacts that require remediation by excavation and removal by off-site disposal. Notwithstanding, the potential for encountering an unexpected find during site remediation works remains, in which there may be a requirement for excavation and removal of impacted materials, that would result in the requirement for the excavations to be validated. The appropriate validation criteria to be applied to the resulting excavations will be dependent on the nature of the impact and the remedial objectives of the excavation.

8.2.2 Imported Materials

With respect to imported materials, consideration will be given to validation criteria derived from the following:

- Health Investigation Levels (HILs) for recreational land use - HIL-C;
- Health Screening Levels (HSLs) for petroleum hydrocarbons considering potential for vapour intrusion, coarse grained soil for recreational land use at 0.0-1.0 m depth; and
- Ecological Investigation Levels (EILs) for recreational land-use.

[14] RBC (Sheep) for COPC are lower than cattle. Therefore, these criteria have been applied in defining the extents of grazing can occur without exposure to materials which exceed RBC.

Moreover, all imported materials will require confirmation that the materials meet requirements of the applicable Order/Exemption[15] as specific to the material proposed to be imported to the site.

8.2.3 Waste Disposal Off-site

All wastes requiring off-site disposal must be classified in accordance with Waste Classification Guidelines (EPA 2014). The Remedial Contractor is responsible for the lawful disposal of the classified waste to a licensed waste disposal facility lawfully able to accept the waste.

Disposal dockets for each individual off-site waste disposal load must be provided to the to the Remediation Consultant by the Contractor to demonstrate appropriate off-site disposal of waste occurred for site validation purposes.

8.3 Validation Reporting

At the completion of the remedial works, a validation report will be prepared in general accordance with the *Consultants Reporting on Contaminated Land Contaminated Land Guidelines* (EPA 2020), documenting the works as completed. The report will contain information including:

- Details of the remediation works conducted;
- Information demonstrating that the objectives of this RAP have been achieved, in particular the validation sample results and assessment of the data against both the pre-defined DQO and the remediation acceptance (validation) criteria;
- Information demonstrating compliance with appropriate regulations and guidelines;
- Any variations to the strategy undertaken during the implementation of the remedial works;
- Results of all environmental monitoring undertaken during the course of the remedial works;
- Details of any environmental incidents occurring during the course of the remedial works and the actions undertaken in response to these incidents;
- Verification of regulatory compliance;
- Details on waste classification, tracking and off-site disposal including landfill dockets;
- Photographic records of applicable remediation works;
- Survey data for all area subject to isolation (fencing) and surface water diversion systems; and
- Clear statement of the suitability of the site with respect to permissible land uses with references for ongoing management.

[15] https://www.epa.nsw.gov.au/your-environment/recycling-and-reuse/resource-recovery-framework/current-orders-and-exemption

9 LIMITATIONS AND ASSUMPTIONS

9.1 Limitations of Existing Scope of Works

This RAP has been developed on the basis of information and data made available to TTC and discussed herein. It is acknowledged that limited sampling and laboratory analyses were undertaken as part of previous investigations undertaken, as described herein. Conditions between sampling locations and media may vary, and this should be considered when extrapolating between sampling points. Chemical analytes are based on the information detailed in the site history. Further chemicals or categories of chemicals may exist at the site, which were not identified in the site history and which may not be expected at the site. Changes to the conditions may occur subsequent to the investigations described herein, through natural processes or through the intentional or accidental addition of contaminants. The conclusions and recommendations reached in this report are therefore based on the information obtained at the time of the investigations. Should information become available regarding conditions at the site including previously unknown sources of contamination, TTC reserves the right to review the report in the context of the additional information.

9.2 Use of XRF data.

This RAP was developed on the basis of available geochemical data provided by the Principal. TTC understands that XRF data was calibrated against ICP-MS for metals in accordance with the guidance provided in USEPA (2020). For COPC where the data returned an acceptable correlation (R^2 = > 79% for a particular analyte) between XRF data and ICPMS the XRF data was deemed reliable in providing an indication of the concentration for that COPC. The data provided is attached to this document as Appendix E.

9.3 Residual Environmental Risks

The remedial works aim to minimize the volume of water which could potentially mobilise contaminants from intersecting with contaminated media and remove media from site which is extremely elevated in total and leachable metals. This design is in alignment with the ALARP principle.

Given the presence of geohazards render remediation plans developed by Okane, (2021) for Mt Stewart technically impractical, associated revegetation is also impractical without extensive earthworks on the area. Gradient at Mt Stewart approach 40% in places and would require a revegetation strategy that adopts a geotechnical approach (rather than bulk earthworks) to neutralise acidity, install a suitable growth media and retain the amended substrate.

It is understood that the NSW EPA conducted a health risk assessment for the Leadville village and found no signs of adverse effect to air and water quality at premises under current site conditions.

In the future, should alternative remedial approaches be developed at Mt Stewart, then revegetation at the scaled areas of Mt Stewart could be achieved and would involve significant bulk earthworks including placing a capillary break layer to stop upwards migration of contaminants and salts to growth media.

9.4 Borrow Materials

In the 2020 field assessment led by Okane, an evaluation of the geotechnical properties of potential borrow materials was conducted. This assessment encompassed test pitting to a depth of 1.5 metres at intervals of 100 metres across a tree-free area exhibiting surface indications of clayey substances. Observations from the logs suggest a relatively consistent lateral uniformity of the material between test pits, with a higher concentration of finer materials observed around TP10. While some variability might be present within the borrow area, it is anticipated that achieving the required K_{sat} performance could be attained through material reworking involving dozing and compaction.

Field validation will be required to ensure that the prescribed drainage designs meet the specifications presented in IFC drawings and designs as prescribed in Section 8.1.3.

9.5 Workplace Health and Safety Protocol

The SoW has not included the development of Workplace Health and Safety protocol in regard to undertaking the works prescribed in the RAP. The Leadville site contains elevated levels of heavy metals which may exceed the relevant exposure standard. The ESP must prepare appropriate WHS controls in accordance with state and federal legislation to be protective of workers and the community. The advice provided herein is general in nature, the specific requirements of WHS plans should be developed in consideration of relevant legislation and guidance.

9.6 Work in or Near Geohazards zones.

It is acknowledged that the drainage network designed for Mt Stewart is in and around an area identified as including subsidence risk zones (GHD, 2023b). The designs have been developed in consideration of the requirement for heavy plant to avoid trafficking in these zones however, works plans developed by the Remedial Works Principal Contractor (for example on bund construction) should consider recommendations provided in GHD (2023b) relating to works around subsidence/geohazards zones (summarised in Section 7.4).

The development of safe work methods for construction of specified designs is the responsibility of the remedial works Principal Contractor. In addition, TTC accepts no liability for any safety issued encountered when the remedial works are performed. To ensure the nominated remedial works contractor has developed appropriate controls in consideration of the advice provided in GHD (2023b), it is recommended that that a geohazard management plan be developed and included in the execution SoW. This document will provide guidance as to the required safety management systems and measures to be implemented to safely construct the designs presented herein.

10 REFERENCES

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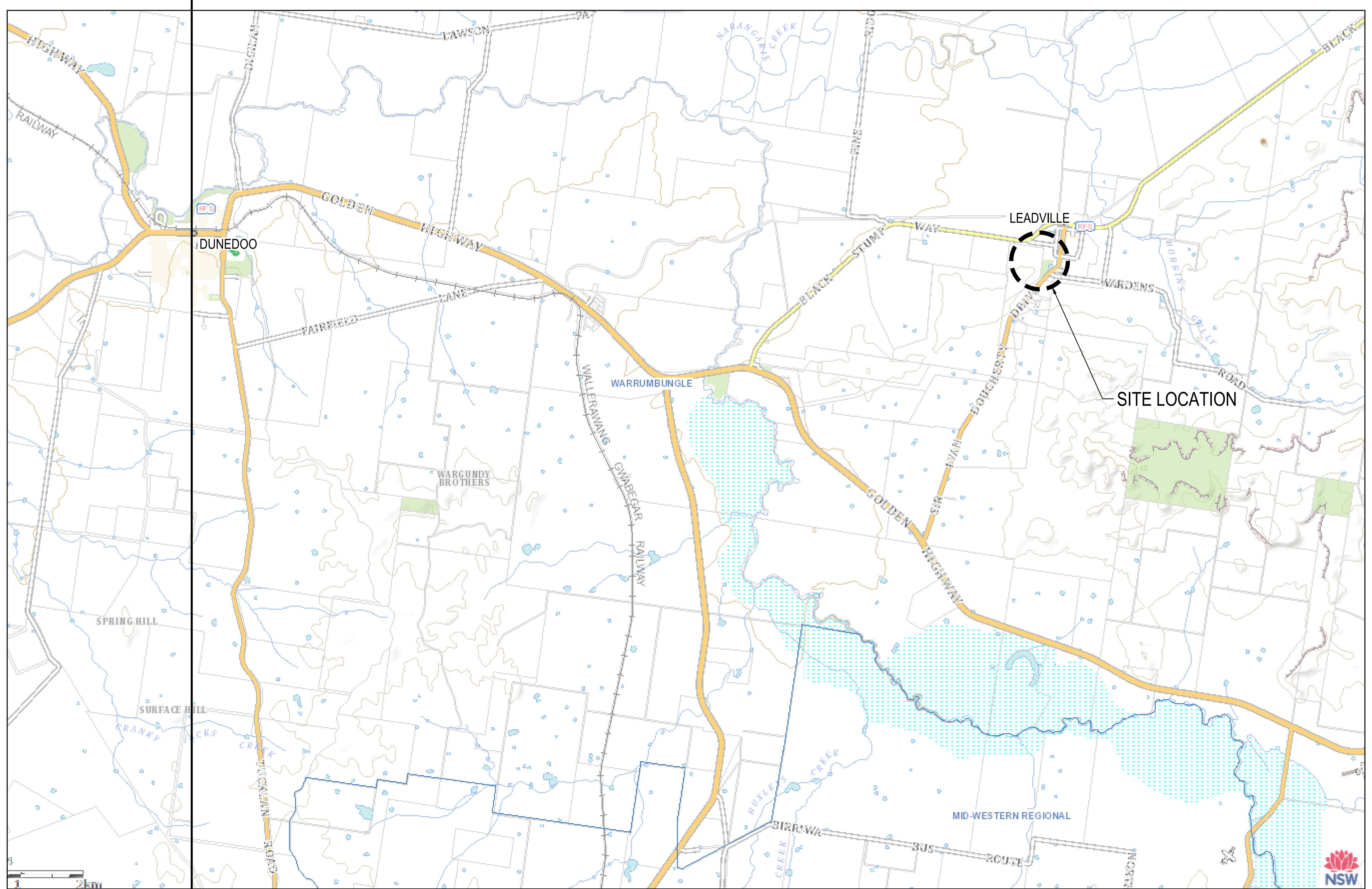
Appendix A

Drawings

LEGACY MINES PROGRAM
LEADVILLE MINE REMEDIATION



LOCALITY PLAN

DRAWING LIST

C00	COVER SHEET AND DRAWING LIST
C01	CIVIL SPECIFICATION
C10	SITE PLAN
C20	MOUNT STEWART AND PADDOCK SHAFT AREA SITEWORKS PLAN
C23	MOUNT STEWART LONGITUDINAL SECTIONS SHEET 1
C24	MOUNT STEWART LONGITUDINAL SECTIONS SHEET 2
C25	MOUNT STEWART EARTHWORKS SECTIONS
C27	MOUNT STEWART EARTHWORKS DETAILS SHEET 1
C30	SMELTER AND BORROW ZONE SITEWORKS PLAN
C35	SMELTER AND BORROW ZONE EARTHWORKS SECTIONS
C37	SMELTER AND BORROW ZONE EARTHWORKS DETAILS
C40	GROSVENOR DAM SITEWORKS PLAN

FOR CONSTRUCTION

DATE
18.03.2024
19.01.2024
22.12.2023

CLIENT: NSW GOVERNMENT
LEGACY MINES PROGRAM
DEPARTMENT OF REGIONAL NSW

ROC ENGINEERING DESIGN
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PROJECT: **LEGACY MINES PROGRAM LEADVILLE MINE REMEDIATION**

DRAWING TITLE: **COVER SHEET AND DRAWING LIST**

SCALE (A1)

JOB NUMBER	DATUM	DRAWING NUMBER	REVISION
23293	AHD	C00	C

ALL WORKS TO BE UNDERTAKEN IN ACCORDANCE WITH CURRENT AUSTRALIAN STANDARDS

ALL DRAWINGS ARE TO BE READ IN CONJUNCTION WITH ALL OTHER CONSULTANTS DRAWINGS AND SPECIFICATIONS INCLUDING BUT NOT LIMITED TO ARCHITECTURAL, STRUCTURAL,

THE CONTRACTOR SHALL PROVIDE SUFFICIENT NOTICE TO THE PRINCIPAL CERTIFYING AUTHORITY AND ENSURE ALL WORKS ARE INSPECTED TO ENABLE COMPLIANCE

RESTORE ALL PAVED, COVERED, GRASSED AND LANDSCAPED AREAS TO THEIR ORIGINAL

CO-ORDINATES FOR SETOUT ARE MGA2020, THE SOURCE OF THE VERTICAL DATUM: PM2977

VERIFY ALL DIMENSIONS AND EXISTING LEVELS AND CONDITIONS ON SITE PRIOR TO

SURVEY ACCURACY TO BE IN ACCORDANCE WITH TfNSW QA SPECIFICATION G71 TABLE G71.6

ARE APPROXIMATE
OBTAINED FROM DATA

FROM THE RELEVANT

LOCATION OF ALL EXISTING

THE VICINITY OF THE

COMMUNICATION, GAS OR

CAUSED TO EXISTING

SUBSTITUTION OF SEED SPECIES SPECIFIED SHALL BE SUBJECT TO APPROVAL BY PRINCIPALS

PROTECT THE NEWLY SEEDED AREAS FROM TRESPASS AND TRAFFIC UNTIL THE GRASS IS

ALLOW FOR RE-SEEDING ALL AREAS WHERE GRASS FAILS TO GROW WITHIN 1 MONTH FROM

ALL REVEGETATED AREAS SHALL BE WATERED FREQUENTLY TO GERMINATION AND

DISTURBED AREAS ARE TO BE SEEDED WITH ONE OF THE FOLLOWING SEED MIXES:
ANY COMBINATION OF THE FOLLOWING SPECIES TO 20% MAX PER SPECIES AT A RATE OF

ANY COMBINATION OF THE FOLLOWING SPECIES TO 30% MAX PER SPECIES AT A RATES OF

THE SEED MIX SHALL BE MIXED WITH SAND BROADCAST MEDIUM AT A RATE OF 2.1kg SEED TO

APPLY GRANULAR FERTILISER TO THE DISTURBED AREA AT THE FOLLOWING RATES

SPECIFICATION

4.2 OF THE
DRAWING NUMBER

TfNSW DRAWING

THE BOUNDARY
FENCES SPECIFICATION TS 01110:1.0 AND TfNSW DRAWINGS CV 0285934.
TfNSW STANDARD

EARTHWORKS

1. EARTHWORKS TO BE IN ACCORDANCE WITH AS3798, THE REFERENCED CURRENT AUSTRALIAN STANDARDS.
2. STRIPPING OF TOPSOIL AND VEGETATION SHOULD ONLY BE COMPLETED WITHIN THE REMEDIATION WORK EXTENT. VEGETATION SHOULD BE PUSHED OVER (NOT CHIPPED) AND DRAGGED (IN MANAGEABLE PORTIONS TO A LOCATION ON-SITE WHICH DOES NOT IMPEDE SAFE INGRESS / EGRESS OR WORKS. RE-USE CLEARED VEGETATION ON RE-VEGETATED AREAS AS APPROPRIATE.
3. ALL FILL SHOULD BE PLACED AND COMPACTED UNDER LEVEL 1 SUPERVISION AS SPECIFIED IN AS3798 U.N.O. THE CONTRACTOR TO PROVIDE LEVEL 1 CERTIFICATION UPON COMPLETION OF EARTHWORKS.
4. TOPSOIL TO BE EXCAVATED MINIMUM 200mm TO EXPOSE SUB-GRADE & STOCKPILED.
5. PROOF ROLL EXPOSED SUBGRADE TO ACHIEVE THE MINIMUM COMPACTION SPECIFIED. ANY SOFT OR WEAK AREAS ARE TO BE EXCAVATED AND REPLACED BY COMPACTED FILL AS PER SPECIFICATION.
6. TESTS SHALL BE UNDERTAKEN ON ANY PROPOSED FILL MATERIALS TO ENSURE THAT THEY DO NOT HAVE A HIGH DISPERSION POTENTIAL AS DEFINED BY THE EMERSON CRUMB/DISPERSION TESTS (AS1289 C8-1980).
7. ALL EARTHWORKS SHALL BE TESTED AND CERTIFIED BY A N.A.T.A. REGISTERED LABORATORY. ALL TEST CERTIFICATES, ACCOMPANIED BY AN OVERALL SITE PLAN, CLEARLY INDICATING THE LOCATION OF EACH TEST AND FILL AREAS ETC., AND THE LABORATORY CERTIFICATE COVERING THE WHOLE OF THE AREA TESTED ARE TO BE FORWARDED TO THE DESIGN REPRESENTATIVE UPON COMPLETION.
8. REQUIRED DENSITY AND MINIMUM FREQUENCY OF TESTING FOR COMPACTION CONTROL AS DETAILED IN AS 3798-2007 ARE SUMMARIZED BELOW:
   - 1 TEST PER LAYER PER MATERIAL TYPE PER 2500 m^2.
9. TESTING SHOULD BE UNDERTAKEN IN ACCORDANCE WITH AS 1289.5. TESTED LAYERS THAT DO NOT SATISFY THE OUTLINED CRITERIA SHALL BE STRIPPED, REPLACED, RECOMPACTED AND RETESTED TO ACHIEVE THE MINIMUM COMPACTION REQUIREMENT MENTIONED ABOVE.
10. UNSUITABLE MATERIALS (E.G. LOOSE ROCK OR SOFT SOIL, ROOTS OR OTHER ORGANIC MATERIALS) MUST BE REMOVED AND REPLACED BY APPROVED ENGINEERED FILL OR AS APPROVED BY THE PRINCIPAL.
11. BACKFILL MATERIALS SHOULD BE FREE FROM ANY ORGANIC, PLASTIC, METAL, RUBBER OR ANY OTHER SYNTHETIC MATERIAL, INORGANIC CONTAMINANTS, DANGEROUS OR TOXIC MATERIAL OR MATERIAL SUSCEPTIBLE TO COMBUSTION. MATERIALS SHOULD CONSIST OF NATURALLY OCCURRING OR PROCESSED MATERIALS THAT ARE CAPABLE OF BEING COMPACTED IN ACCORDANCE WITH AS3798.
12. FILL IS TO BE SOURCED FROM IDENTIFIED AREAS. NO FILL IS TO BE IMPORTED WITHOUT NOTIFYING THE PRINCIPALS REPRESENTATIVE FOR APPROVAL.
13. FILL TO BE COMPACTED TO ACHIEVE A COMPACTION (STANDARD COMPACTIVE EFFORT) WHEN TESTED IN ACCORDANCE WITH AS1289.5.1.1 AS SHOWN BELOW:

FILL TYPE	LOCATION	MAXIMUM LAYER THICKNESS	RELATIVE COMPACTION
LOW PERMEABILITY MATERIAL	CONSTRUCTION OF DAM BUNDS	150mm	98% SMDD
STORE AND RELEASE MATERIAL	DIVERSION BUNDS	200mm	95% SMDD
	ALL OTHER LOCATIONS	200mm	95% SMDD
SUBGRADE	BELOW BUNDS	N/A	98% SMDD

14. MATERIALS DERIVED FROM ARGILLACEOUS ROCK SUCH AS SHALES AND CLAYSTONES OR OTHER FRIABLE MATERIALS WHICH ARE SUSCEPTIBLE TO BREAKDOWN NOT TO BE USED AS SELECT BACKFILL.
15. FILL MUST CONFORM TO THE REQUIREMENTS SHOWN BELOW, AND MUST BE CAPABLE OF ACHIEVING THE RELATIVE COMPACTION SPECIFIED.

PROPERTY	REQUIREMENT
MAXIMUM PARTICLE DIMENSION	53mm
PERCENTAGE PASSING: 2.36mm AS SIEVE 0.075mm AS SIEVE	 < 50% < 15%
PLASTICITY INDEX	≤ 15%

16. EXISTING FILL IF REUSED MUST CONFORM TO THE REQUIREMENTS SHOWN BELOW, AND MUST BE CAPABLE OF ACHIEVING THE RELATIVE COMPACTION SPECIFIED:

PROPERTY	REQUIREMENT
MAXIMUM PARTICLE DIMENSION	200mm
PERCENTAGE PASSING: 37.5mm AS SIEVE	> 60%

17. IN AREAS TO BE FILLED WHERE THE SLOPE OF THE NATURAL SURFACE EXCEEDS 1(V):4(H), BENCHES ARE TO BE CUT TO PREVENT SLIPPING OF THE PLACED FILL MATERIAL AS REQUIRED BY THE COUNCIL.
18. ALL BATTERS ARE TO BE SCARIFIED TO A DEPTH OF 50mm TO ASSIST WITH ADHESION OF TOP SOIL TO BATTER FACE.
19. PROVIDE MINIMUM 100mm AND MAXIMUM 200mm TOPSOIL TO ALL FILLED AREAS AND ALL OTHER AREAS DISTURBED DURING CONSTRUCTION. TOPSOILED AREAS TO BE STABILISED WITH SEED AS PER SPECIFICATION AFTER TOPSOILING AND IS TO BE WATERED TO ENSURE GERMINATION.
20. THE CONTRACTOR SHALL IMPLEMENT EROSION AND SEDIMENT CONTROL MEASURES AS NECESSARY, AND TO THE SATISFACTION OF COUNCIL PRIOR TO THE COMMENCEMENT OF CONSTRUCTION AND DURING CONSTRUCTION. MAINTENANCE OF THE EROSION AND SEDIMENT CONTROL IS TO BE UNDERTAKEN ON A REGULAR BASIS & AS PER PRINCIPAL'S DIRECTION AND IN ACCORDANCE WITH THE REQUIREMENTS OF THE CURRENT EDITION OF MANAGING URBAN STORMWATER: 'SOILS AND CONSTRUCTION' PRODUCED BY LANDCOM 4TH EDITION MARCH 2004"

TOP SOILING

1. PRIOR TO SPREADING, STOCKPILED SITE SUBGRADE MATERIAL AND/OR IMPORTED TOPSOIL SHALL BE INSPECTED BY THE PRINCIPALS REPRESENTATIVE. NO MATERIAL SHALL BE IMPORTED FROM OFF SITE UNLESS APPROVED BY THE PRINCIPALS REPRESENTATIVE.
2. UNLESS NOTED OTHERWISE, ALLOW FOR CLEARING AND REMOVING STONES EXCEEDING 25mm AND ANY RUBBISH BROUGHT TO THE SURFACE DURING THE CULTIVATION OF THE SUBGRADE.
3. AFTER PREPARATION OF THE SUBGRADE SURFACE, PLACE TOPSOIL AS APPROPRIATE FOR THE SPECIFIED LANDSCAPE TREATMENTS AND AS INDICATED BY THE DRAWINGS.
4. THE FINISHED SURFACE OF THE TOPSOIL SHALL BE SMOOTH, FREE OF LUMPS OF SOIL AND LEFT READY FOR CULTIVATING AND PLANTING.
5. TOPSOIL SHALL BE PLACED AND LIGHTLY COMPACTED TO A THICKNESS AS SHOWN BY THE DRAWINGS OR A MINIMUM OF 150mm.

DAM EARTHWORKS

1. THE BASE OF THE EMBANKMENT SHOULD BE STRIPPED OF ALL TOPSOIL, SILT, LOOSE MATERIAL, VEGETABLE MATTER, AND THEN SCARIFIED OVER ITS WHOLE AREA.
2. ALL FILL MATERIAL FOR THE EMBANKMENT SHOULD BE PLACED IN LAYERS (OR LIFTS) NO GREATER THAN 150mm THICK.
3. THE LARGEST SIZE PARTICLE SHOULD NOT BE GREATER THAN 1/3RD THE HEIGHT OF THE LIFT,THAT IS, 50mm.
4. EACH LAYER SHOULD BE THOROUGHLY COMPACTED BEFORE THE NEXT LAYER IS PLACED. A MINIMUM OF 6 PASSES TO ACHIEVE THE REQUIRED COMPACTION EFFORT IS GENERALLY REQUIRED BY A SUITABLE MACHINE (SEE BELOW).
5. THE COMPACTION EFFORT ACHIEVED SHOULD BE ON AVERAGE 98% STANDARD MAXIMUM DRY DENSITY AS PER AUSTRALIAN STANDARD: AS1289.0-2000 METHODS OF TESTING SOILS FOR ENGINEERING PURPOSES.
6. THE MINIMUM COMPACTION EFFORT SHOULD BE 95% STANDARD MDD.
7. THE MOISTURE CONTENT SHOULD BE IN THE RANGE OF –1% TO + 3% OF OPTIMUM MOISTURE CONTENT (OMC). IF THE MATERIAL IS TOO DRY, WATER SHOULD BE ADDED. IF THE MATERIAL IS TOO WET IT SHOULD BE SPREAD AND MIXED.
8. PREPARE THE SITE UNDER THE EMBANKMENT BY RIPPING A MINIMUM OF 100mm TO ENSURE BOND BETWEEN EXISTING SUBSTRATE AND COMPACTED FILL.
9. BEFORE EACH ADDITIONAL 150mm LIFT IS ADDED TO THE EMBANKMENT, THE PRECEDING LIFT SHOULD BE SCARIFIED TO ENSURE THAT THE TWO LIFTS ARE PROPERLY JOINED SO THAT NO NATURAL PATHS FOR SEEPAGE ARE PRESENT THAT MAY RESULT IN DAM FAILURE.
10. MAINTAIN CUT-OFF TRENCH FREE OF WATER.

SCOUR PROTECTION

1. THE THICKNESS OF THE RIP-RAP PROTECTION SHALL BE A MINIMUM OF THE D_{50} STONE SIZE SPECIFIED ON THE DRAWINGS. THE STONE SHALL BE WELL GRADED IN ACCORDANCE WITH THE FOLLOWING TABLE:

ROCK SIZE	% PASSING (BY WEIGHT)
2 x D_{50}	100%
D_{50}	40 - 60%
0.3 x D_{50}	10 - 20%

   ROCK IS TO BE HARD, DENSE, DURABLE, RESISTANT TO WEATHERING AND ANGULAR SHAPE. IT SHALL BE FREE FROM OVERBURDEN SPOIL, SHALE AND ORGANIC MATTER. ROCK THAT IS LAMINATED, FRACTURED, POROUS OR OTHERWISE PHYSICALLY WEAK IS UNACCEPTABLE.

   THE PROPERTIES OF THE ROCK SHALL BE IN ACCORDANCE WITH AS2758.6 SPECIFICATION FOR EROSION CONTROL TO THE SATISFACTION OF THE PRINCIPALS REPRESENTATIVE.

   AN APPROXIMATE GUIDE TO STONE SHAPE IS THAT BREADTH OR THICKNESS OF A SINGLE STONE SHOULD BE NOT LESS THAN ONE-THIRD ITS LENGTH. ROUND MATERIAL CAN BE USED AS RIP RAP PROVIDED IT IS NOT PLACED ON SLOPES GREATER THAN 3H:1V.
2. STONE SHOULD BE DARK IN COLOUR EITHER GREY OR DARK BROWN SMIILAR TO SOIL PROFILE.
3. GEOTEXTILE UNDER ROCK FILLED MATTRESS AND RIP-RAP TO BE IN ACCORDANCE WITH TfNSW SPECIFICATION R63.
4. ROCKS AND BOULDERS TO HAVE TOTAL UNIT WEIGHT OF 21 TO 27kN/m^3.
5. ALL RIP-RAP SPECIFIED ON THE DRAWINGS ARE PLACED ROCKS.

SAFETY

1. THE CONTRACTOR IS RESPONSIBE FOR SAFETY ONSITE.
2. THE CONTRACTOR IS RESPONSIBLE FOR MAINTAINING ALL EXCAVATION WORKS IN A STABLE CONDITION, AND ENSURING NO PART SHALL BE OVERSTRESSED DURING CONSTRUCTION ACTIVITIES. PROVISION OF TEMPORARY BRACING, SHORING AND BATTERING IS BY THE CONTRACTOR AS REQUIRED TO PROVIDE A SAFE WORKING ENVIRONMENT.
3. THE CONTRACTOR MUST MAKE PROVISION FOR THE SAFETY OF NORMAL VEHICULAR TRAFFIC AND PEDESTRIANS, AND OTHERS INCLUDING UNAUTHORISED INTRUDERS.
4. ALL PITS, MANHOLES, PUMPSTATIONS AND OTHER CONFINED SPACES MUST BE FITTED WITH A CONFINED SPACE WARNING SIGN TO THE APPROVAL OF THE PRINCIPAL'S REPRESENTATIVE.
5. ALL CONDITIONS OF WITH THE REMEDIAL ACTION PLAN MUST BE MET.

SEDIMENT CONTROL NOTES

1. THE CONTRACTOR SHALL AT ALL TIMES BE RESPONSIBLE FOR THE ESTABLISHMENT & MANAGEMENT OF SEDIMENT AND EROSION CONTROL.
2. THE CONTRACTOR SHALL INSTIGATE ALL SEDIMENT AND EROSION CONTROL MEASURES IN ACCORDANCE WITH STATUTORY REQUIREMENTS AND IN PARTICULAR THE 'BLUE BOOK' (MANAGING URBAN STORMWATER SOILS AND CONSTRUCTION), PRODUCED BY THE DEPARTMENT OF HOUSING AND COUNCILS POLICIES. THESE MEASURES ARE TO BE INSPECTED AND MAINTAINED ON A DAILY BASIS.
3. THE CONTRACTOR SHALL INFORM ALL SUB CONTRACTORS OF THEIR RESPONSIBILITIES IN MINIMISING THE POTENTIAL FOR SOIL EROSION AND POLLUTION TO DOWNSLOPE LANDS AND WATERWAYS.
4. WHERE PRACTICAL, THE SOIL EROSION HAZARD ON THE SITE SHALL BE KEPT AS LOW AS POSSIBLE. TO THIS END, WORKS SHOULD BE UNDERTAKEN IN THE FOLLOWING SEQUENCE;
   - 4.1. CONSTRUCT TEMPORARY STABILISED SITE ACCESS INCLUSIVE OF SHAKE DOWN / WASH PAD.
   - 4.2. INSTALL ALL TEMPORARY SEDIMENT FENCES AND BARRIER FENCES. WHERE FENCES ADJACENT EACH OTHER, THE SEDIMENT FENCE CAN BE INCORPORATED INTO THE BARRIER FENCE.
   - 4.3. INSTALL SEDIMENT CONTROL MEASURES AS OUTLINED ON THE APPROVED PLANS.
5. UNDERTAKE SITE DEVELOPMENT WORKS SO THAT LAND DISTURBANCE IS CONFINED TO AREAS OF MINIMUM WORKABLE SIZE.
6. AT ALL TIMES AND IN PARTICULAR DURING WINDY AND DRY WEATHER, LARGE UNPROTECTED AREAS WILL BE KEPT MOIST (NOT WET) BY SPRINKLING WITH WATER TO KEEP DUST UNDER CONTROL ENSURING CONFORMITY TO REGULATORY AUTHORITY REQUIREMENTS.
7. ANY SAND USED IN THE CONCRETE CURING PROCESS (SPREAD OVER THE SURFACE) SHALL BE REMOVED AS SOON AS POSSIBLE AND WITHIN 10 WORKING DAYS FROM PLACEMENT.
8. WATER SHALL BE PREVENTED FROM ENTERING THE PERMANENT DRAINAGE SYSTEM UNLESS THE CATCHMENT AREA HAS BEEN STABILISED AND/OR ANY LIKELY SEDIMENT BEEN FILTERED OUT.
9. TEMPORARY SOIL AND WATER MANAGEMENT STRUCTURES SHALL BE REMOVED ONLY AFTER THE LANDS THEY ARE PROTECTING ARE STABILISED / REHABILITATED.
10. ALLOW FOR GRASS STABILISATION OF EXPOSED AREAS, OPEN CHANNELS AND ROCK BATTERS DURING ALL PHASES OF CONSTRUCTION.
11. EROSION AND SEDIMENT CONTROL MEASURES SHALL BE INSPECTED TO ENSURE THAT THEY OPERATE EFFECTIVELY. REPAIRS AND/OR MAINTENANCE SHALL BE UNDERTAKEN REGULARLY AND AS REQUIRED, PARTICULARLY FOLLOWING RAIN EVENTS.
12. RECEPTORS FOR CONCRETE AND MORTAR SLURRIES, PAINTS, ACID WASHINGS, LIGHT-WEIGHT WASTE MATERIALS AND LITTER SHALL BE DISPOSED OF IN ACCORDANCE WITH REGULATORY AUTHORITY REQUIREMENTS. CONTRACTOR TO PAY ALL FEES AND PROVIDE EVIDENCE OF SAFE DISPOSAL.
13. DISTURBED AREAS ARE TO BE TOPSOILED AND REVEGETATED WITHIN 10 WORKING DAYS OF COMPLETION OF WORK.
14. CONTRACTOR TO ENSURE NO CONTAMINATED WATER AND MATERIAL IS TO ESCAPE SITE FOR THE DURATION OF THE WORKS.

FOR CONSTRUCTION

18.03.2024
19.01.2024
22.12.2023
DATE

CLIENT

NSW GOVERNMENT

LEGACY MINES PROGRAM
DEPARTMENT OF REGIONAL NSW

ROC ENGINEERING DESIGN
Ph (02) 4244 4017
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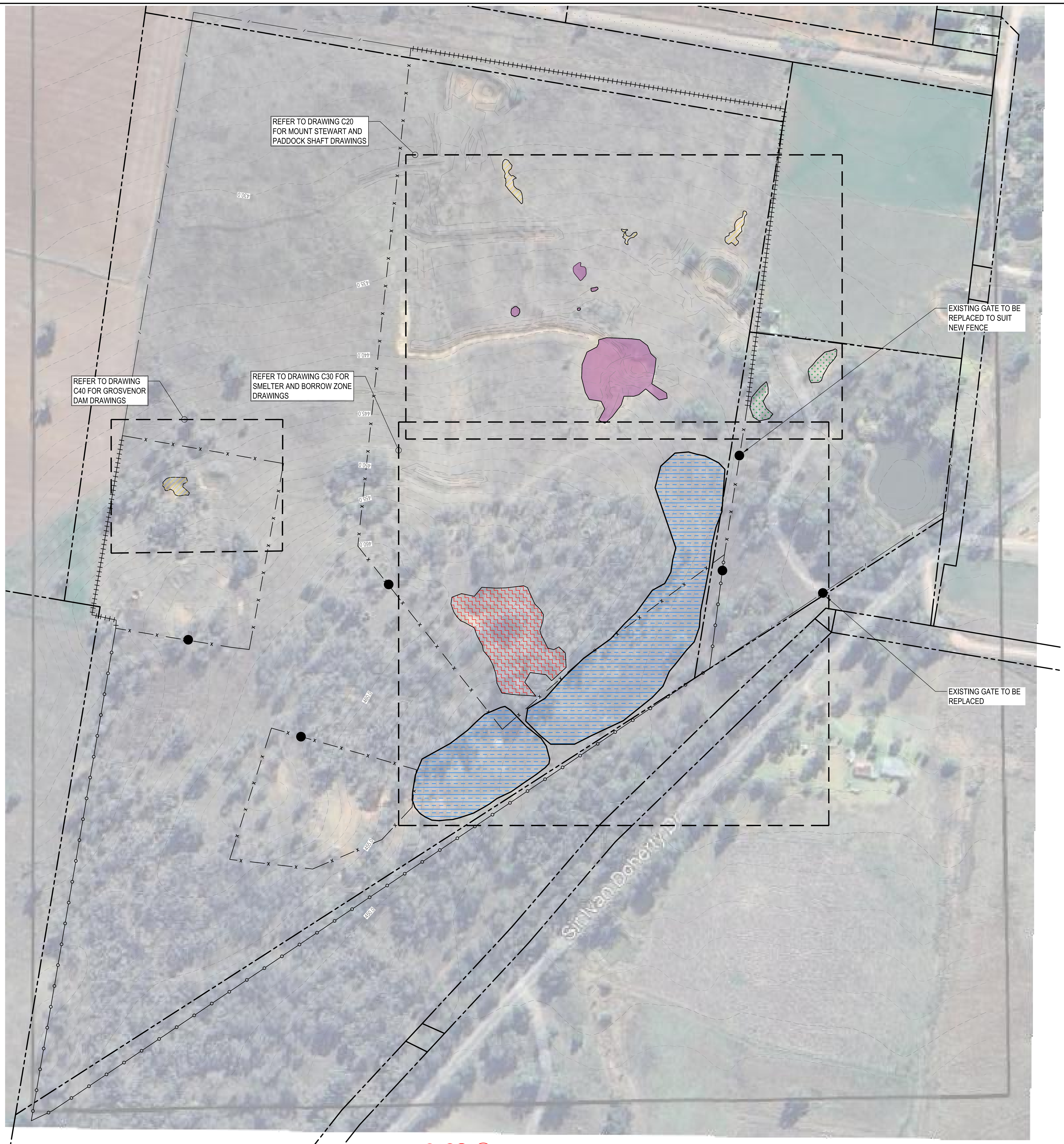
PROJECT
LEGACY MINES PROGRAM
LEADVILLE MINE REMEDIATION

DRAWING TITLE
CIVIL SPECIFICATION SHEET 1

SCALE (A1)

JOB NUMBER	DATUM	DRAWING NUMBER	REVISION
23293	AHD	C01	C



LEGEND

- APPROX. BOUNDARY
- EXISTING CONTOUR (1m)
- EXISTING FENCE ALIGNMENT (APPROX.) TO BE RETAINED
- EXISTING FENCE ALIGNMENT (APPROX.) TO BE REPLACED WITH NEW HINGED JOINT FENCE ON SAME ALIGNMENT
- NEW 1.8m HIGH CHAIN LINK FENCE
- EXISTING FENCE ALIGNMENT (APPROX.) TO BE REPLACED WITH NEW 1.8m HIGH CHAIN LINK FENCE ON SAME ALIGNMENT
- GATE TO SUIT PROPOSED FENCE
- EXCAVATE AND DISPOSE
- EXCAVATE AND VEGETATE
- MOUNT STEWART HIGH ONGOING AMD POTENTIAL
- BORROW SOURCE
- LEAVE IN-SITU AND ISOLATE

NOTES

1. SURVEY PROVIDED BY CENTURION SURVEY. SURVEY OUTSIDE THE AREA SURVEYED HAS BEEN DERIVED FROM NSW SPATIAL SERVICES 'ELEVATION FOUNDATION SPATIAL DATA' (ELVIS).
2. COORDINATE ZONE - MGA2020 ZONE 55S.

SITE PLAN
SCALE: 1:2000

FOR CONSTRUCTION

REV	DESCRIPTION	DESIGN	DRAWN	CHECK	DATE
D	FENCE ALIGNMENT REVISED	CW	RP		26.03.2024
C	FOR CONSTRUCTION	CW	RP		18.03.2024
B	FOR CONSTRUCTION	CW	RP	TMC	19.01.2024
A	FOR CONSTRUCTION	CW	RP	TMC	22.12.2023

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DRAWING TITLE
SITE PLAN

SCALE (A1)
0 20 40 60 80 120 160 200m
1 : 2000

JOB NUMBER	DATUM	DRAWING NUMBER	REVISION
23293	AHD	C10	D

SITEWORKS PLAN
SCALE: 1:500

FOR CONSTRUCTION

REV	DESCRIPTION	DESIGN	DRAWN	CHECK	DATE
D	FENCE ALIGNMENT REVISED	CW	RP		26.03.2024
C	FOR CONSTRUCTION	CW	RP		18.03.2024
B	FOR CONSTRUCTION	CW	RP	TMC	19.01.2024
A	FOR CONSTRUCTION	CW	RP	TMC	22.12.2023

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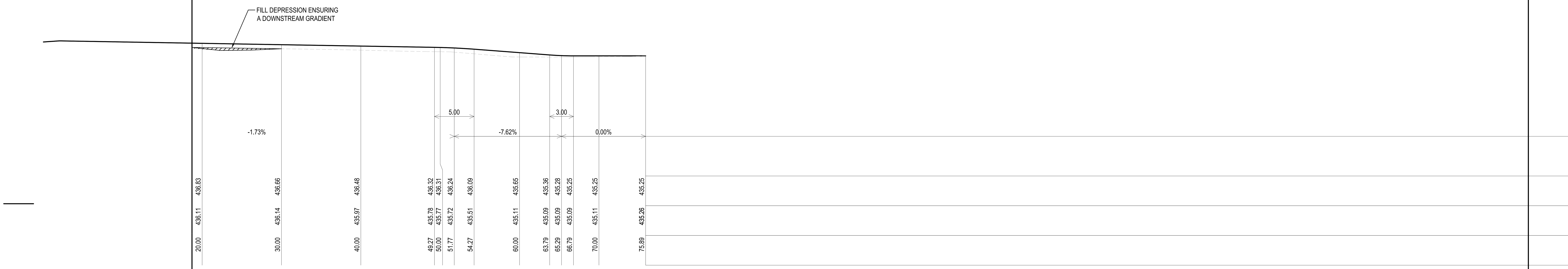
DRAWING TITLE
MOUNT STEWART AND PADDOCK SHAFT AREA SITEWORKS PLAN

SCALE (A1)
0 5 10 15 20 30 60 75m
1 : 500

JOB NUMBER	DATUM	DRAWING NUMBER	REVISION
23293	AHD	C20	D

CW BUND 1 AND 2
LONGITUDINAL SECTION
SCALE: V 1:250, H 1:250



CW BUND 3
LONGITUDINAL SECTION
SCALE: V 1:250, H 1:250

FOR CONSTRUCTION

DATE
18.03.2024
19.01.2024
22.12.2023

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PROJECT
LEGACY MINES PROGRAM
LEADVILLE MINE
REMEDIATION

DRAWING TITLE
MOUNT STEWART
LONGITUDINAL SECTIONS
SHEET 1

SCALE (A1)
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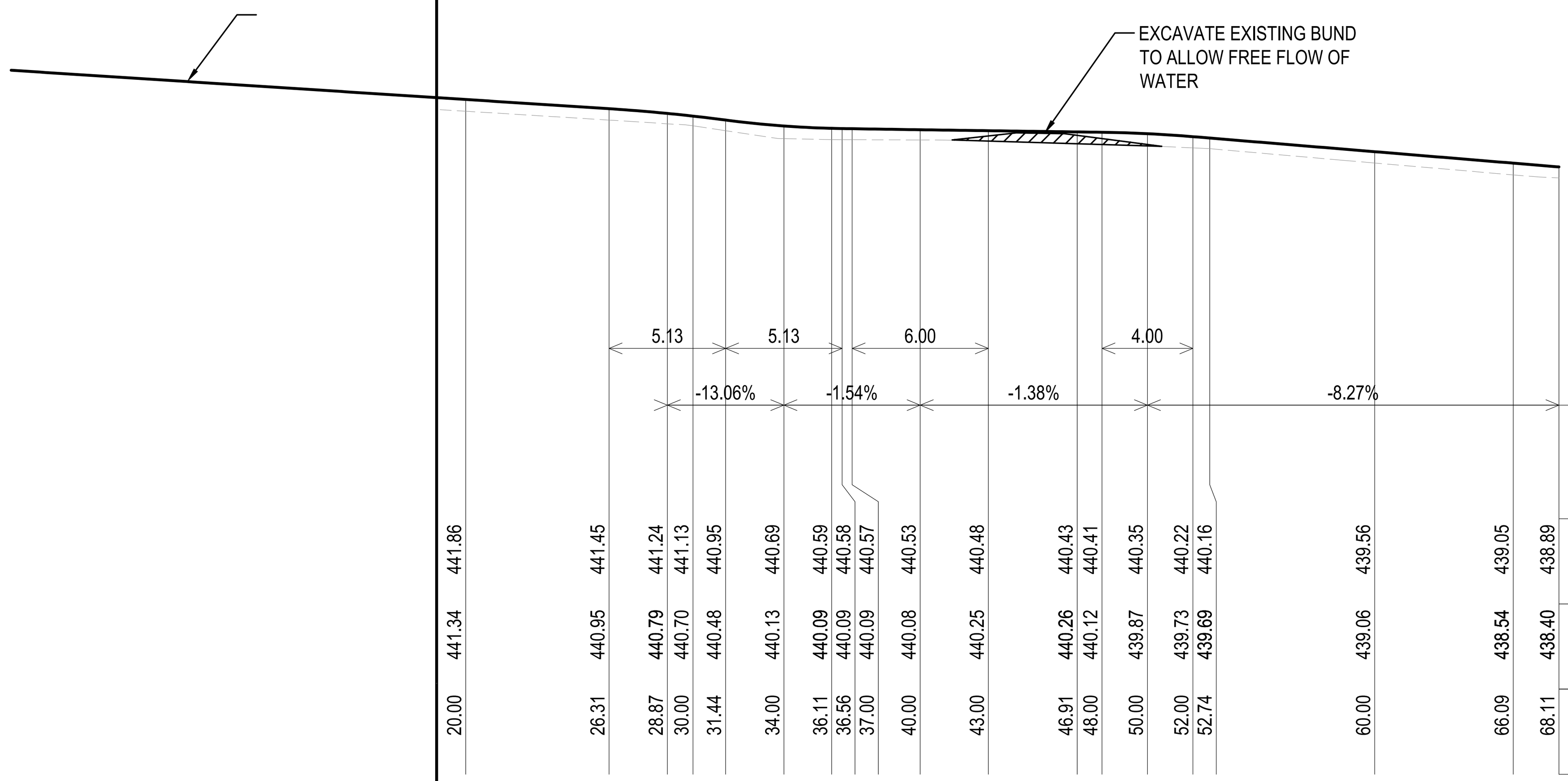
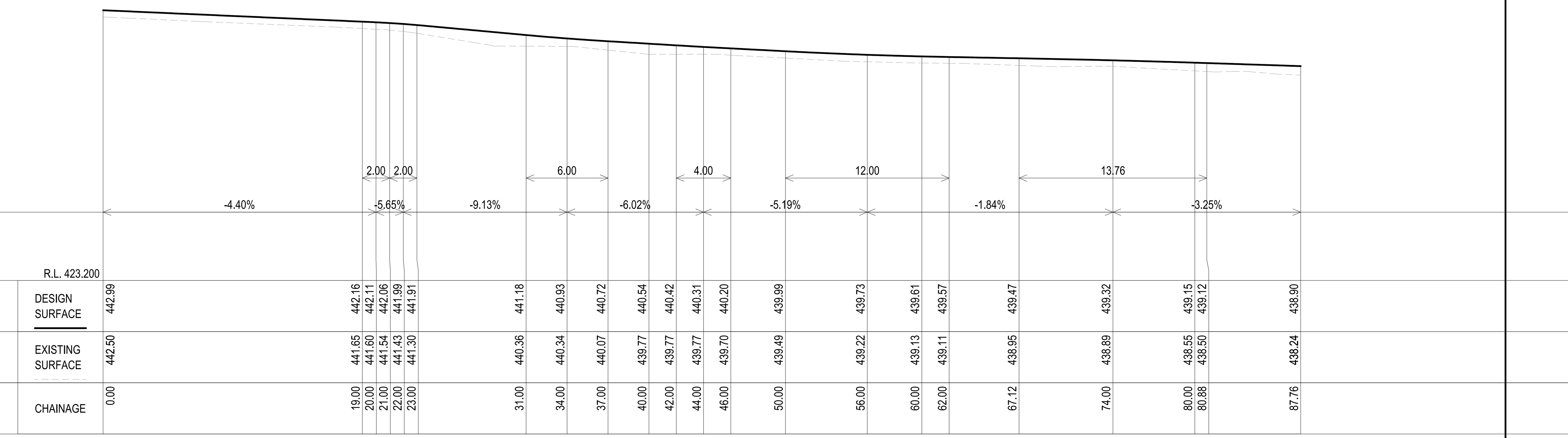
1 : 250

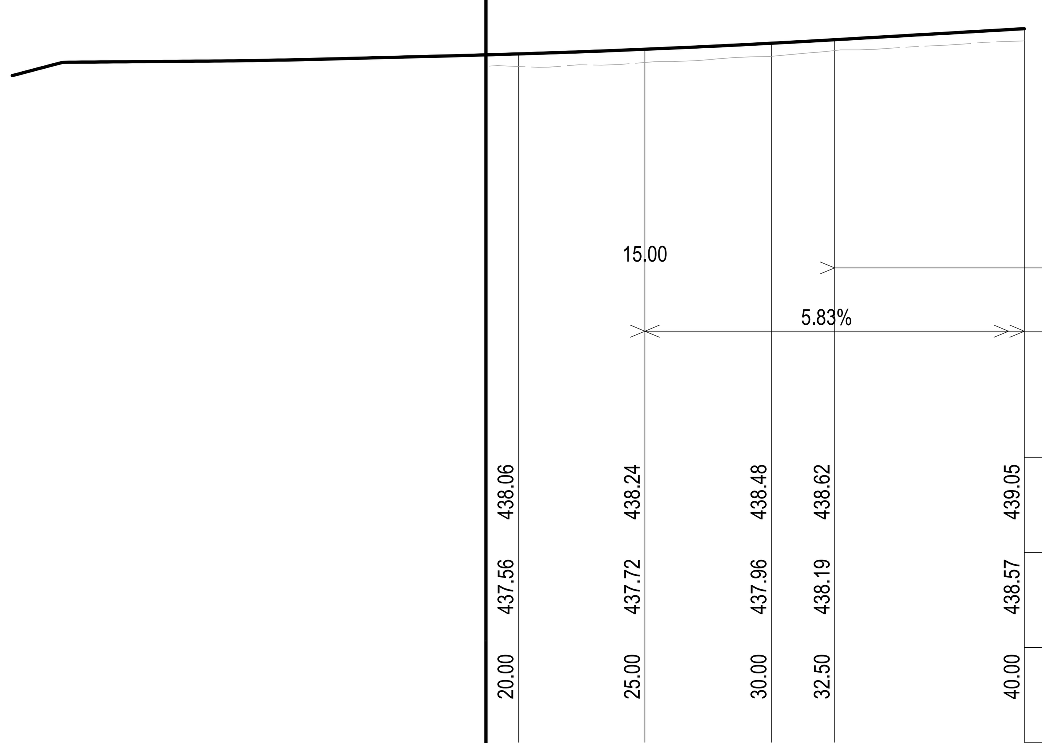
JOB NUMBER	DATUM	DRAWING NUMBER	REVISION
23293	AHD	C23	C



DW BUND 1
LONGITUDINAL SECTION
SCALE: V 1:250, H 1:250



DW BUND 2
LONGITUDINAL SECTION
SCALE: V 1:250, H 1:250



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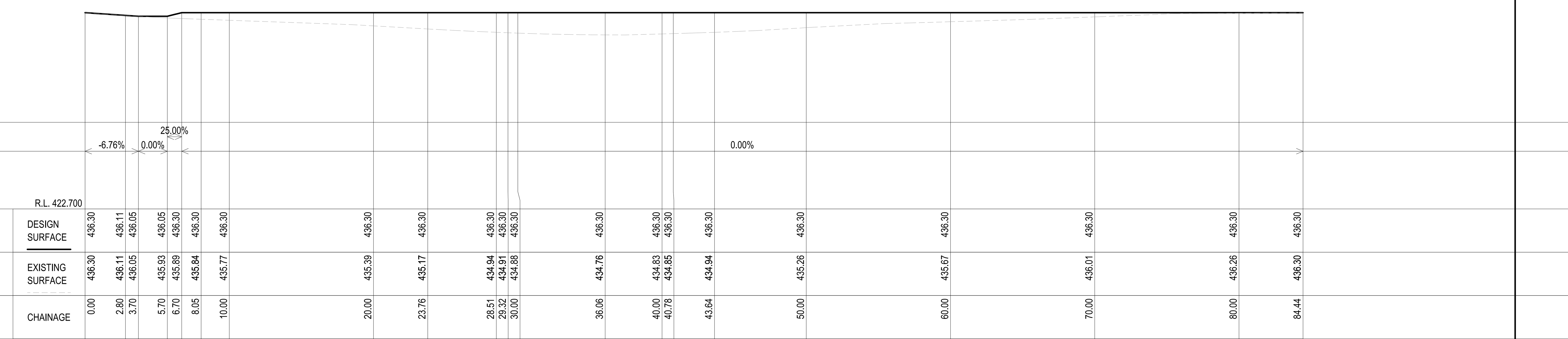
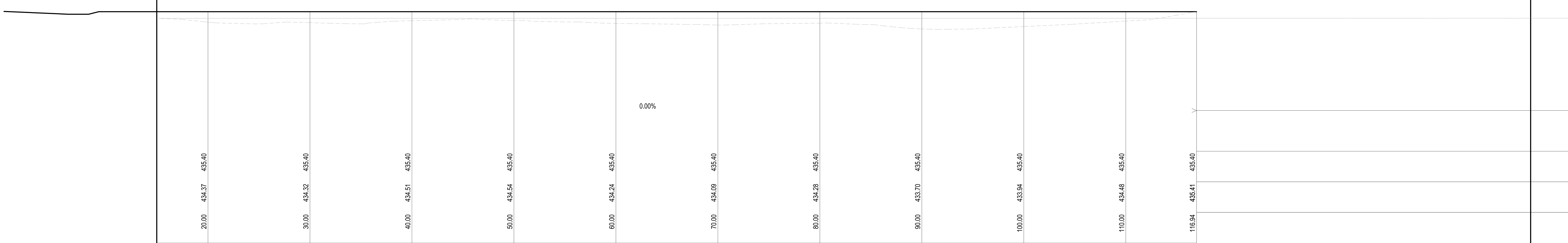
LONGITUDINAL SECTION
SCALE: V 1:250, H 1:250



DAM 2 - TOP OF BUND
LONGITUDINAL SECTION
SCALE: V 1:250, H 1:250



DAM 1 - TOP OF BUND
LONGITUDINAL SECTION
SCALE: V 1:250, H 1:250

FOR CONSTRUCTION

18.03.2024	
19.01.2024	
22.12.2023	
DATE	

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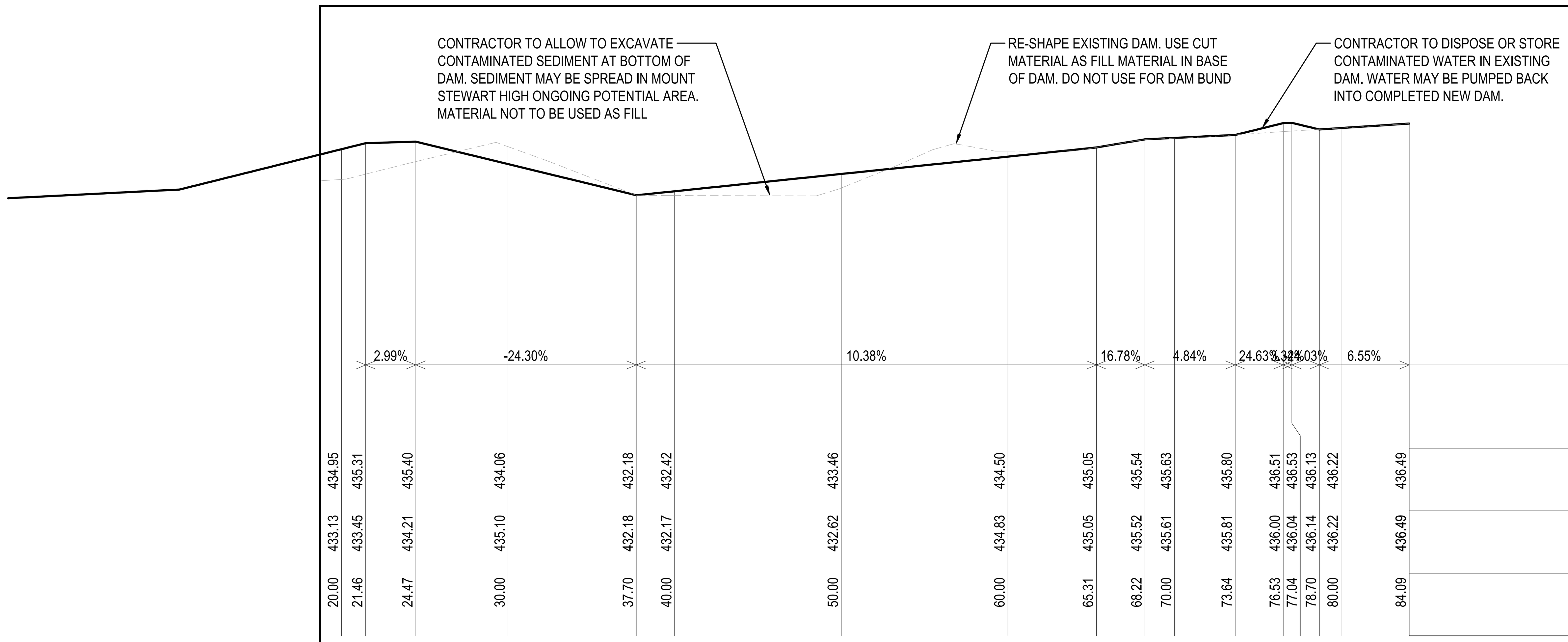
PROJECT: **LEGACY MINES PROGRAM LEADVILLE MINE REMEDIATION**

DRAWING TITLE: **MOUNT STEWART LONGITUDINAL SECTIONS SHEET 2**

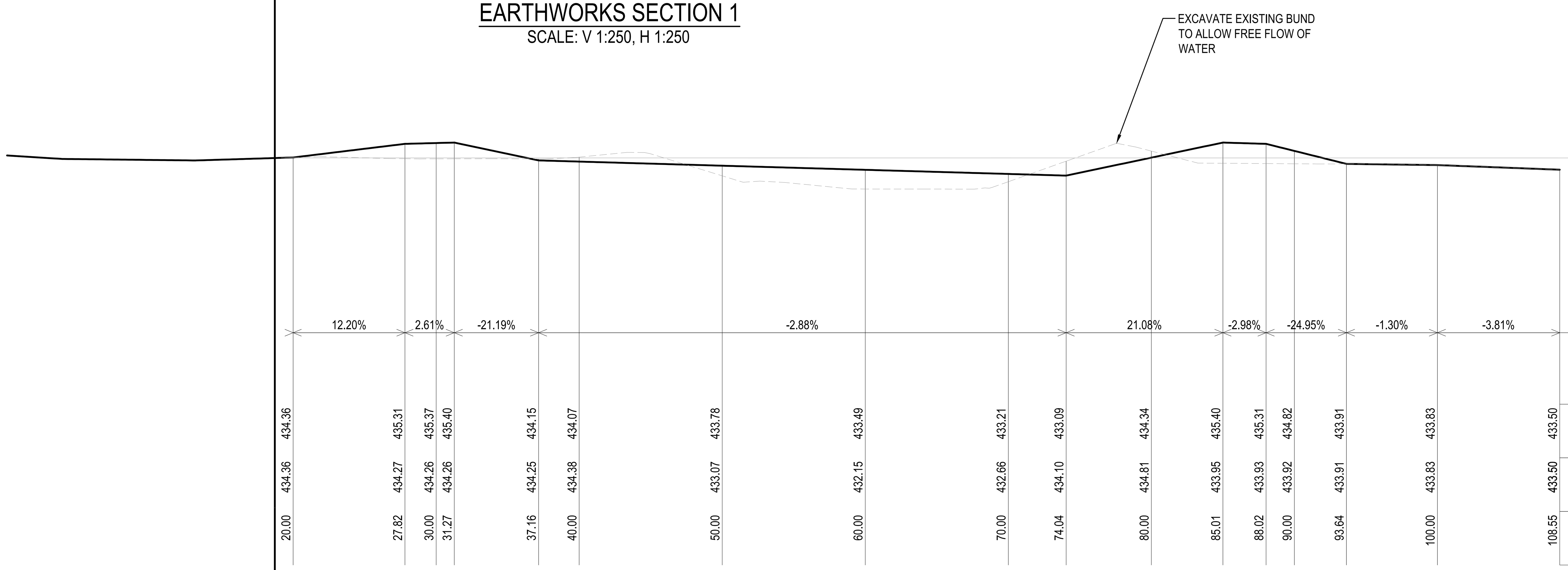
SCALE (A1): 0 2.5 5 7.5 10 15 20 25m — 1 : 250

JOB NUMBER	DATUM	DRAWING NUMBER	REVISION
23293	AHD	C24	C



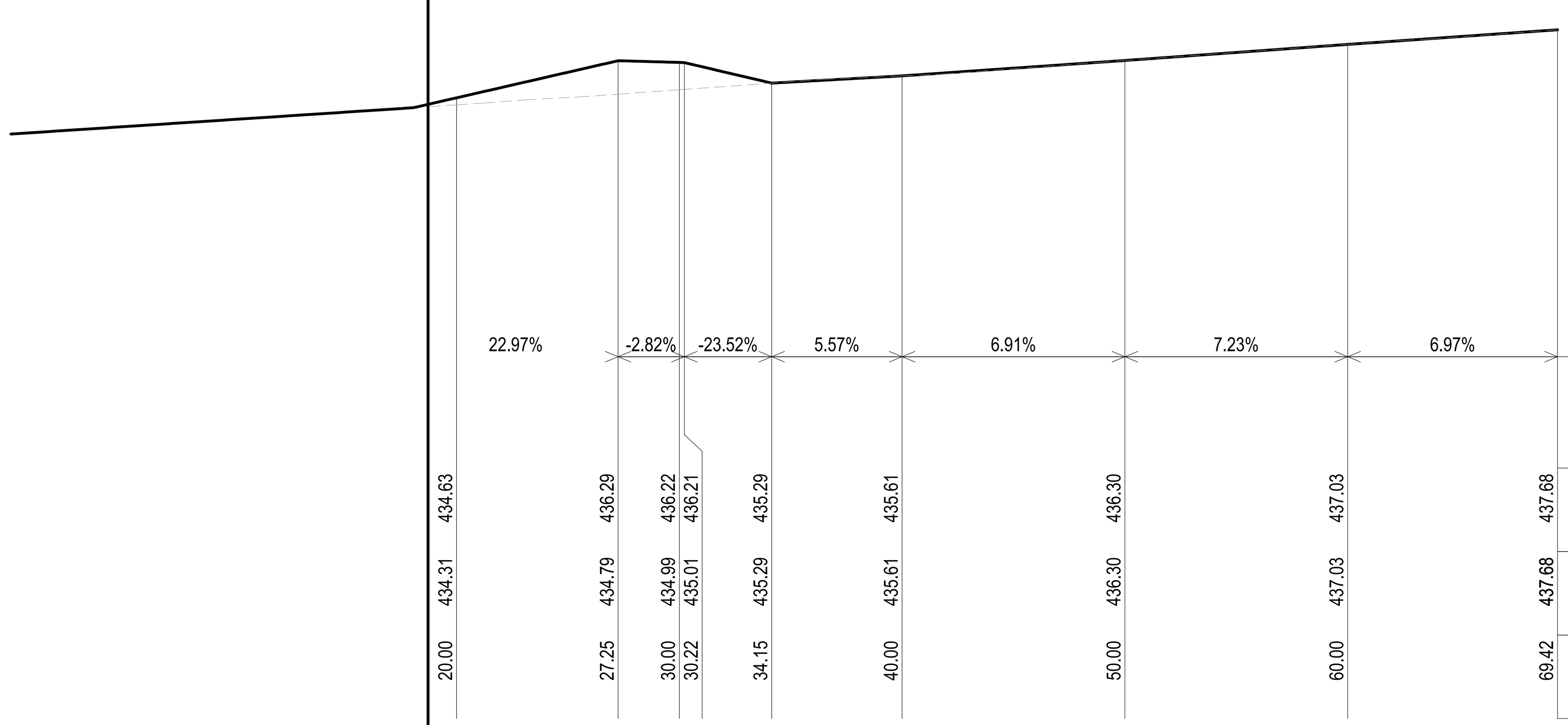
EARTHWORKS SECTION 1

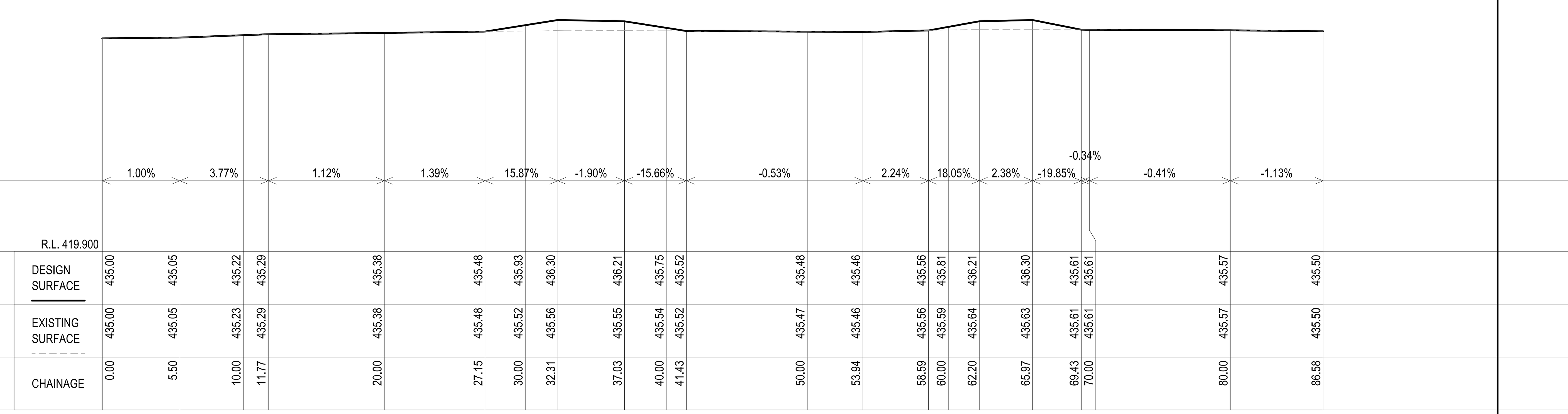
SCALE: V 1:250, H 1:250



EARTHWORKS SECTION 2

SCALE: V 1:250, H 1:250





EARTHWORKS SECTION 3

SCALE: V 1:250, H 1:250

EARTHWORKS SECTION 4

SCALE: V 1:250, H 1:250

FOR CONSTRUCTION

DATE
18.03.2024
19.01.2024
22.12.2023

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PROJECT
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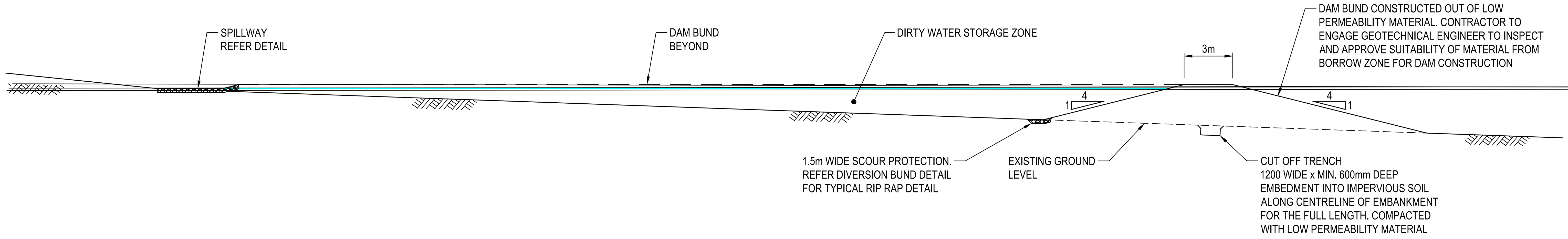
LEADVILLE MINE REMEDIATION

DRAWING TITLE
MOUNT STEWART EARTHWORKS SECTIONS

SCALE (A1)
0 2.5 5 7.5 10 15 20 25m
1 : 250

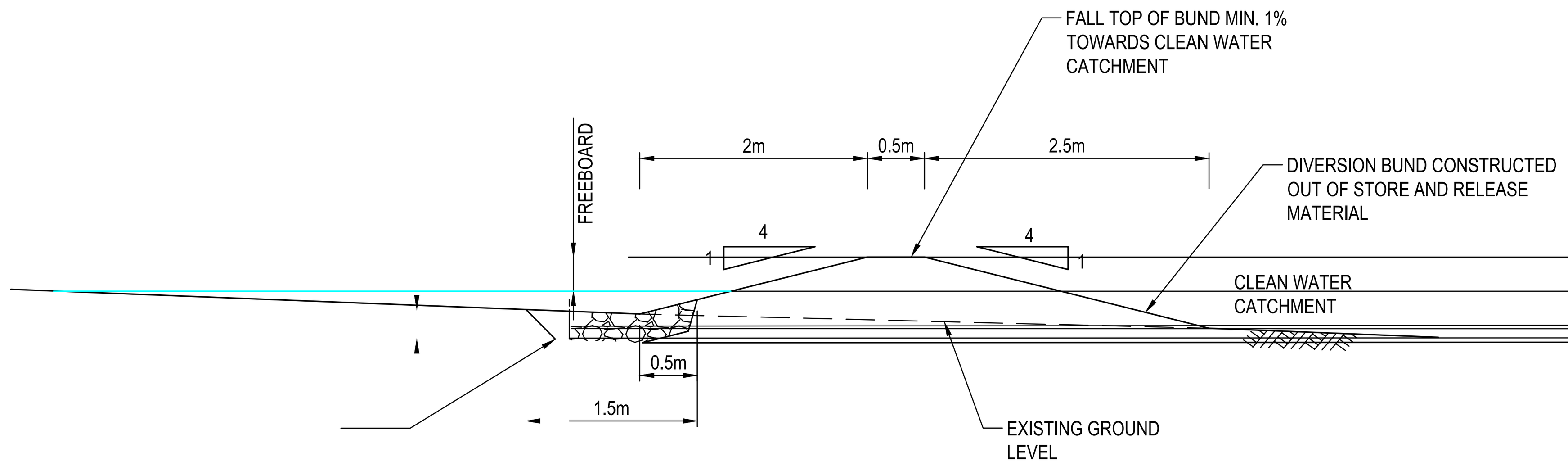
JOB NUMBER	DATUM	DRAWING NUMBER	REVISION
23293	AHD	C25	C



TYPICAL CONTAINMENT DAM DETAIL

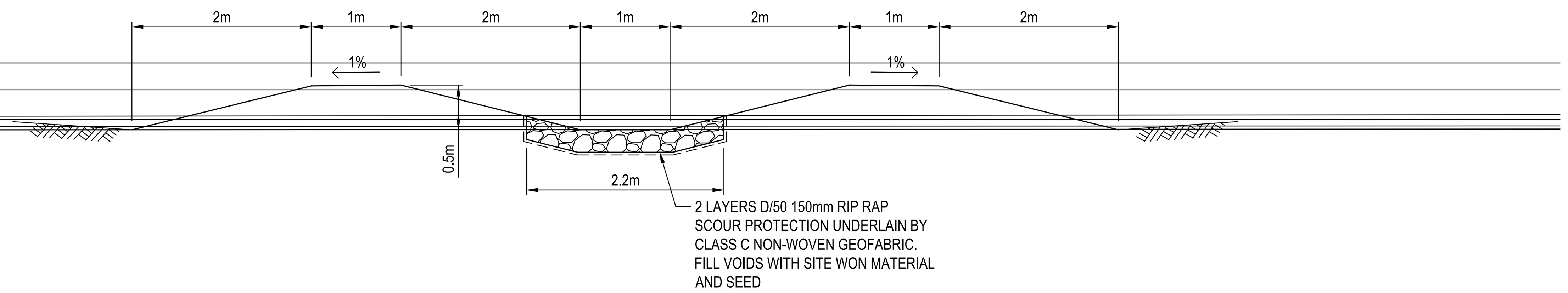
NOT TO SCALE

NOTE: REFER C01 FOR DAM EARTHWORKS SPECIFICATION



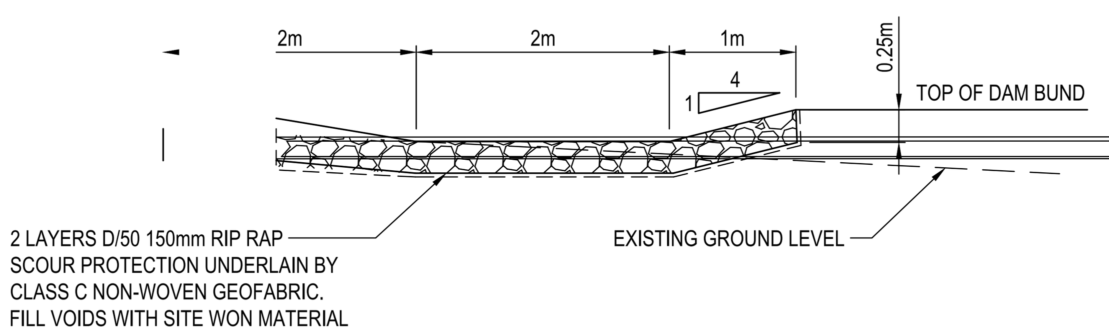
TYPICAL DIVERSION BUND DETAIL

SCALE: 1:50



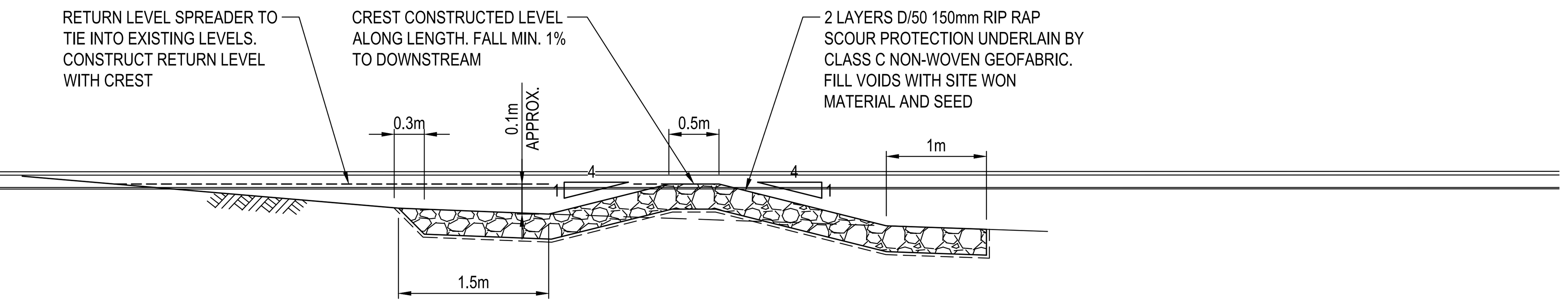
DIVERSION CHANNEL DETAIL

SCALE: 1:50



DAM SPILLWAY DETAIL

SCALE: 1:50



LEVEL SPREADER DETAIL

SCALE: 1:50

FOR CONSTRUCTION

DATE	18.03.2024 / 19.01.2024 / 22.12.2023
CLIENT	NSW GOVERNMENT — LEGACY MINES PROGRAM DEPARTMENT OF REGIONAL NSW
PROJECT	LEGACY MINES PROGRAM LEADVILLE MINE REMEDIATION
DRAWING TITLE	MOUNT STEWART EARTHWORKS DETAILS SHEET 1
SCALE (A1)	0 1000 2000 3000 4000 5000mm — 1 : 50
JOB NUMBER	23293
DATUM	AHD
DRAWING NUMBER	C27
REVISION	C

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SITEWORKS PLAN

SCALE: 1:750

LEGEND

	APPROX. BOUNDARY
435.0	EXISTING CONTOUR
435.0	PROPOSED CONTOUR
	EXISTING FENCE ALIGNMENT (APPROX.) TO BE RETAINED
	EXISTING FENCE ALIGNMENT (APPROX.) TO BE REPLACED WITH NEW HINGED JOINT FENCE ON SAME ALIGNMENT
	NEW 1.8m HIGH CHAIN LINK FENCE
	EXISTING FENCE ALIGNMENT (APPROX.) TO BE REPLACED WITH NEW 1.8m HIGH CHAIN LINK FENCE ON SAME ALIGNMENT
	GATE TO SUIT PROPOSED CHAINLINK FENCE
	GATE TO SUIT PROPOSED HINGED JOINT FENCE
	TEST PIT LOCATION
	CLEAN WATER FLOW DIRECTION
	DIRTY WATER FLOW DIRECTION
	STORMWATER DRAINAGE LINE
	BORROW SOURCE
	LEAVE IN-SITU AND ISOLATE

FOR CONSTRUCTION

REV	DESCRIPTION	DESIGN	DRAWN	CHECK	DATE
D	FENCE ALIGNMENT REVISED	CW	RP		26.03.2024
C	FOR CONSTRUCTION	CW	RP		18.03.2024
B	FOR CONSTRUCTION	CW	RP	TMC	19.01.2024
A	FOR CONSTRUCTION	CW	RP	TMC	22.12.2023

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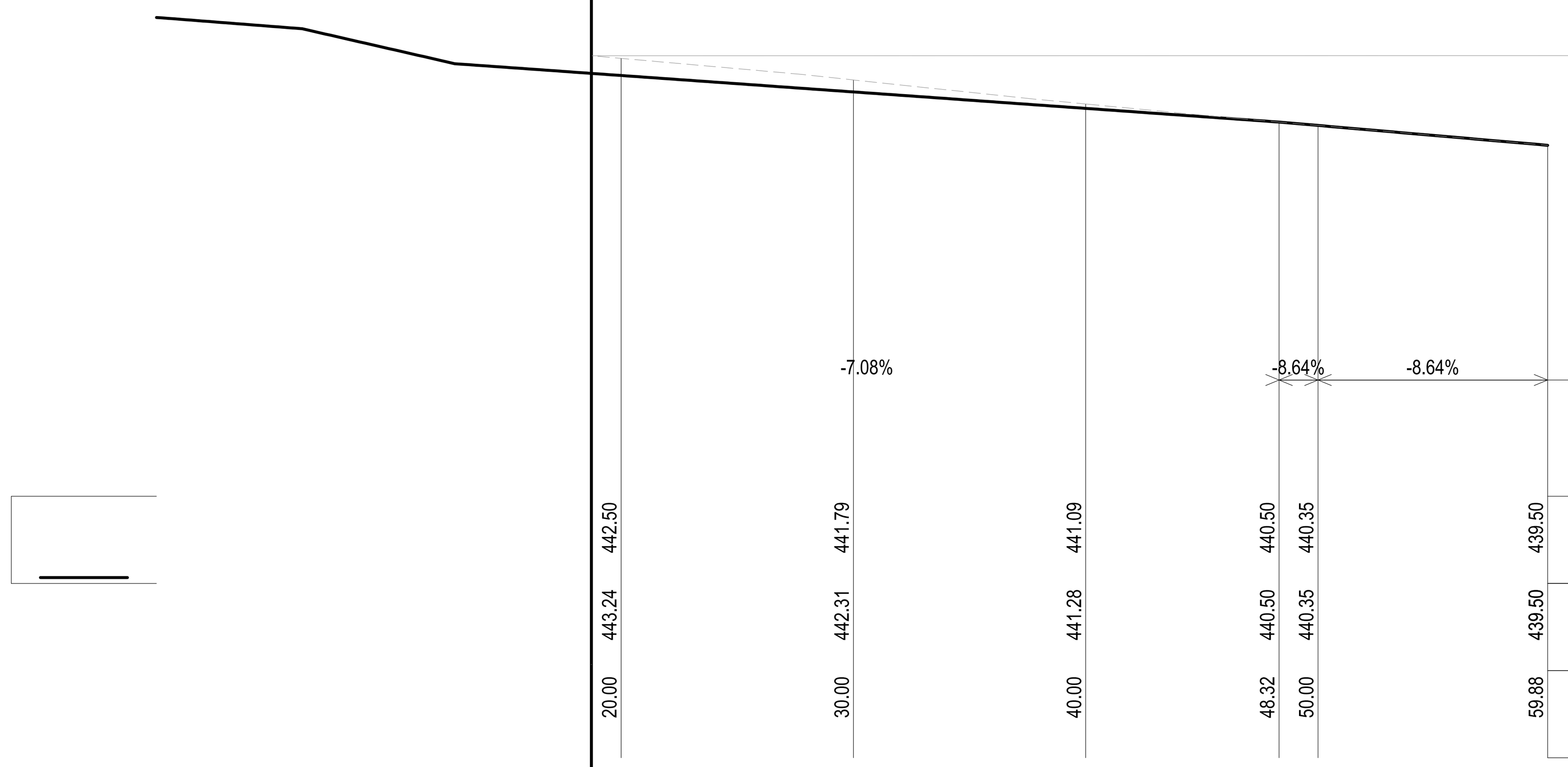
PROJECT
LEGACY MINES PROGRAM LEADVILLE MINE REMEDIATION

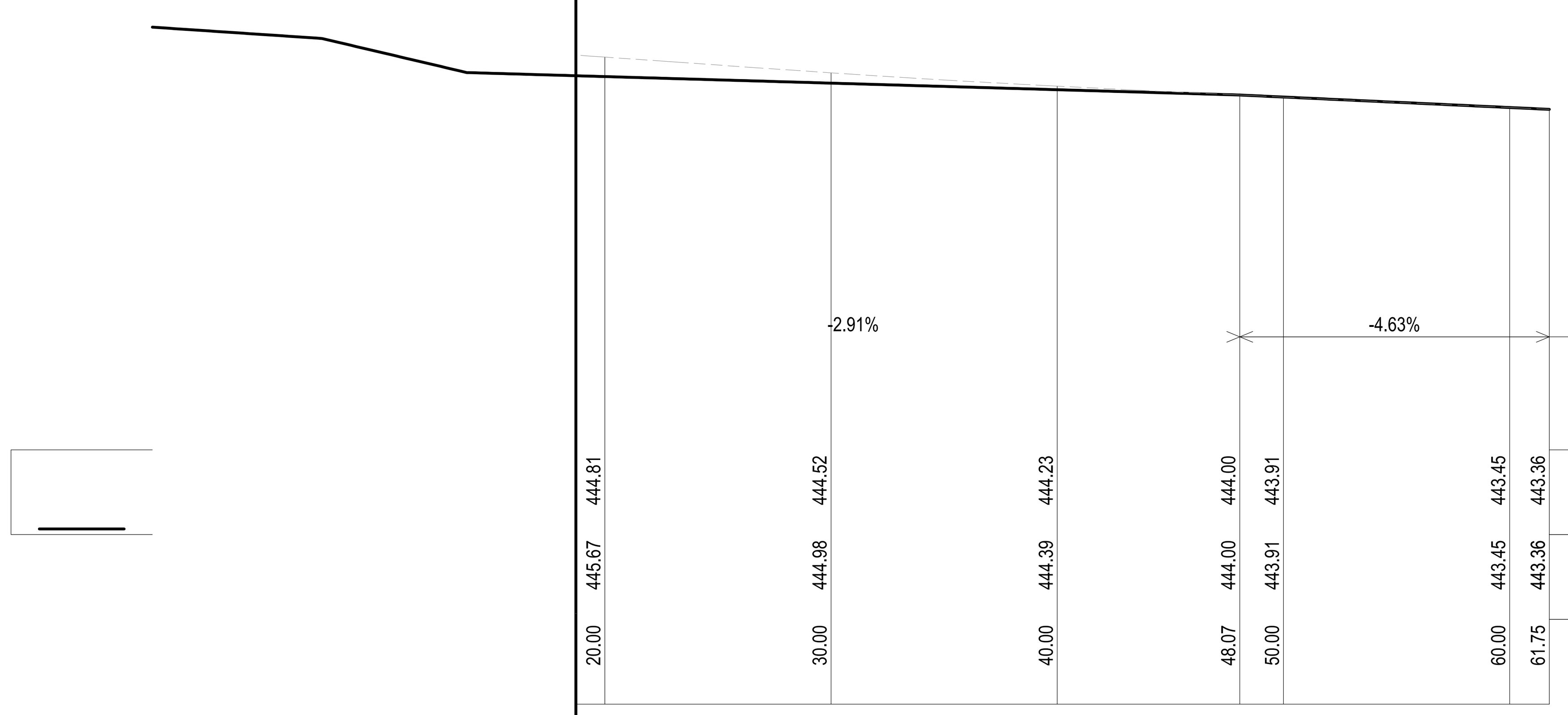
DRAWING TITLE
SMELTER AND BORROW ZONE SITEWORKS PLAN

SCALE (A1)
0 7.5 15 22.5 30 45 40 50m
1 : 750

JOB NUMBER	DATUM	DRAWING NUMBER	REVISION
23293	AHD	C30	D



EARTHWORKS SECTION 5
SCALE: V 1:250, H 1:250



EARTHWORKS SECTION 6
SCALE: V 1:250, H 1:250

FOR CONSTRUCTION

DATE
18.03.2024
19.01.2024
22.12.2023

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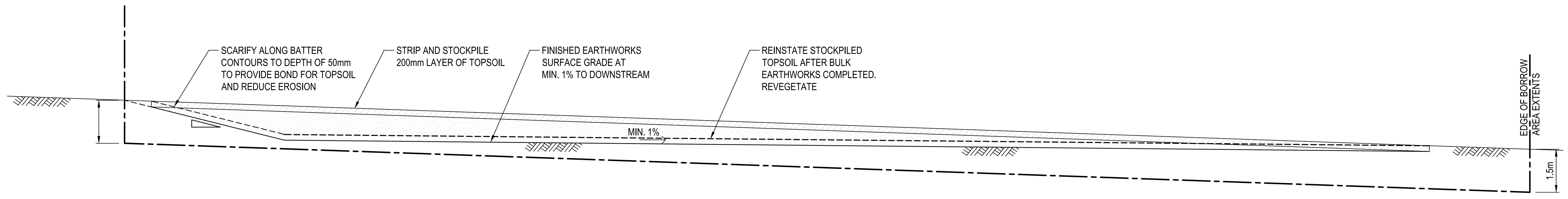
DRAWING TITLE
SMELTER AND BORROW ZONE EARTHWORKS SECTIONS

SCALE (A1)
0 2 4 6 8 12 16 20m
1 : 200

JOB NUMBER	DATUM	DRAWING NUMBER	REVISION
23293	AHD	C35	C



TYPICAL BORROW AREA
EARTHWORKS SECTION
SCALE: 1:100

FOR CONSTRUCTION

					18.03.2024
					19.01.2024
					22.12.2023
					DATE

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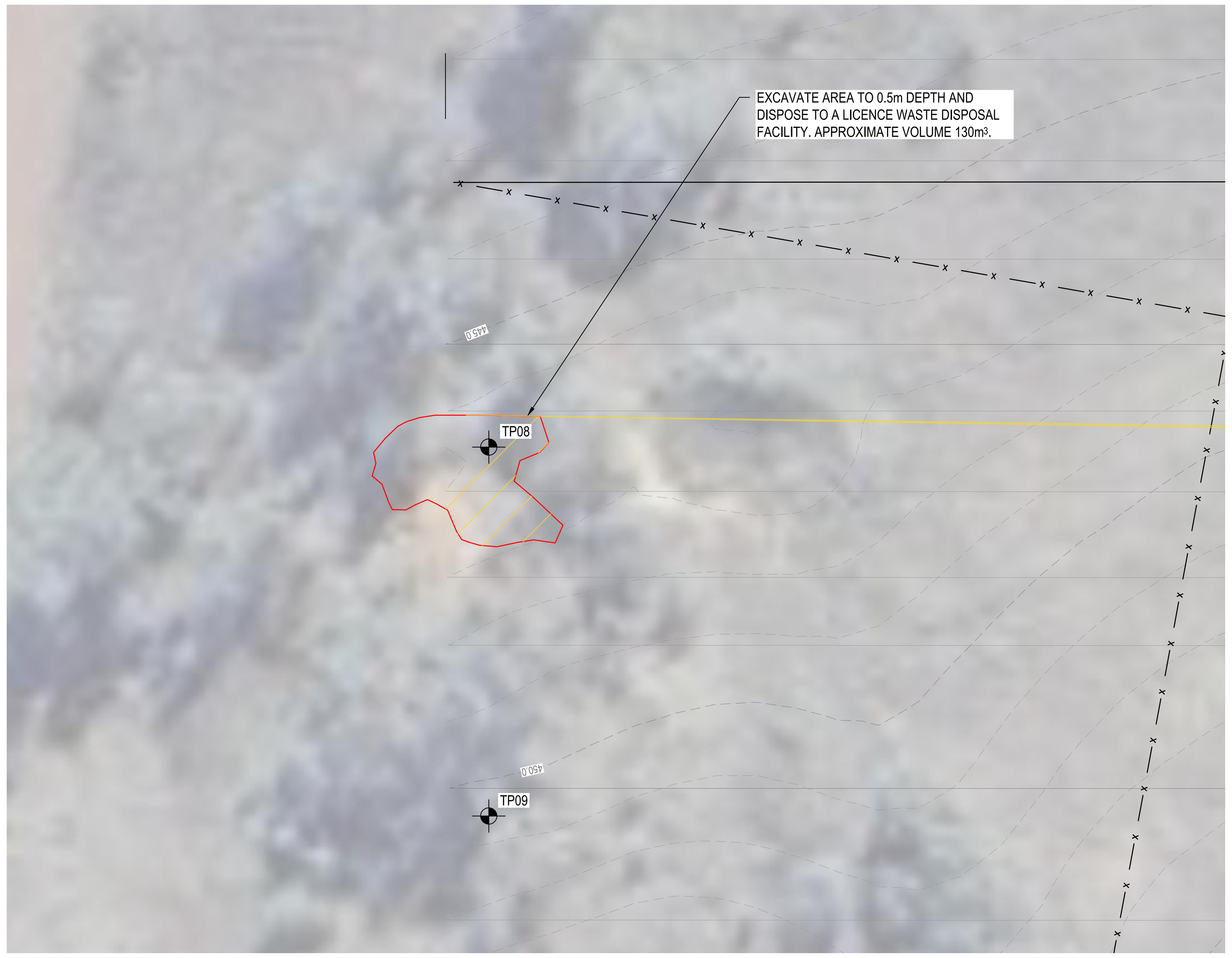
PROJECT
LEGACY MINES PROGRAM LEADVILLE MINE REMEDIATION

DRAWING TITLE
SMELTER AND BORROW ZONE EARTHWORKS DETAILS

SCALE (A1)
0 2 4 6 8 12 16 20m
1 : 200

JOB NUMBER	DATUM	DRAWING NUMBER	REVISION
23293	AHD	C37	C



SITEWORKS PLAN
SCALE: 1:500

LEGEND

- EXISTING CONTOUR (435.0)
- EXISTING FENCE ALIGNMENT (APPROX.) TO BE RETAINED
- NEW 1.8m HIGH CHAIN LINK FENCE
- EXISTING FENCE ALIGNMENT (APPROX.) TO BE REPLACED WITH NEW 1.8m HIGH CHAIN LINK FENCE ON SAME ALIGNMENT
- TEST PIT LOCATION
- APPROXIMATE REMEDIAL EXTENT

FOR CONSTRUCTION

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19.01.2024
22.12.2023

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PROJECT: **LEGACY MINES PROGRAM LEADVILLE MINE REMEDIATION**

DRAWING TITLE: **GROSVENOR DAM SITEWORKS PLAN**

SCALE (A1): 0 5 10 15 20 30 60 75m — 1 : 500

JOB NUMBER	DATUM	DRAWING NUMBER	REVISION
23293	AHD	C40	C

Appendix B

GHD Geohazards Assessment

Leadville Remediation Technical Oversight

Hazard Assessment Report

Department of Regional NSW (Legacy Mines Program)

08 August 2023

→ **The Power of Commitment**

Project name	Leadville Remediation Technical Oversight
Document title	Leadville Remediation Technical Oversight | Hazard Assessment Report
Project number	12588769
File name	12588769-REP_Hazard Assessment Report.docx

Status Code	Revision	Author	Reviewer		Approved for issue		
			Name	Signature	Name	Signature	Date
S4	0	S Mackenzie	S Winchester		S Winchester		08/08/23

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The Power of Commitment

Contents

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Figure index

Appendices

1. Introduction

1.1 Background

GHD Pty Ltd (GHD) was commissioned by NSW Department of Regional NSW - Legacy Mines Program (LMP) to provide Technical Oversight of the Leadville Remediation Project (the Project). The Project is to be undertaken at the legacy Leadville Mine (the site), located approximately 500 m west of the village of Leadville and 16 km east of Dunedoo. A site location plan is presented as Figure 1 in Appendix A. Also in Appendix A are plans for the Mount Stewart, Mount Stewart Extended and Grosvenor working areas as Figures 2, 3, and 4 respectively.

The proposed remediation works broadly involve earthworks, including capping and drainage works, final landform shaping, revegetation and fencing of specific areas. Some of the remediation activities will be undertaken over and adjacent to former mine entries and/or areas of subsidence hazard associated with the abandoned underground mine workings. The Principal Works Contractor (PWC) undertaking the remediation work will be exposed to these hazards and will need to review, assess, and mitigate the associated risks.

A description of site surface conditions, as well as an overview of site geology is provided in the GHD report: *Environmental Monitoring Sampling, Analysis and Quality Management Plan* (GHD Ref. 12588769_SAQMP, Rev. 1, 31 January 2023). Information on the site's mining history is presented in Everick (2016), Fredrickson (1993) and Dickson (1963) in particular, and a collation of historical material is available from the DIGS database as report R00046075.

1.2 Purpose of this report

This report presents a hazard assessment in the form of a geotechnical assessment and subsequent advice regarding working around old mine workings and former shafts to facilitate the proposed remediation works. Specifically, advice is provided on subsidence hazards and their likelihood to assist LMP and the PWC with risk assessments and risk mitigation during the remediation works.

Aspects not included in this hazard assessment

This report does not provide assessment or advice on:

- Other geotechnical hazards such as slope instability (landslides and rock falls).
- Hazards posed to the general public or workers, other than the PWC and site inducted personnel.
- Subsidence hazards and associated safety and environmental risks post remediation project.
- Assessment of shaft seal adequacy/ durability.
- Unknown hazards. That is, subsidence hazards not listed in Table 5.1 of this report (hazard register).

1.3 Scope and limitations

This report has been prepared by GHD for *Department of Regional NSW* and may only be used and relied on by *Department of Regional NSW* for the purpose agreed between GHD and *Department of Regional NSW* as set out in Section 1 of this report. GHD otherwise disclaims responsibility to any person other than *Department of Regional NSW* arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

GHD has prepared this report on the basis of information provided by *Department of Regional NSW* and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

The site walkover was limited in coverage and the location of many shafts have not been confirmed due to vegetation cover, ground disturbance, shaft backfilling or a combination of the these. As such, there is the possibility of other shafts / subsidence being present but obscured and for error in the mapped locations of shafts and mine workings.

2. Assessment methodology

The assessment comprised a desktop review, collation and georeferencing of historical plans into an ArcGIS project map and site walkover by a GHD Technical Director - Geotechnical Engineer (Sam Mackenzie) on 9 and 10 February 2023.

The desktop review included the following information types:

- Geological exploration reports including plans.
- Various historical plans of the mine workings showing shaft locations, areas of cave-in and stopes.
- Consulting reports associated with remediation.
- Aerial imagery, including historical aerial photographs from 1964, 1971, 1980, 1990, 1994, 1998 and a recent high-resolution orthophoto provided by LMP.
- Recent digital terrain model provided by LMP.

Specific references are provided in Section 6.

Before and after the site walkover, mine and geology plans, aerial photographs and the digital terrain model were imported into an ArcGIS project map and georeferenced (scaled and rotated to fit). As expected with hand drawn maps, georeferencing could only be approximated (nominally within 10 m). The high-resolution aerial orthophoto greatly aided this process and allowed visual identification (off the orthophoto) and location of some shafts to an accuracy of a few meters.

During the site walkover, mapped shaft locations and other areas of interest such as former cave-ins or existing surface anomalies were visited, with shafts located using a handheld GPS (iPad with ArcGIS Field Maps) and subsequently photographed. Selected photographs are included in Appendix B for each shaft or general shaft area (where a specific shaft location could not be confirmed). Notes regarding the location of a shaft, such as the dimensions of any surface depressions or other salient features were made and are included in Table 5.1. The extent of the walkover included all areas of mapped shafts within the Mount Stewart, Mount Stewart Extended and Grosvenor workings. The locations of these three workings are shown on Figure 1 in Appendix A; all of which are located within the project site.

Following the site walkover, field observations were compared to georeferenced maps and the subsidence hazard register in Section 5.2 finalised together with the figures in Appendix A to show:

- shaft locations
- tunnels (levels), generally only those labelled as shallower than 100 feet (about 30 m)
- recorded cave-in and reported stope areas
- subsidence hazard zones

The rationale for the subsidence hazard zones is discussed in Section 4.

3. Correlation with historical plans to identify shafts and georeferenced mine plans

Historical plans, sections and geological maps relating to mine workings were reviewed and selected maps georeferenced and compared to features such as holes and fences visible on the high-resolution orthophoto and observed during the walkover. These visible features and their correlation to named shafts, as described below, have been relied on to position non-visible shafts, mine workings and areas of reported cave-in.

A brief description of this process for each of the three mining areas is provided under the sub-headings below.

Measurements of hole dimensions for visible shafts are included in Table 5.1.

Historical aerial photograph resolution was too poor to be useful for identifying shafts, cave-ins or open cuts.

3.1 Mount Stewart workings

3.1.1 Western and Middle Lodes

Visible shafts within this mining area comprise:

– ‘Underlay Shaft’ or ’90 Feet Level’ Shaft in the Western Lode which reportedly extends (inclined) to the 90-foot level (about 27 m).

– ’50 Feet Level’ Shaft in the Western Lode which appears to be an underlay shaft (inclined) to the 50-foot level.

The above shafts are matched to visible features as shown in Figure 3.1. The Western Shaft is not visible but may be the rectangular area circled in the aerial photo in Figure 3.1.

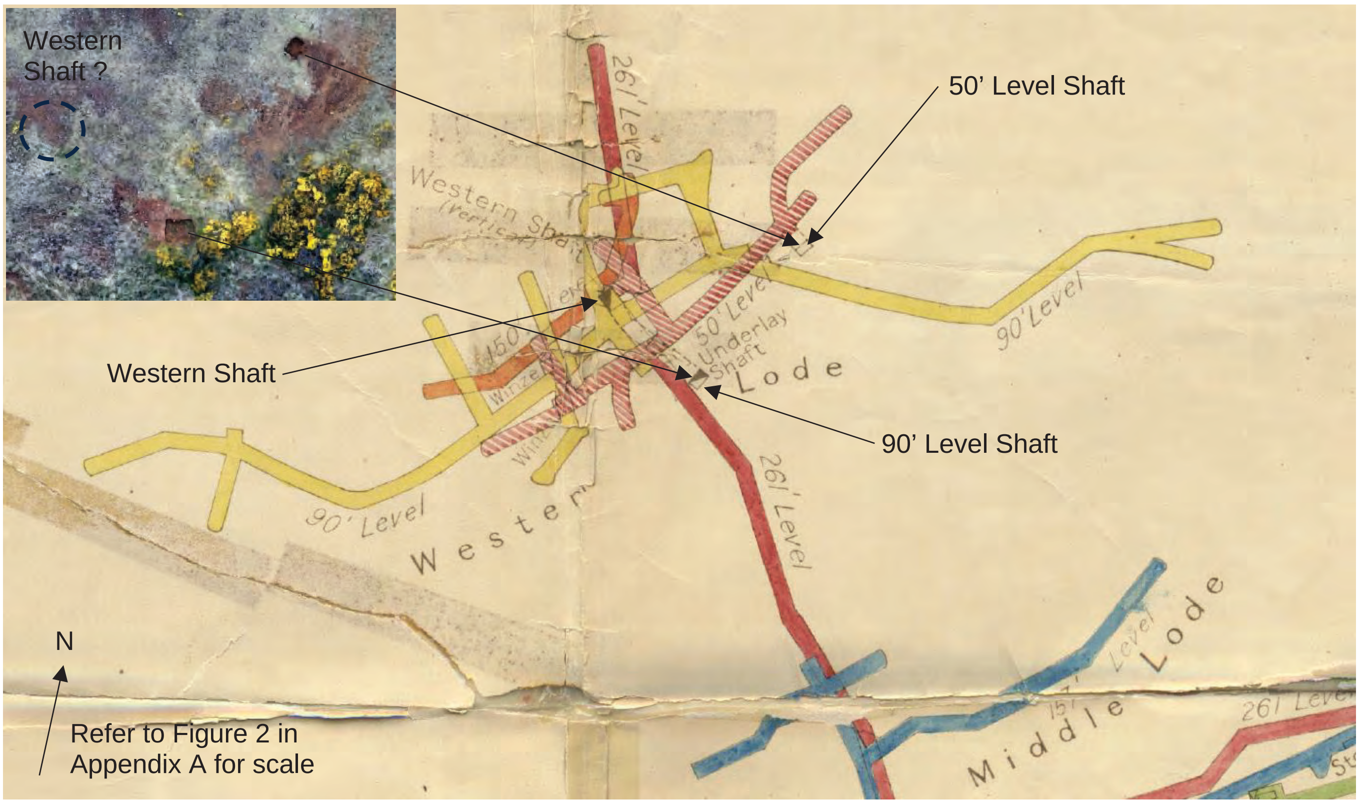

Figure 3.1 Mount Stewart Western and Middle Lode workings from ‘Plan of Mount Stewart Workings – Leadville’. 1922. In GS1922/016 (DIGS Ref. D003796350) with inset from orthophoto

A second unnamed shaft location to the north was marked by a small mound of rocks. This shaft is not shown to extend to any workings on the 1922 plan but is mapped on a 1948 geology map as shown in Figure 3.2.

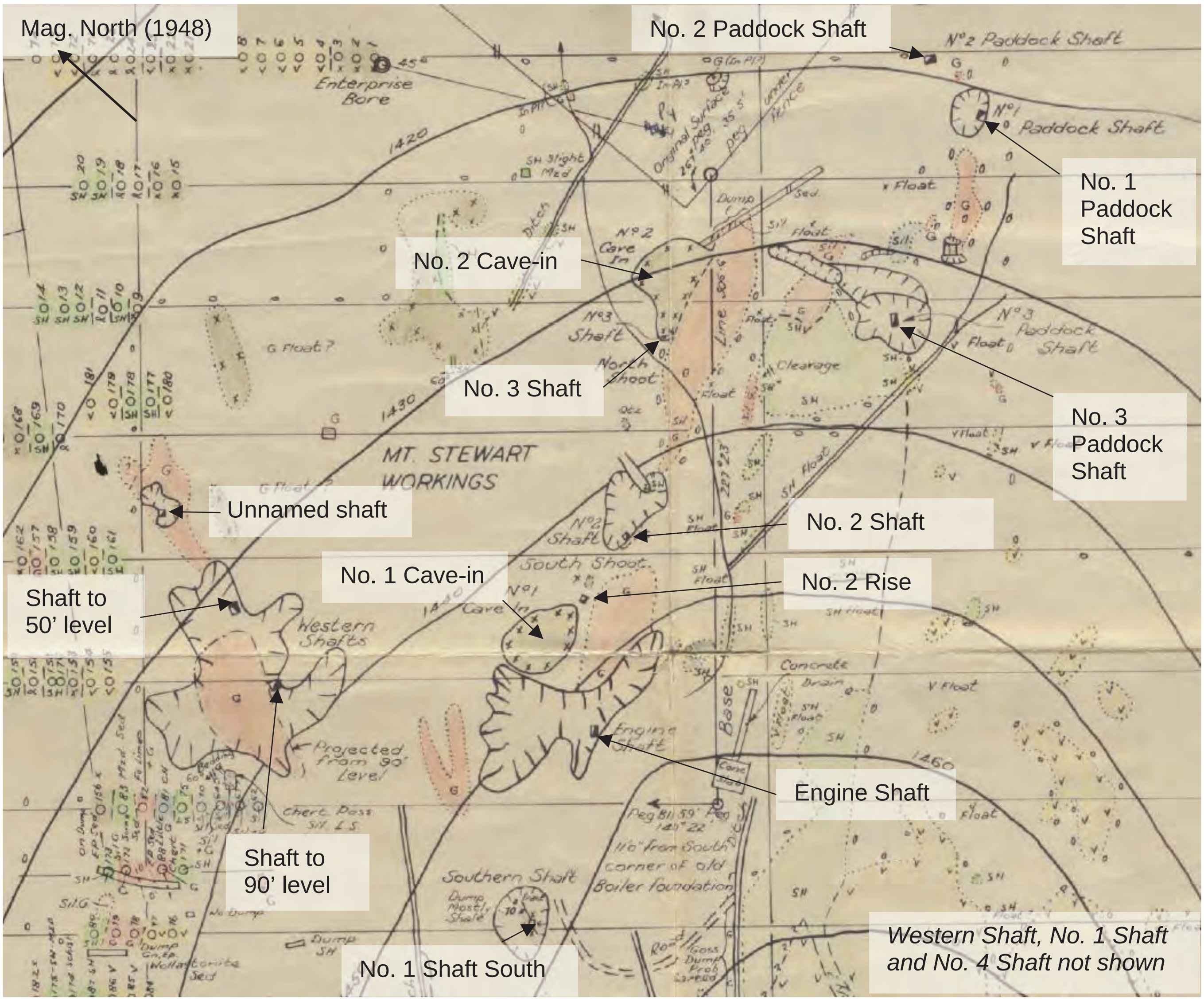

Figure 3.2 ***Extract of Mount Stewart workings from 'Geological Map of Leadville – N.S.W' by The Zinc Corporation Ltd, 1948. In GS1948/008 (DIGS Ref. D00586920)***

Fordon-Bellgrove (1969, GS1970/304), referencing Willian (1925) noted that that the '90 Feet Level' shaft is shown in section as being vertical from the surface for 18 feet (5.5 m), before being inclined. However, the shaft is noted as now being underlay (inclined) from the surface toward the north-west "due to erosion of the collar". The 'erosion' of the collar noted by Fordon-Bellgrove (*ibid*) probably amounts to removal of the collar mounds which are shown around most shafts in the 1948 geology map (Figure 3.2).

The 'levels' are nominal depths referenced from the Engine Shaft datum (Fordon-Bellgrove, *ibid*). As the Engine Shaft collar is higher than other shafts (as shown in Figure 3.4), the actual depths of levels noted on mine plans below ground surface will be less than indicated. In the Western Lode area, the depth to levels below existing ground surface is generally expected to be about 3 m less than the nominal mine level depth. For example and as annotated in Figure 3.4, the '50 foot level' is more likely to be in the order of 35 feet (~11 m) below the existing ground surface.

Willan (1925) provides plans and sections of the workings following surface and underground geological mapping. These include depiction of geology at various levels as shown in Figure 3.3. In the Southern and Northern Shoots of the Eastern Lode workings, stopes are associated with what Willan labelled "silver lead gossan ore" and "pyrites ore". It follows that stoping in other areas of these ores is more likely and so these areas have been traced in the various plans and sections reproduced from Willan.

Note that Willan's labelling of the Western Shaft is in error on one occasion as shown below with this actually being the '90 Feet Level' Shaft.

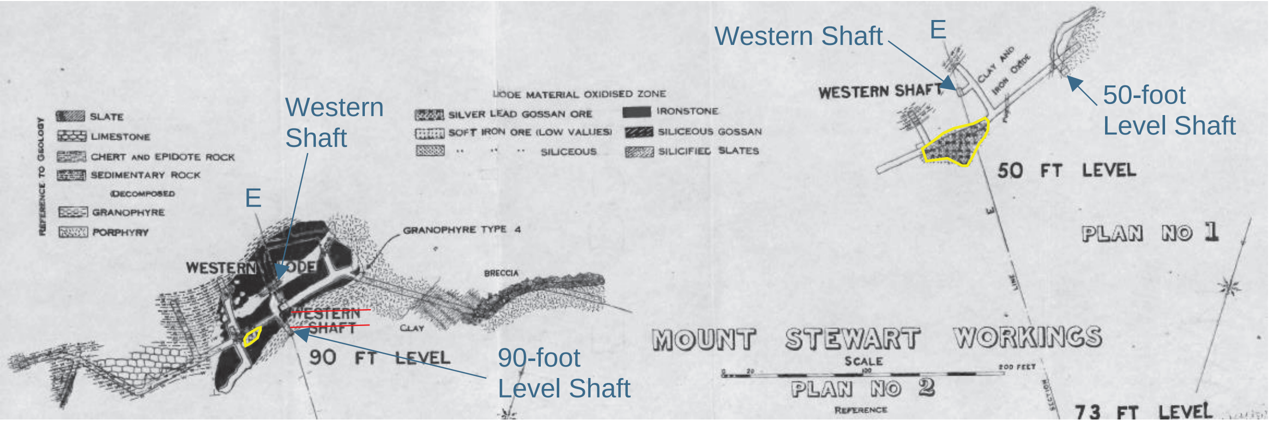

Figure 3.3 *Mount Stewart workings – Western Lode 50 to 90 foot levels after Willan (1925) with "silver lead gossan ore" area traced in yellow*

A section along "line E" is reproduced in Figure 3.4, again with "silver lead gossan ore" and "pyrites ore" areas traced in yellow and shaft names added.

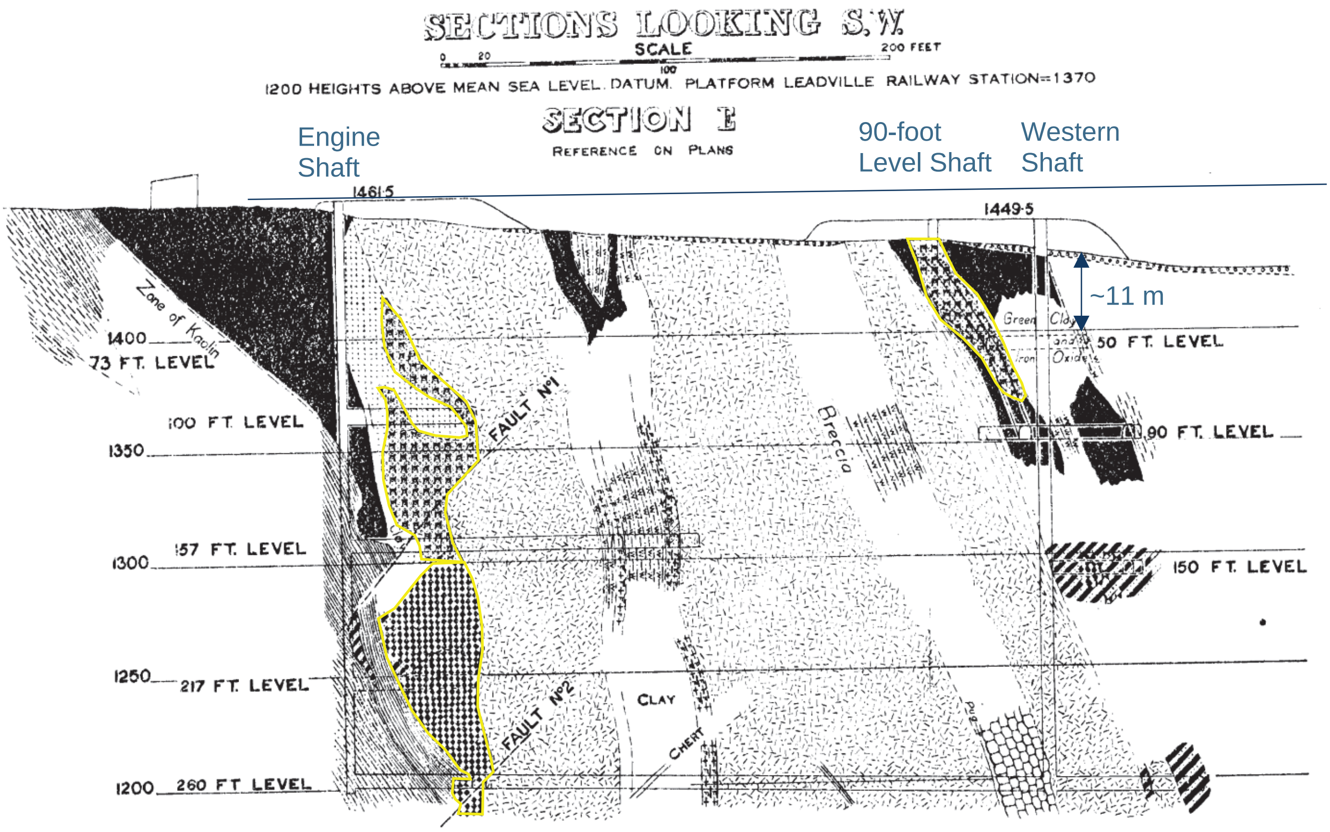

Figure 3.4 *Mount Stewart workings – Section E after Willan (1925) with "silver lead gossan ore" and "pyrites ore" areas traced in yellow*

Stoping / cave-in to the ground surface in the Western Lode area is mentioned in Fordon-Bellgrove (*ibid*) as follows: "Bad caving of the surface occurs westward from the '90' Feet Level' Shaft and may represent a collapse of the 50 feet level workings, north westward from the Western Shaft". Willan (1925) shows "silver lead gossan ore" in this area but no labelling of a stope in this area.

3.1.2 Eastern and Paddock Lodes

Visible shafts within this mining area comprise:

- 'Engine Shaft' – also known as Main Shaft
- 'No. 1 Paddock Shaft'
- 'No. 3 Paddock Shaft' (fenced and open) – also known as Burkhard's Shaft

The above shafts are matched to visible features as shown in Figure 3.5.

The No. 2 Paddock Shaft is probably marked by a pile of logs and the No. 1 Shaft South by a mound of rocks and grass beside a dead tree. The locations of other shafts and the two cave-ins and past open cuts shown on Figure 3.2 are not discernible.

Regarding the No. 3 Paddock Shaft', Fordon-Bellgrove (*ibid*) reports at least 81 feet (24.7 m) of vertical shaft was visible in 1969 and that the shaft is likely to have a 100 foot (30.5 m) vertical section as per McKeown (1951).

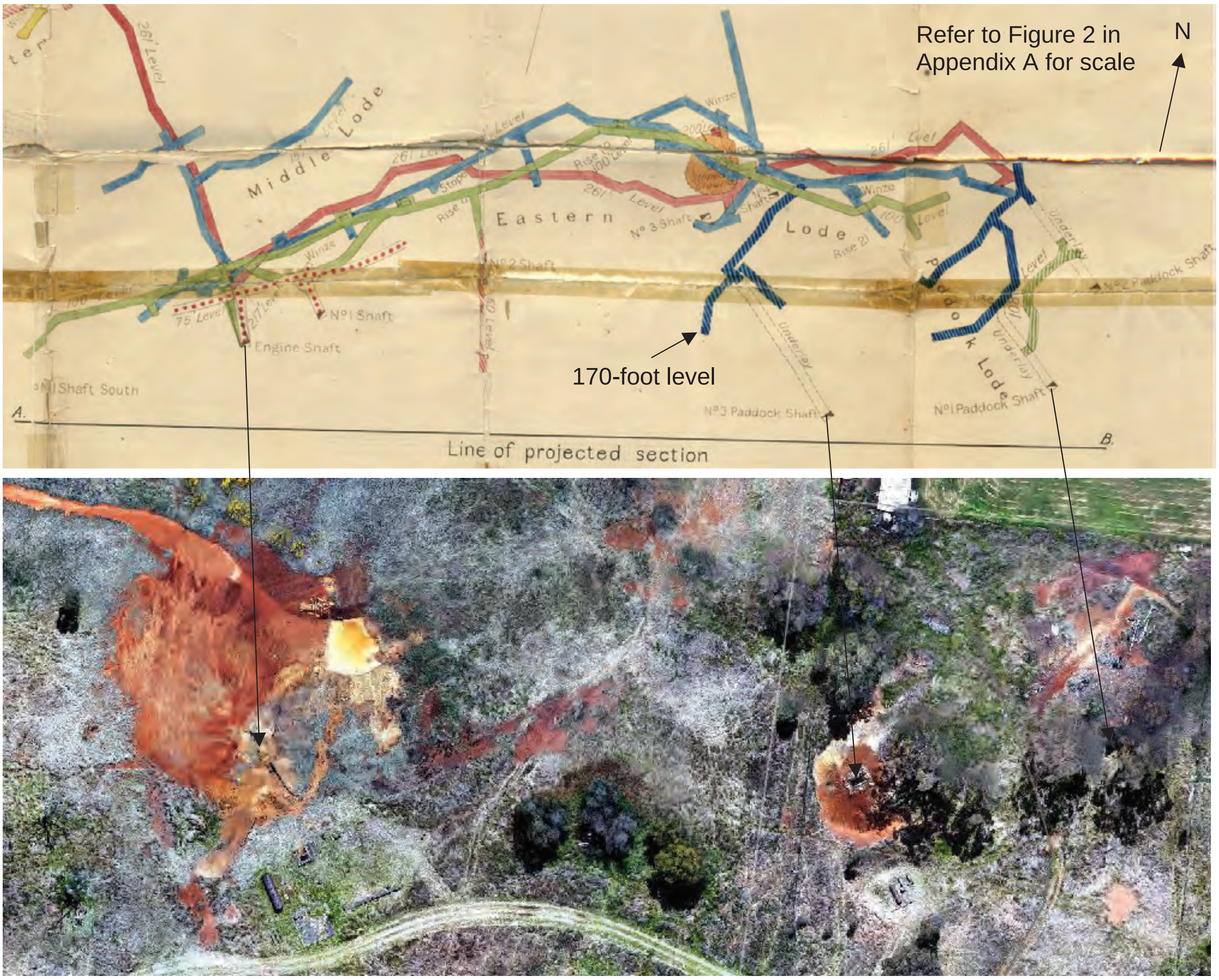

Figure 3.5 Mount Stewart Eastern and Paddock Lode workings from 'Plan of Mount Stewart Workings – Leadville'. 1922. In GS1922/016 (DIGS Ref. D003796350) and orthophoto

The noted in Section 3.1.1, 'levels' are nominal depths referenced from the Engine Shaft datum (at 1461.5 feet above mean sea level). In the Eastern Lode and Paddock Lode area, the depth to levels below existing ground surface is generally expected to be up to about 3 m less than the nominal mine level depth. For example, the 60 foot level off No. 2 Paddock Shaft is shown to be at a depth of about 50 feet (15 m) below ground surface in Figure 3.11.

The 'Line of projected section' indicated in the upper image in Figure 3.5 is included as Figure 3.6 below. Stoped ground is shown as hatching with a 'South Shoot' extending to the surface around the No. 1 Shaft and a 'North Shoot' almost reaching the surface around No. 3 and No. 4 Shafts. The 'South Shoot' corresponds to the 'No. 1 Cave-in' and the 'North Shoot' to the 'No. 2 Cave-in' shown on Figure 3.2.

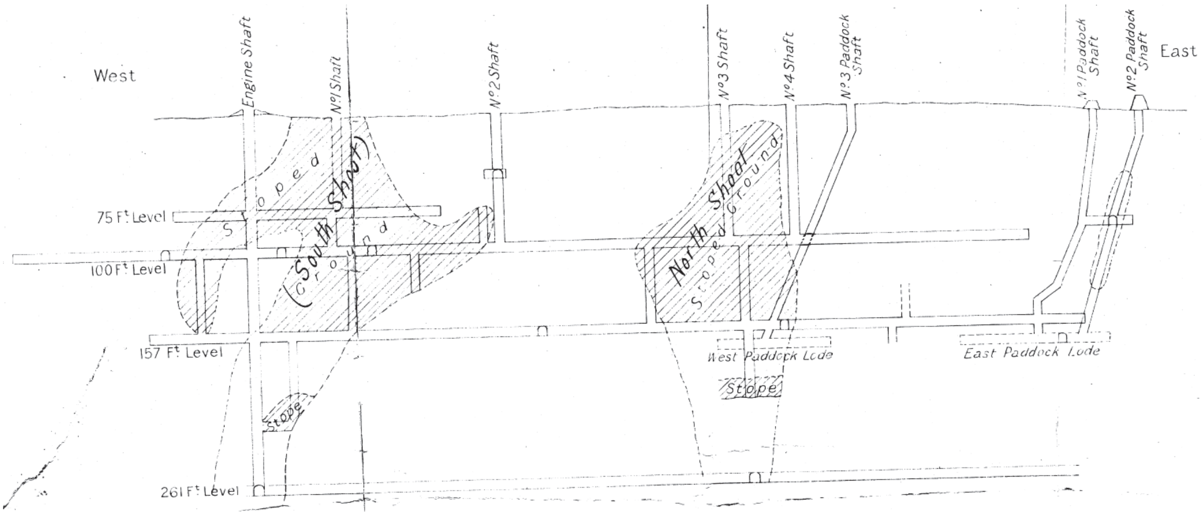

Figure 3.6 'Projected Section along Line A.B.' from GS1922/016 (DIGS Ref. D003796370)

A similar section from before 1915 and facing the opposite direction is provided in the Mine Record 0091 compilation (DIGS Ref. R00046075) and is shown in Figure 3.7. A trace of the stope outline (mirror image) from the 1922 section (Figure 3.6) is shown in red.

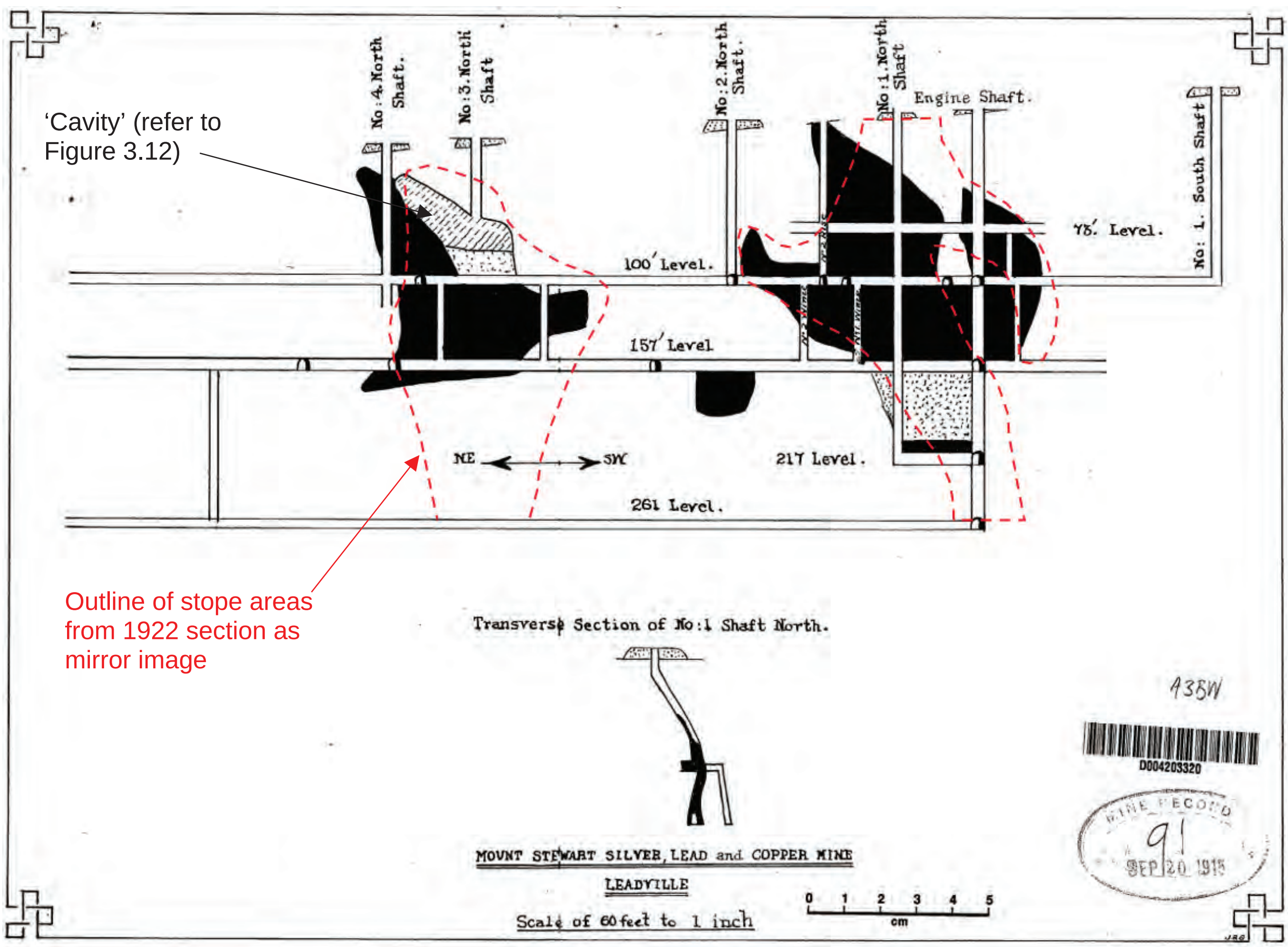

Figure 3.7 Pre 1915 section of Mount Stewart workings Eastern Lode (DIGS Ref. D004203320)

Accounting for measurement and drawing inaccuracy, the stope areas in the two sections appear similar above the 157-foot level.

The 1922 section shows additional stoping below the 157-foot level and also in the upper portions. In the South Shoot (around the Engine Shaft), both sections show the stope has progressed to the surface, although the 1922 section shows this as occurring around the No. 1 Shaft rather than the No. 2 Rise as in the pre-1915 section. The 1948 geology map (Figure 3.2) shows the cave-in at the South Shoot occurred between the No. 2 Rise and Engine Shaft and so agrees with the 1922 section. It's likely the area of cave-in started around the No. 2 Rise and extended toward the Engine Shaft but did not reach the Engine Shaft or No. 1 Shaft.

The width of stoping around the Engine Shaft at the 157-foot level is given in a 1920 report (MR 0091, p54, DIGS Ref. D004203110) to be 35 feet (10.7 m) for a length of about 40 feet (12.2 m) and up to about 17 feet (5.2 m) above the level. The same 1920 report indicates the Northern Shoot stope ("about 350' N.E. of Engine Shaft") has been stoped from the 157-foot level to the surface. At the 157 level the width is given as 35 feet. At the 205' level the width is reported as 30 feet and at 261' level only 6 feet.

Willan (1925) provides plans and sections depicting geology at various levels as shown in Figure 3.8 and Figure 3.9 with labels of 'stope' in some areas. In the Southern and Northern Shoots, the stopes are associated with what Willan labelled "silver lead gossan ore" and "pyrites ore". It follows that stoping in other areas of these ores is more likely and so these areas have been traced in the various plans and sections reproduced from Willan.

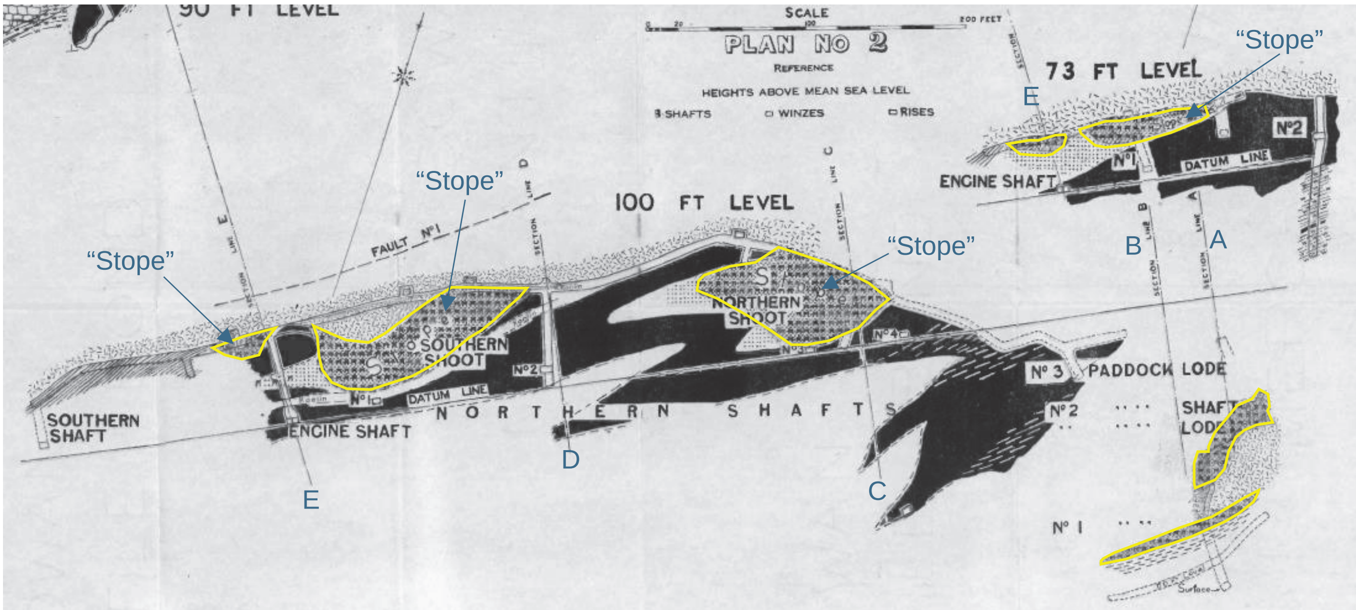

Figure 3.8 ***Mount Stewart workings Eastern Lode and Paddock Lode - 73 to 100 foot levels after Willan (1925) with "silver lead gossan ore" and "pyrites ore" traced in yellow***

Figure 3.8 shows splitting of the stope with the smaller area on section line E northwest of the Engine Shaft. The larger stope area progressed to the ground surface to form the No. 1 Cave-in as shown on Figure 3.2 from 1948.

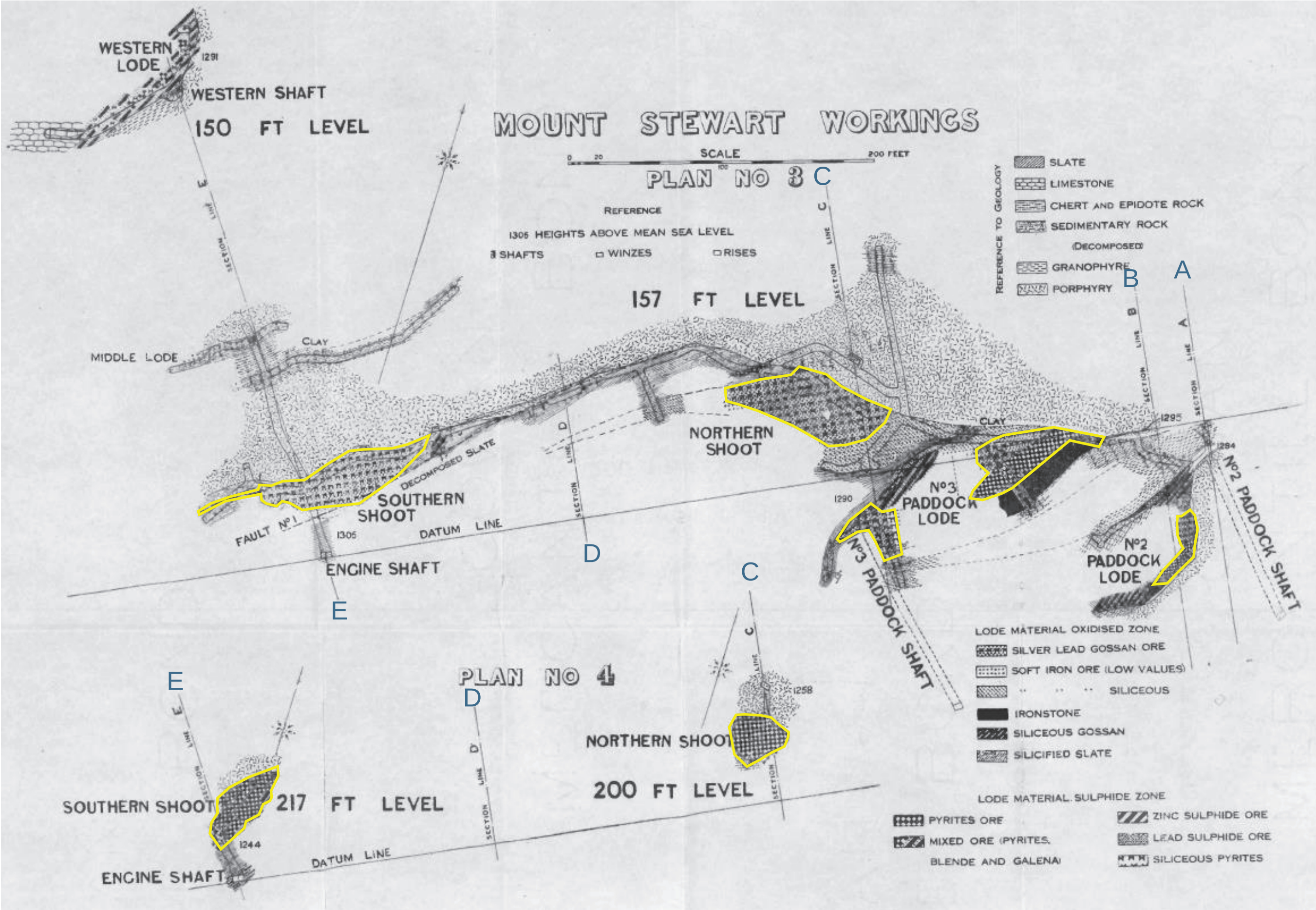

Figure 3.9 ***Mount Stewart workings - 150 to 217 foot levels after Willan (1925) with "silver lead gossan ore" and "pyrites ore" areas traced in yellow***

Sections along lines C and D are reproduced in Figure 3.10 and section lines A and B in Figure 3.11, again with "silver lead gossan ore" and "pyrites ore" areas traced in yellow and shaft names added.

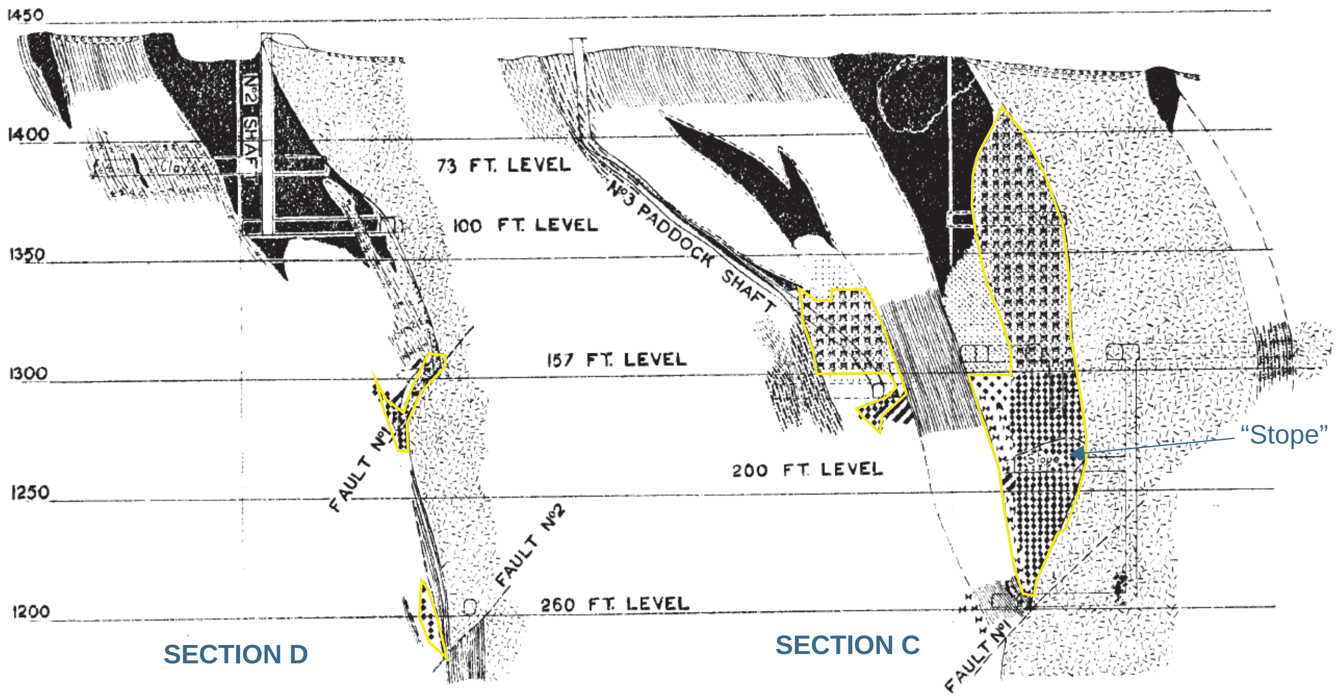

Figure 3.10 ***Mount Stewart workings – Section C and D after Willan (1925) with "silver lead gossan ore" and "pyrites ore" areas traced in yellow***

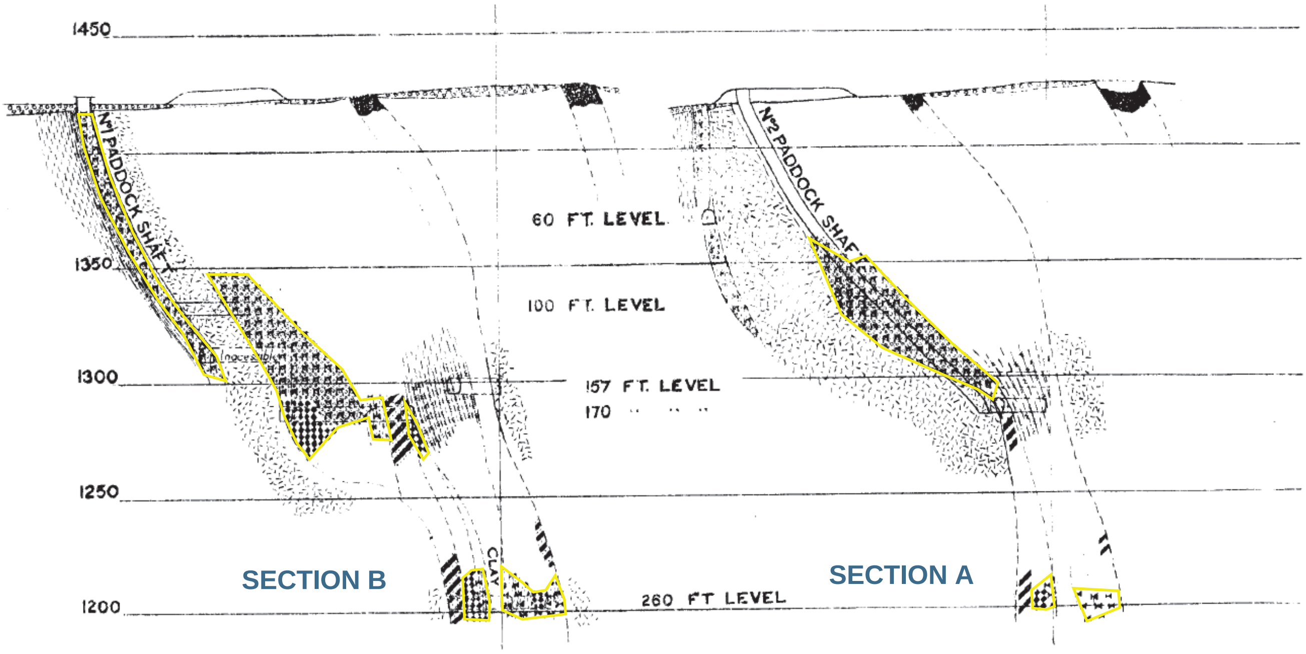

Figure 3.11 Mount Stewart workings – Section A and B after Willan (1925) with "silver lead gossan ore" and "pyrites ore" areas traced in yellow

A longitudinal section through the Eastern and No. 3 Paddock Lode is shown in Figure 3.12.

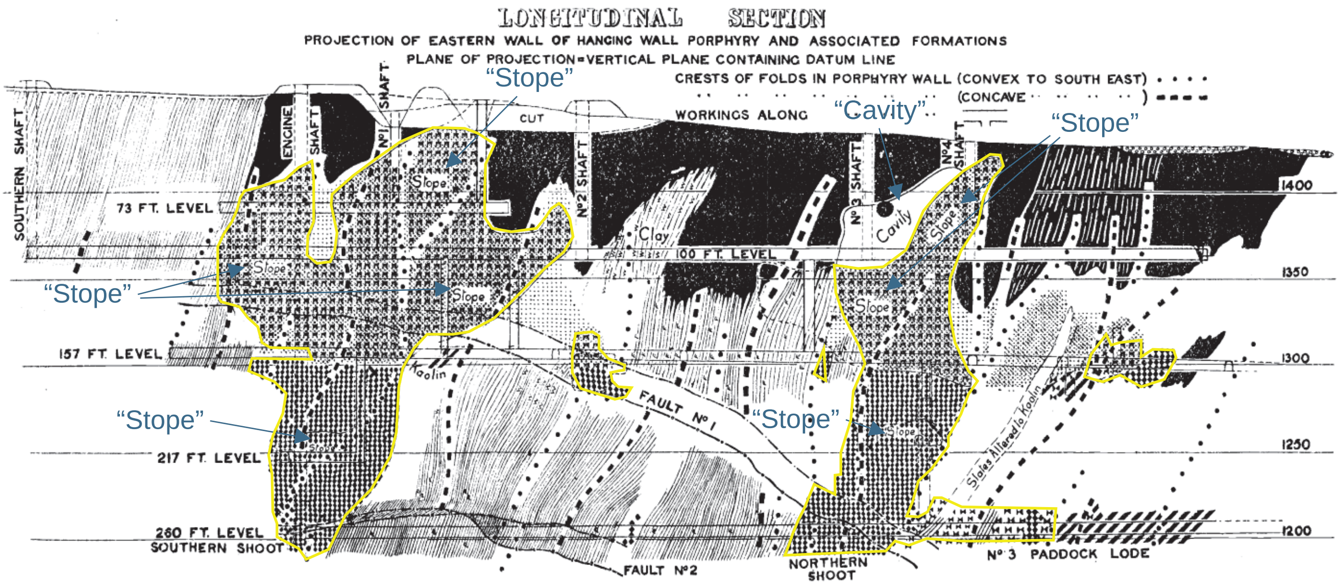

Figure 3.12 Mount Stewart workings – Eastern and No. 3 Paddock Lode longitudinal Section after Willan (1925) with "silver lead gossan ore" and "pyrites ore" areas traced in yellow

Plans of the workings at the 260-foot level is also included in Willan (1925).

3.2 Extended workings

Visible shafts within this mining area comprise:

– 'Engine Shaft' – also known as "Eastern Shaft"
– 'Blind Shaft'
– 'Copper Shaft' – also known as "Old Copper Shaft"
– 'Marshall's Shaft'

The above shafts are matched to visible features as shown in Figure 3.13. The Western Shaft is probably marked by a mound of rocks beside a tree.

Figure 3.13 Mount Stewart Extended workings from. 1922. In GS1922/016 (DIGS Ref. D003796360) and orthophoto

The 1948 geology map also shows the same shafts in this area although with slightly different names in some cases as shown in Figure 3.14.

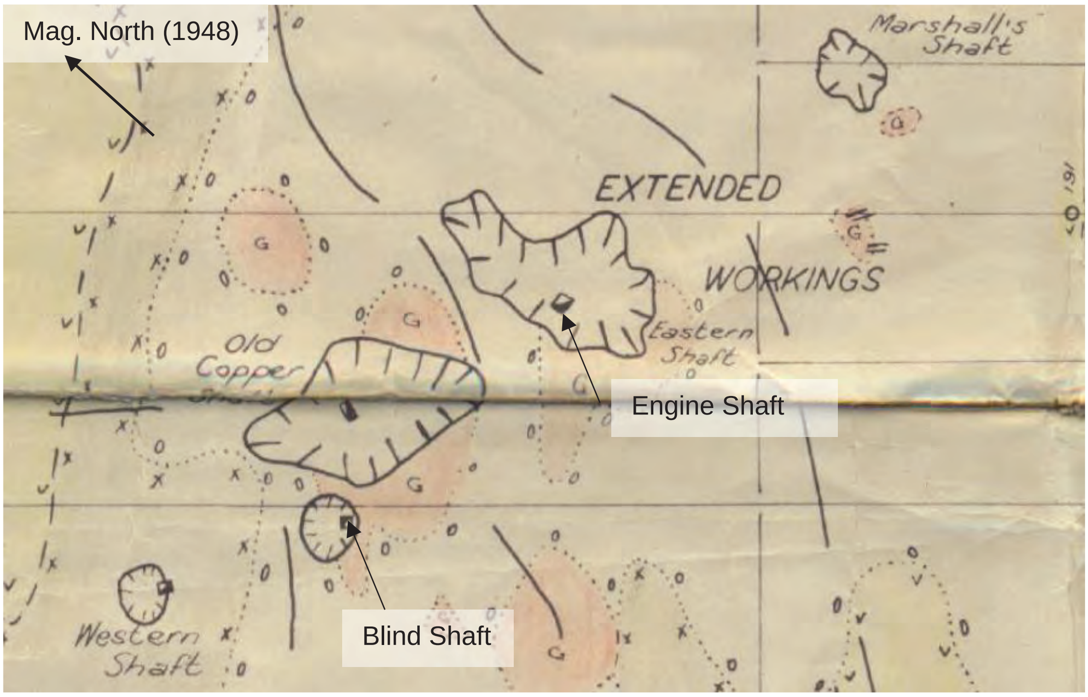

Figure 3.14 Extract of Mount Stewart Extended workings from 'Geological Map of Leadville – N.S.W' by The Zinc Corporation Ltd, 1948. In GS1948/008 (DIGS Ref. D00586920)

As noted in Section 3.1.1, 'levels' are nominal depths referenced from a datum. In the Extended Working area, the datum is the Engine Shaft (Eastern Shaft) which is given by Willan (1925) as having a collar level of 1496 feet above mean sea level. Marshall's Shaft (the lowest in the Extended workings area) has a collar 20 feet (about 6 m) lower and so the mine levels in this area are about 6 m shallower than indicated by the nominated level. For example, the 145-foot level would actually be at about 38 m depth rather than 44 m.

3.3 Grosvenor workings

Visible shafts within this mining area comprise:

– 'No. 3 Shaft'
– 'No. 4 Shaft'
– 'No. 5 Shaft'

The above shafts are matched to visible features as shown in Figure 3.15. Mining lease and portion boundaries and fence lines were used to assist in georeferencing of mine plans, but no physical boundary markers were observed. It was assumed that the visible fences are consistent with mapped portion boundaries.

As noted in Section 3.1.1, 'levels' are nominal depths referenced from a datum. In the Grosvenor area, the datum is the No. 4 Shaft with a collar level of about 1494 feet above mean sea level (Willan, 1925). The other shafts have similar or high collar levels and to the actual depth below ground surface to the mine levels is expected to be as indicated or slightly deeper.

Figure 3.15 Mount Stewart Extended workings from. 1922. In GS1922/016 (DIGS Ref. D003796380) and orthophoto

The 1948 geology map also shows the same shafts in this area although with slightly different names in some cases and two rises becoming the Rabbit and Wheat Shafts as shown in Figure 3.16.

Figure 3.16 Extract of Grosvenor workings from 'Geological Map of Leadville – N.S.W' by The Zinc Corporation Ltd, 1948. In GS1948/008 (DIGS Ref. D00586920) correlation to Grosvenor plan DIGS Ref. D003796380

Willan (1925) provides plans and sections depicting geology as shown in Figure 3.17. In the Southern and Northern Shoots of the Mount Stewart workings, stopes are associated with what Willan labelled "silver lead gossan ore" and "pyrites ore". It follows that stoping in other areas of these ores is more likely and so these areas have been traced in the various plans and sections reproduced from Willan.

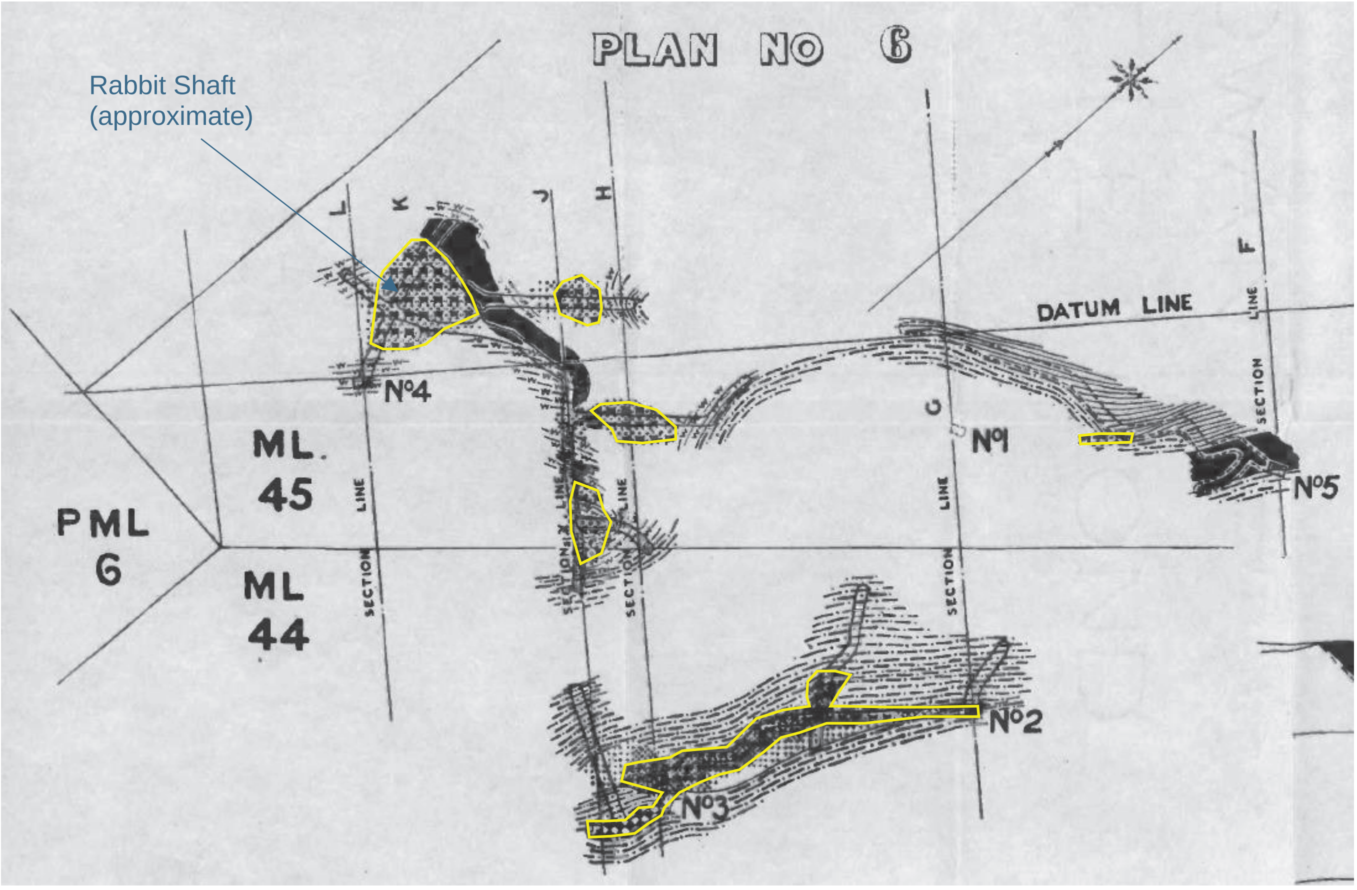

Figure 3.17 Grosvenor workings - after Willan (1925) with "silver lead gossan ore" and "pyrites ore" traced in yellow

A 12 July 1950 mine inspection report by Inspector Edwards (MR 0091, DIGS Ref. D004203190) mentions a 6 m (20 foot) by 4.6 m (15 foot) surface subsidence of 4.6 m depth (20 foot) between the No. 4 Shaft and Rabbit Shaft at the Grosvenor workings. As shown in Figure 3.18, this is where "silver lead gossan ore" is shown in section K to extend to about 2 m from the ground surface and may be where stoping was undertaken after 1925.

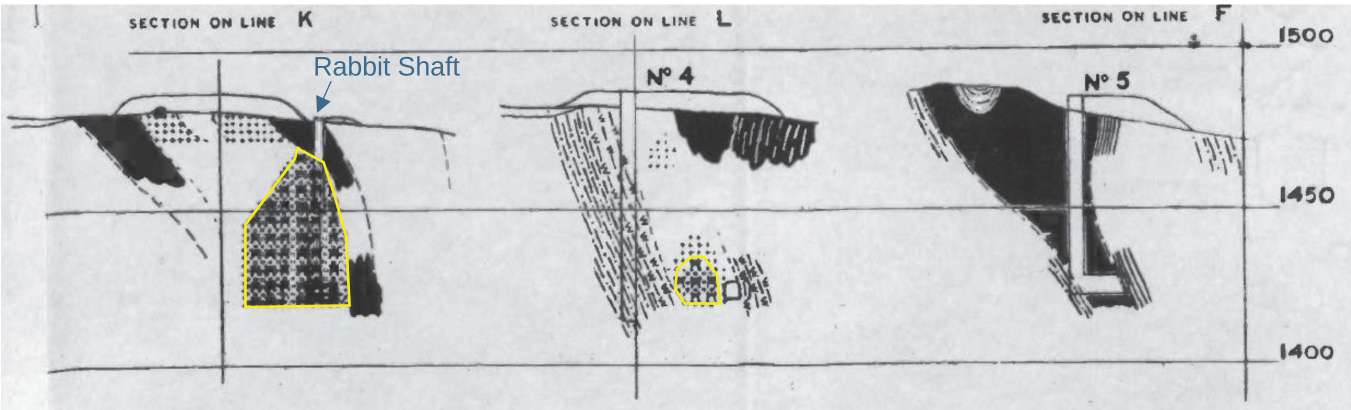

Figure 3.18 Grosvenor workings – Section lines K, L and F after Willan (1925) with "silver lead gossan ore" and "pyrites ore" traced in yellow

4. Historical filling of shafts and subsidence features

As reported in Fordon-Bellgrove (1969, GS1970/304), active mining of ore ceased in the early 1950's but in 1952 the mine was unwaterered (dewatered) and the main shaft (Mount Stewart Engine Shaft) re-timbered from the surface and a "considerable amount" of repair work was completed in the north-east drive on the 260-foot level.

Fordon-Bellgrove (*ibid*) also reports that following relinquishment of mining titles in 1966: "the dangerously caved areas were also fenced and the old shafts were either filled or covered with heavy timber". A summary of comments relating to shafts and caved areas is provided in Table 4.1.

Table 4.1 Summary of shaft and cave-in filling as per Fordon-Bellgrove (1969, GS1970/304),

Area	Feature label	Reported for 1969
Mount Stewart Western Lode	Western Shaft	Filled at surface
	Shaft to 90' level	Open – single compartment 4'6" x 4'6", partly collapsed
	Shaft to 50' level	Open – single compartment 2'8" x 4'2", partly collapsed
	unnamed shaft	Filled at surface
	50' Level	"Bad caving of the surface occurs westward from the '90' Feet Level' Shaft and may represent a collapse of the 50 feet level workings, north westward from the Western Shaft"
Mount Stewart Main/ Lode	No.1 South Shaft	Filled at surface
	Engine Shaft	Open – water at 105 feet (32 m)
	No.1 Shaft	Filled at surface
	No.2 Shaft	Filled at surface
	No.3 Shaft	Open – partly collapsed
	No.4 Shaft	Open – extensive caving. "The ground is in a dangerous state, probably as a consequence of the extensive stoping that has taken place directly below, from the 157 feet level upwards to a few feet from the surface"
	No.2 Rise (surface)	*Not mentioned*
	No.1 stope / cave	"The ground, 50 to 100 feet to the north-east of the Engine Shaft or Main Shaft is caved at the surface. This is probably due to a collapse of the stope workings directly below it."
	No.2 stope / cave	*Not mentioned*
Mount Stewart Paddock Lode	No.1 Paddock Shaft	Filled at surface
	No.2 Paddock Shaft	Filled at surface
	No.3 Paddock Shaft	Open - water at 82 feet (25 m)
Grosvenor	Rabbit Shaft	Filled at surface
	Wheat Shaft	Filled at surface
	No.1 Shaft	Filled at surface
	No.2 Shaft	Filled at surface
	No.3 Shaft	Filled at surface
	No.4 Shaft	Open - water at 55 feet (~17 m). Three compartment 8'0" x 4'0"
	No.5 Shaft	Filled at surface
	Cave-in	*Not mentioned*

Area	Feature label	Reported for 1969
Extended	Western Shaft	Filled at surface
	Copper Shaft	Filled at surface
	Blind Shaft	*Not mentioned*
	Engine Shaft	Open to about 61 feet (~19 m). Single compartment 3’ x 5’
	Marshall’s Shaft	Filled at surface

Pietsch (1988) makes no mention of shaft filling as this report is for relinquishment of an exploration lease rather than a mining lease.

Fredrickson (1993) includes a letter dated 17 March 1993 to the Department of Mineral Resources from the Department of Conservation and Land Management which briefly mentions open shafts, but no details are given. El-Chamy (1993) also includes mention of filling dangerous mine shafts and includes some photos of open shafts but no details.

Land and Water Conservation (1996) provides a summary of rehabilitation work carried out which included burial of overburden in underground shafts with heaping and sealing with 0.3 m of impervious clay. Only two shafts (presumable the Engine Shaft and No. 3 Paddock Shaft) were left open.

Of the eight shafts open in 1969, six are expected to be filled in 1995 / 1996, with these probably being the:

- Shaft to 90' level – Mount Stewart workings
- Shaft to 50' level – Mount Stewart workings
- No.3 Shaft – Mount Stewart workings
- No.4 Shaft – Mount Stewart workings
- No.4 Shaft – Grosvenor workings
- Engine Shaft – Extended workings

From the site visit on 9th and 10th February 2023, some 28 years later, the fill within Shaft to 90' level and Shaft to 50' level were found to have subsided up to about 0.8 m and 1.4 m respectively. The No. 4 Shaft of the Grosvenor workings has subsided up to about 0.4 m and the Extended workings Engine Shaft about 1.4 m.

Observations of other visible shafts made on 9th and 10th February 2023 are provided in Table 5.1.

5. Identified subsidence hazards and zones

5.1 Subsidence hazards register and map

The subsidence hazards identified are listed in Table 5.1 and their locations shown on the figures in Appendix A. Selected photographs of hazards or the general area where they are mapped are provided in Appendix B.

The type of hazard is listed as:

- **Shaft**: a vertical or steeply inclined (underlay) passage for people, ore or waste rock connecting with the surface. Shafts are distinguished from a ‘pass’ or ‘winze’ / ‘raise’ which are between levels (tunnel mine workings). In some cases, a pass may be converted to a shaft as is the case for the Rabbit and Wheat Shafts of the Grosvenor workings and the ‘No. 2 Rise’ of the Mount Stewart workings.
- **Tunnel**: horizontal mine working passages called levels along the lode and connecting shafts and passes (winzes and rises/raises).
- **Cave-in:** Where the rock above the mine workings has collapsed (caved) and propagated to the surface. The two cave-in locations at Mount Stewart are associated with stopes. The cave in at the Grosvenor workings may be due to stoping or could simply be collapse of the rock above a level, underlay shaft or cross-cut.
- **Unknown:** While many surface anomalies such as shallow depressions and piles of rocks were observed and may indicate other shafts, cave-ins or backfilled open cuts, two features in the Grosvenor workings area were noteworthy as they appeared likely to be a shaft in the case of #103 and a cave-in in the case of #104.

The visibility of the hazard relates to observed conditions during the site visit on 9 and 10 February 2023. The term ‘not visible’ is used where a shaft is shown on plans but no positive indications of it were observed on site. The locations of such hazards are therefore known with less certainty.

The approximate coordinates of identified shafts are provided in Table 5.2.

Table 5.1 Register of identified subsidence hazards within the project boundary

Area	Feature label	Type	Visibility	Source	Comment
Mount Stewart Western Lode	Western Shaft	Shaft	Not visible	2, 3	Rocky and fla.t
	Shaft to 90' level	Shaft	Visible	2, 3, 9	~3 m diameter and up to 0.8 m deep.
	Shaft to 50' level	Shaft	Visible	3, 9	1.2 by 1.9 m, up to 1.4 m deep.
	unnamed shaft	Shaft	Not visible	7	Probably bowl depression in grass, ~4 m diameter, up to 0.3 m deep.
	50' Level	Tunnel	Not visible	6	Connects to ‘Shaft to 50’ level’ and 90’ level via two winzes.
	90’ Level	Tunnel	Not visible	6	-
Mount Stewart Main/ Lode	No.1 South Shaft	Shaft	Not visible	3, 4	Probably mound beside dead tree.
	Engine Shaft	Shaft	Visible	2, 3, 9	Mound subsided by ~ 0.5 to 1 m in centre.
	No.1 Shaft	Shaft	Not visible	2, 3	Possibly water filled depression.
	No.2 Shaft	Shaft	Not visible	2, 3	-
	No.3 Shaft	Shaft	Not visible	2, 3	-
	No.4 Shaft	Shaft	Not visible	2, 3	Possibly bare rocky ground beside fence.
	No.2 Rise (surface)	Shaft	Not visible	4	-
	No.1 stope / cave	Cave-in	Not visible	5, 6, 7, 9	Cave-in depression near Shaft No. 1.
	No.2 stope / cave	Cave-in	Visible	5, 6, 7, 9	Cave-in. Currently settling area within mound near Shaft No. 3.
	50’ Level	Tunnel	Not visible	5, 6	Connects to Shaft No.2.
	75’ Level	Tunnel	Not visible	5, 6	Connects to Engine Shaft and Shaft No.1.
	100’ Level	Tunnel	Not visible	3, 5, 6	Connects all shafts in Main/Eastern Lode.

Area	Feature label	Type	Visibility	Source	Comment
Mount Stewart Paddock Lode	No.1 Paddock Shaft	Shaft	Visible	2, 3, 6, 9	1.2 by 2.2 m, 0.2 to 0.3 m rock fill settlement.
	No.2 Paddock Shaft	Shaft	Not visible	2, 3, 6	Possibly beside logs and rocks.
	No.3 Paddock Shaft	Shaft	Visible	2, 6, 9	Fenced and timbered. 1.6 by 2.8 m. Greater than 10 m depth to water.
	100’ Level	Tunnel	Not visible	5, 6	Joins to ‘No.2’ and ‘No.3’ paddock shafts.
Grosvenor	Rabbit Shaft	Shaft	Not visible	1, 7	Former rise.
	Wheat Shaft	Shaft	Not visible	1, 7	Former rise.
	No.1 Shaft	Shaft	Not visible	1, 3	Beside rocky outcrop. Possibly two shafts.
	No.2 Shaft	Shaft	Not visible	1, 3, 9	Grassed. Possibly two shafts.
	No.3 Shaft	Shaft	Visible	1, 9	Backfilled, meshed. Shallow depression ~ 4m toward tank possible 2nd shaft.
	No.4 Shaft	Shaft	Visible	1, 9	1.1 by 2.2 m depression, up to 0.4 m deep.
	No.5 Shaft	Shaft	Visible	1, 3, 9	1.7 by 3 m, up to 0.4 m deep.
	Cave-in	Cave-in	Not visible	10	20 ft by 15 ft and 20 ft deep between No.4 Shaft and Rabbit Shaft.
	#103	Unknown (cave-in)	Visible	9	~ 1 m by 10 m linear depression, ~ up to 0.8m deep with crack in rock.
	#104	Unknown (shaft)	Visible	9	Steep sided depression in grass, ~ 1.2 m diameter and 0.6 m deep. Adjacent to #103.
	60’ Level	Tunnel	Not Visible	1	Connects from No.5 Shaft.
	50’ Level	Tunnel	Not Visible	1	Connects from No.2 Shaft.
	90’ Levels	Tunnels	Not Visible	1	Two tunnels. One connects to No.2 and No.3 shafts, the other No.4, Rabbit and Wheat Shafts.
Extended	Western Shaft	Shaft	Not Visible	3	Pile of rocks with nearby depression (trench).
	Copper Shaft	Shaft	Visible	2, 3, 9	1.6 by 2.4 m, up to 0.6 m deep. Undercut on side.
	Blind Shaft	Shaft	Visible	2, 3, 9	1.2 by1.6 m, up to 0.5 m deep.
	Engine Shaft	Shaft	Visible	2, 3, 9	Mesh over. 1.7 by 2.7 m, up to 1.4 m deep.
	Marshall’s Shaft	Shaft	Visible	2, 3, 9	1.2 by 1.6 m, up to 1.4 m deep.

Information sources:

1. Plan 3267 Leadville; Grosvenor workings Rescanned (D005124501). 1915.
2. Map 3268 Geology SW of Leadville Rescanned (D005124511). 1915.
3. Plan of Workings Mt Stewart Leadville. Dickson, T.,1963 – page 109
4. Mount Stewart Silver, Lead and Copper Mine Leadville. 1915. Dickson, T.,1963 – page 116
5. Projected Section along Line A.B. Dickson, T.,1963 – page 119
6. Plan of Mount Stewart Workings. Dickson, T.,1963 – page 121
7. Geological map of Leadville-NSW. Berning, J., 1948 – page 29
8. Plan of Extended Workings Mount Stewart. *undated*
9. Observed by GHD during site visit on 9th and 10th February 2023
10. Mine Record MR.0091 "247. Mount Stuart zinc - Leadville - Inspected 25/7/57" Page 85 of Mt_Stewart_Mine,_Leadville,_Gulgong_(R00046075) 2020-01-23

Table 5.2 Approximate coordinates of identified shafts (MGA 2020 zone 55)

Area	Shaft label	Easting (m)	Northing (m)	Estimated accuracy (m)[1]
Mount Stewart Western Lode	Western Shaft	739879	6454560	± 4.0
	Shaft to 90' level	739890	6454551	± 1.5
	Shaft to 50' level	739901	6454568	± 1.5
	unnamed shaft to north	739910	6454596	± 4.0
Mount Stewart Main/ Lode	No.1 South Shaft	739873	6454465	± 4.0
	Engine Shaft	739922	6454478	± 1.5
	No.1 Shaft	739939	6454486	± 4.0
	No.2 Shaft	739974	6454498	± 4.0
	No.3 Shaft	740024	6454510	± 4.0
	No.4 Shaft	740039	6454516	± 4.0
	No.2 Rise (surface)	739953	6454500	± 4.0
Mount Stewart Paddock Lode	No.1 Paddock Shaft	740101	6454478	± 1.5
	No.2 Paddock Shaft	740113	6454500	± 4.0
	No.3 Paddock Shaft	740048	6454469	± 1.5
Grosvenor	Rabbit Shaft	739482	6454313	± 4.0
	Wheat Shaft	739498	6454325	± 4.0
	No.1 Shaft	739537	6454337	± 4.0
	No.2 Shaft	739562	6454314	± 4.0
	No.3 Shaft	739545	6454287	± 1.5
	No.4 Shaft	739485	6454302	± 1.5
	No.5 Shaft	739566	6454357	± 1.5
	#103	739537	6454322	± 1.5
	#104	739540	6454325	± 1.5
Extended	Western Shaft	739595	6454141	± 4.0
	Copper Shaft	739633	6454133	± 1.5
	Blind Shaft	739621	6454125	± 1.5
	Engine Shaft	739665	6454113	± 1.5
	Marshall’s Shaft	739720	6454098	± 1.5

1. Based on perceived error from high resolution orthophoto matching to visible shafts and overlaying of historical mine plans where shafts were not visible in the orthophoto

5.2 Hazard zones

The zones associated with each identified hazard are shown on Figures 2, 3 and 4 in Appendix A. These hazard zones are larger than the hazard features mapped to reflect uncertainty in their locations and / or the potential extent of subsidence associated with the feature.

For visible shafts, circular ‘specific’ hazard zones of 3 m diameter have been used. For non-visible shafts, circular specific hazard zones of 8 m diameter are used. While visible, the locations of shafts have not been surveyed. The establishment of specific hazard zone flagging / fencing should be based on the actual observed feature rather than locations scaled off plans or coordinates taken from spatial databases where survey has not been undertaken. Where not-visible, the coordinates extracted from this report can be used to ‘peg-out’ feature locations and establish flagging / fencing. Flagging / fencing should surround the hazard zone with the addition of at least a 1 m wide buffer. For example, fencing around a 3 m diameter hazard zone would be at least 5 m in diameter.

In addition to the specific hazard zones, general subsidence hazard zones are also provided to address the potential for future cave-ins associated with tunnels (levels) marked as less than 100 feet (about 30 m) and stopes that may extend above them. Additionally, lengths of inclined underlay shafts above 100-foot levels are also included as general subsidence hazard zones.

As noted in Section 3.1.1, 'levels' are nominal depths referenced from a datum. The depth to levels below existing ground surface will vary with the topography and elevation difference to the datum.

The purpose of this report is to identify geotechnical hazards that the PWC may encounter during remediation work. The choice of the 100-foot level as a limit for general subsidence hazard zones is based on defining the limits of shallow workings in each mining area and an assumption that caving would occur upwards and toward the lode sub-crop. Workings without levels shallower than 100 feet, such as the Mount Stewart Middle Lode and Extended workings could also be stoped along the lode with the potential for surface caving in these areas, albeit much less likely than where levels shallower than 100 feet are mapped.

Fordon-Bellgrove (ibid) reports that, "Bad caving of the surface occurs westward from the '90' Feet Level' Shaft and may represent a collapse of the 50 feet level workings, north westward from the Western Shaft" and a 12 July 1950 mine inspection report by Inspector Edwards (MR 0091, DIGS Ref. D004203190) mentions a 6 m (20 foot) by 4.6 m (15 foot) surface subsidence of 4.6 m depth (20 foot) between the No. 4 Shaft and Rabbit Shaft at the Grosvenor workings.

Importantly, no documentation or evidence of subsidence or caving in areas without levels shallower than 100 feet was found. This is not to say that such subsidence may not occur in the distance future. As such, the possibility of caving (subsidence) associated with all mine levels should be reasonably considered within the context of future land use. This consideration, however, remains beyond the scope of this report.

5.3 Hazard mechanisms and triggers

5.3.1 General comments

Subsidence is often first observed as cracks and / or a depression in the ground surface. The rate of crack growth and deepening of the depression can vary widely. Typically, where surface water is present (either ponding or flowing), the rate of subsidence will be greater.

The surface impact from subsidence of a shaft would be expected to be localised and limited to the shaft excavation. In comparison, subsidence from collapse of a tunnel would probably affect a larger area and may be elongated along the axis of the tunnel. Subsidence of the workings generally (from caving) is likely to be similar to the two Eastern Lode cave-in areas (north and south shoots) mapped on the 1948 geology plan (Figure 3.2) or that reported in the Grosvenor workings in 1950 or Western Lode area by Fordon-Bellgrove in 1969.

The descriptions of subsidence presented below for each hazard type are provided as a general guide to assist the PWC with recognising when subsidence might be occurring, as well as for the purposes of assessing risk and revising risk assessments when changes occur, including when to seek advice. The ability to recognise and respond to changes in site conditions is critical in the management of subsidence hazards as the ground may not be stable and trigger events. This factor, along with the passage of time, can drastically change hazards, and therefore, the associated risks. To that end, the hazards identified in this report will likely change over time. Knowledge of the site and what is 'normal' is key in being able to recognise change. Additionally, knowledge of the mining conditions and subsidence hazards will assist in appreciating the significance of observed changes.

Brief recommendations regarding risk assessment, seeking advice and documenting site conditions are provided in Sections 5.4 and 5.5. However, the PWC is advised to retain the services of a Geotechnical Engineer or Engineering Geologist experienced in mine subsidence and risk assessment to assist with risk assessments, risk mitigation measures as well as assisting with identifying and responding to changes in site conditions.

5.3.2 Shafts

Shafts represent localised hazards in that people (and animals) can fall into them. The fall can result in fatality directly or debris and objects can fall on top of an individual. Where the shaft is water filled, the potential for drowning is also present. Examples and statistics of fatalities relating to abandoned mine shafts is presented in Mackenzie (2022).

Where shafts are earth filled, the fill often subsides over time with the shaft reopening to some depth. This appears to have occurred / be occurring at many of the shafts identified in this report (refer to Table 5.1). While the settlement of fill presents a 'fall' hazard, the settlement is often slow to progress and the location of the hazard evident such that it can be fenced, avoided and later filled. Where such fencing excludes the general public, and in particular children, the hazards associated with the shaft could be effectively managed in the interim.

Where shafts are capped with rigid material such as concrete, they generally appear safe. There is often an expectation that the capping is stable. However, it is sometimes the case that earth fill beneath a cap or plug has settled and that the concrete is spanning over a void which can deepen without any surface manifestation. Over time, the ground around a cap / plug can erode or the concrete itself can deteriorate and fail. This may occur rapidly and with little warning. The resulting void could be tens of meters deep and water filled.

Heavy and prolonged rainfall, particularly where water accumulates in and around shaft depressions could trigger fill settlement or capping collapse. Other conceivable triggers are the transport of earth backfill by water flow through the workings over time, or underground caving that could pressurise mine water and 'blow out' fill or erode around caps. In the absence of engineering details and as-built documentation for the shafts, earth filled and capped shafts should not be considered safe.

This report does not include an assessment of shaft filling / capping adequacy or longevity. Records of shaft filling such as Land and Water Conservation (1996) and Soil Conservation Service (1993) could be used to 'track' the rate of backfill settlement, and hence identify those shafts more likely to become hazardous.

5.3.3 Mine tunnels, stopes and caving

Collapse (caving) of mine workings reaching the ground surface has occurred at the Mount Stewart workings (three documented locations) and the Grosvenor workings (one documented location). Such caving could occur again. While filling of mine voids with waste rock appears to have occurred, a detailed review of historical records to ascertain where and to what extent has not been undertaken and, based on the limited mine sections seen, would probably not be a particularly useful exercise.

The size and depth of caving expressed at the ground surface would be dependent on the width of ore body (lode) extracted as well as the amount of mine filling and properties of the overburden material. Provided no people are present on the surface when caving occurs, a fatality would be highly unlikely given the hazard (caved ground) would be visible and hence avoidable, assuming vehicle speed and/or poor visibility weren't limiting factors. If people were present when such a caving event occurred, they may be able to escape the area without injury as the cave developed. However, the cave-in could occur rapidly over a large area and fatalities are a possibility.

Caving to the ground surface is more likely along the surface exposure of the ore body. A tracing of levels at the 100-foot level or shallower is provided in the figures in Appendix A and has been used to define (somewhat arbitrarily) general hazard zones being up-dip from this level and encompassing what is expected to be the ore body surface exposure and areas directly above underlay shafts. The shallowest level in the Extended working area is shown to be 145 foot (about 44 m) and whilst traced, is not included as a general hazard zone.

Settlement of waste rock over time, or gradual weathering of waste rock and host rock (above the ore body) are possible triggers for caving. This occurs through weathering of rock over time and/or changes in groundwater levels, particularly rapid draw-down of mine water levels. Mine dewatering in the 1950's is not reported to have triggered surface subsidence.

5.4 Risk assessment discussion

The ability to assess risk requires identification of hazards and development of scenarios that could lead to an unfavourable outcome. The risk associated with a particular scenario is the product of:

– The likelihood that a hazard exists and that there is an interaction with it, resulting in the unfavourable outcome being assessed.
– The consequence of the unfavourable outcome (e.g. property damage, single fatality, multiple-fatality).

The likelihood of a subsidence event occurring is often difficult to quantify with reliability and especially without geotechnical investigation. For mobile elements at risk (e.g. people on a worksite), it is often prudent to assume the hazard event will occur / exist and assess risk by considering the likelihood that a person will interact with the hazard and an unfavourable outcome will occur. Risk can be reduced by limiting interaction rather than eliminating the hazard, although the latter would be preferable.

In quantitative risk assessments, the risk-to-life is often expressed in terms of an annual likelihood of fatality of the individual most-at-risk, and also societal risk where the exposed population per annum is ten or more (Australian Geomechanics Society (AGS) 2007) and (Golder 2020).

Where qualitative or semi-quantitative risk assessments are undertaken, the same principals apply but generally there is insufficient information to be able to complete a quantitative risk assessment. With respect to risk-to-life, AGS (2007) recommends that at least a semi-quantitative risk assessment be undertaken and ideally a quantitative risk assessment. Where the risk can be quantified, the concepts of Acceptable Risk and Tolerable / As Low As Reasonably Practicable (ALARP) can be used as a guide to what risks require mitigation. However, the concept of 'Reasonably Practicable' as it applies to NSW workplace health and safety regulation must be satisfied. SafeWork NSW states on their website[1] that:

'Reasonably practicable' is a legal requirement. It means doing what you are reasonably able to do to ensure the health and safety of workers and others like volunteers and visitors.

and;

When determining what is reasonably practicable, you should take into account:

– *the likelihood of the hazard or risk occurring*
– *the degree of harm from the hazard or risk*
– *knowledge about ways of eliminating or minimising the hazard or risk*
– *the availability and suitability of ways to eliminate or minimise the risk*
– *cost.*

The SafeWork NSW website makes reference to Safe Work Australia (2013) to help determine what is reasonably practicable to meet a health and safety duty of care.

5.5 Risk reduction options

Geotechnical subsurface investigation would be required to assess the likelihood of subsidence events occurring with adequate reliability, and even then, elimination of hazards may not be practicable.

Given that the elimination of hazards is not expected to be possible by the PWC, risk reduction through administrative controls (avoidance) is recommended as the primary tool. Other measures such as engineering controls (e.g. grade beams, localised grouting and meshes) may be appropriate to supplement administrative controls but would require more detailed investigation of the hazard as well as engineering design to ensure the measures function satisfactorily.

This report is provided to assist the LMP and PWC in their understanding of mine subsidence hazards so that they can assess and mitigate risk during their project work. The following risk reduction options are provided for consideration and, if considered appropriate, further development and implementation by the PWC.

[1] https://www.safework.nsw.gov.au/about-us/glossary/glossary-acordion/reasonably-practicable

Risk assessment and risk mitigation advice

The PWC is advised to retain the services of a Geotechnical Engineer or Engineering Geologist experienced in mine subsidence and risk assessment to assist with documentation prior to commencement, risk assessments, risk mitigation measures as well as assisting with identifying and responding to changes in site conditions.

Training, induction and awareness

People entering the work site must be inducted and made aware of hazards. Incorporating explanation of mine subsidence hazards and their locations into site inductions and daily pre-work meetings is recommended. More detailed and up to date information should be provided in active work areas.

Training should include how to recognise and report subsidence.

Showing people the locations of hazards, in person, is recommended rather than relying on maps or photos.

Delineation of hazard zones (fencing) and administrative controls

The hazards zones presented in the figures in Appendix A (or amendments of them approved by LMP) should be delineated with flagging and/or fencing with signage. Access into these areas should be restricted with administrative controls such as, but not limited to:

- At least daily pre-work inspection and clearance
- Change identification and reporting protocols
- No working alone
- Supervision by suitable experienced personnel
- Restrictions on people on foot
- Restrictions on light vehicle access and speed
- Restrictions on plant and heavy vehicles
- Restrictions on equipment and material storage
- Restrictions on activities (e.g. no crane lifts, no excavation, no water storage)
- Limiting duration spent within hazard zones
- Cessation of work during or immediately preceding heavy rainfall and poor visibility

Where site personnel change, knowledge on recent observations and hazard controls should be transferred.

The delineation of hazard zones should be based on the actual observable feature where it is visible rather than locations scaled off plans or coordinates taken from spatial databases or this report. Where not visible, the coordinates extracted from this report can be used.

Flagging / fencing should surround the hazard zone with the addition of at least a 1 m wide buffer. For example, fencing around a 3 m diameter hazard zone would be at least 5 m in diameter.

Further geotechnical investigation and assessment

Where hazards can’t be avoided or mitigated adequately with administrative controls, further geotechnical investigation and assessment would provide additional information that may increase the reliability of risk assessments through improved certainty of hazard locations and likelihood of occurrence. Ideally, such investigation work would be targeted to small areas to reduce cost.

In these circumstances, the following investigation activities are recommended for consideration:

- Surface (non-intrusive) geophysical survey using Electrical Resistivity Imaging (ERI) to identify possible voids and hence drilling targets.
- Survey and 3D modelling of shafts, stopes and mine workings from historical sources to relate these plans to the existing ground surface.
- Drilling of inclined boreholes and video inspection and laser scanning of cavities if encountered.

While drilling could be undertaken without an ERI survey, an ERI survey would provide focused targets for drilling. Survey and 3D modelling, at least in a simplistic form, is considered necessary prior to drilling to provide borehole locations, inclinations and directions. Survey work (using real-time kinetic GPS equipment) could be undertaken under the same mobilization as ERI work and by the same team.

An ERI survey would be undertaken along survey lines with sensors spaced along these lines. The survey can be designed to target the upper 20 m of materials, for example, to locate air filled voids and water saturated ground. The method relies on differences in ground resistance (or conductance) to differentiate between ground conditions. An air-filled void for example would be much more resistive than a water filled void or rock. Differences in ground resistance between soil and different rock types above and below the water table would also occur, and potentially, make definitive identification of voids more difficult.

Survey should comprise accurate levelling to AHD of visible shafts in the area of interest as well as establishing the current elevation of the Leadville Railway Station platform (if possible) as this was the datum used by Willan (1925) as being 1370 feet above mean sea level. Levelling of the No. 3 Paddock Shaft and Engine Shaft should also be undertaken and these related to the available digital terrain model. Combining this data with the historical mine plans and sections as well as ERI survey results can then be achieved using 3D geological modelling software such as Leapfrog by Seequent to identify drill targets, safe drill set up locations and the corresponding borehole inclinations and headings.

Borehole locations would be pegged by survey with the addition of a heading reference peg (to aim for). The drill pads would need to be located in safe areas away from suspected stopes and cave-ins and the selection of drilling rig and method would need to suit the hole inclinations. As a guide, most geotechnical site investigation rigs can drill at inclinations down to about 70° from horizontal (90° being vertical). Rigs used for installing ground anchors or horizontal directional drilling (HDD) can drill as flat as horizontal but are not suitable for steep boreholes. In either case, the boreholes need not be diamond cored and could be drilled using washboring or air percussive methods. Casing is likely to be required to maintain an open borehole, particularly where downhole video inspection and laser scanning is proposed.

Downhole video cameras are generally suspended from flexible cables in vertical boreholes. Deployment and retrieval of cameras and laser scanners into voids through inclined boreholes would require particular consideration. Systems such as C-ALS from Carlson Software would be suitable for laser scanning of air-filled voids accessed through inclined boreholes. For water filled voids, sonar scanning would be required. GHD operate a downhole video and sonar system (Imagenex GS-232) rated to 300 m water depth, suspended from a cable and only suited to vertical boreholes. Groundsearch Pty Ltd in Rutherford NSW operate a Flodim sonar system which uses rods (like the C-ALS laser system) and may be suitable for inclined boreholes. GHD have sub-contracted Groundsearch to undertake such surveys of abandoned coal mine workings in NSW.

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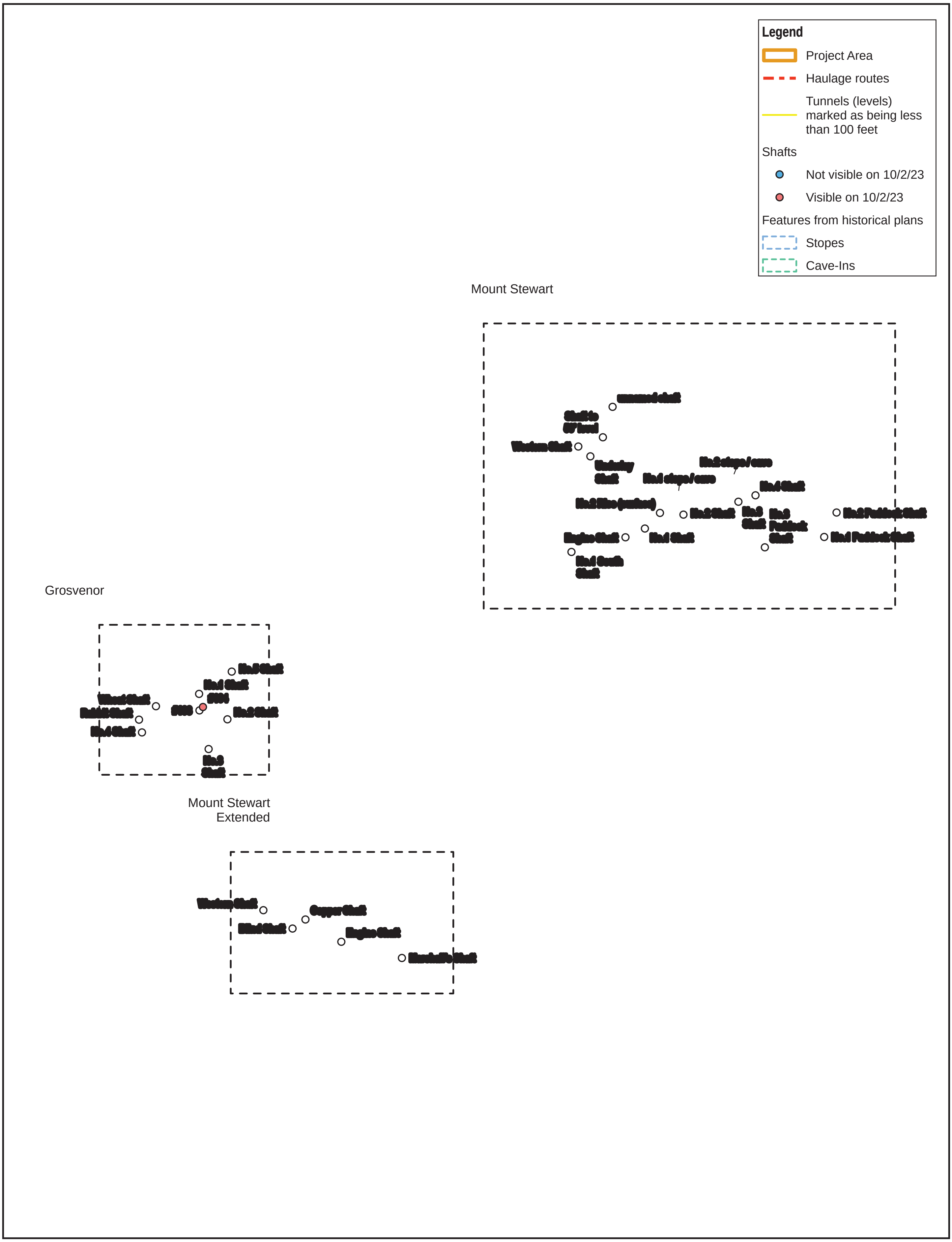
Appendices

Appendix A

Figures



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Map Projection: Transverse Mercator
Horizontal Datum: GDA2020
Grid: GDA2020 MGA Zone 55

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Department of Regional NSW
Leadville Remediation Technical Oversight
Hazard Assessment Report

Project No. **12588769**
Revision No. **0**
Date **8/7/2023**

Site overview

FIGURE 1

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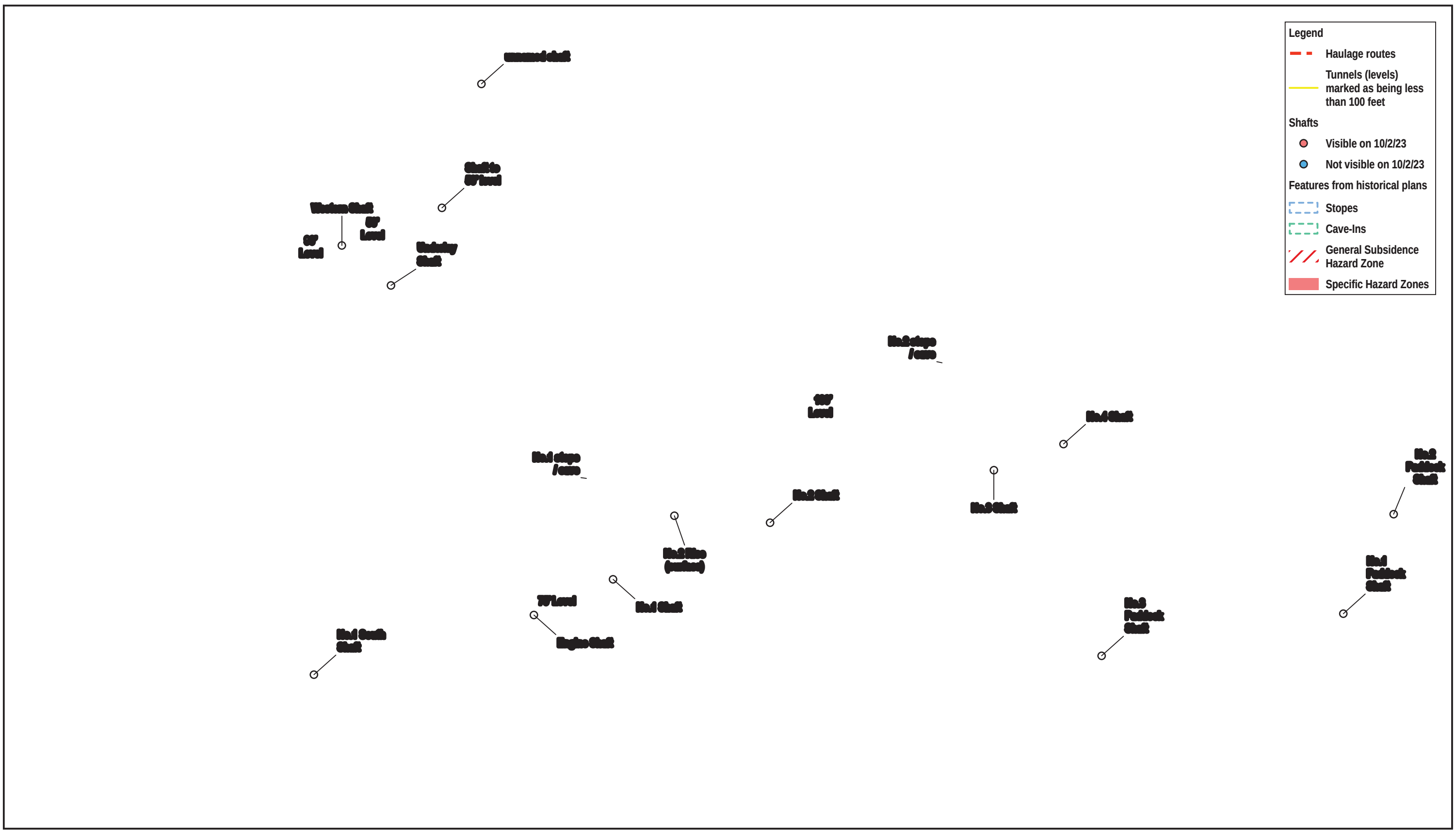

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Map Projection: Transverse Mercator
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Department of Regional NSW
Leadville Remediation Technical Oversight
Hazard Assessment Report

Mount Stewart – Subsidence Hazard Zones

Project No. 12588769
Revision No. 0
Date 8/7/2023

FIGURE 2

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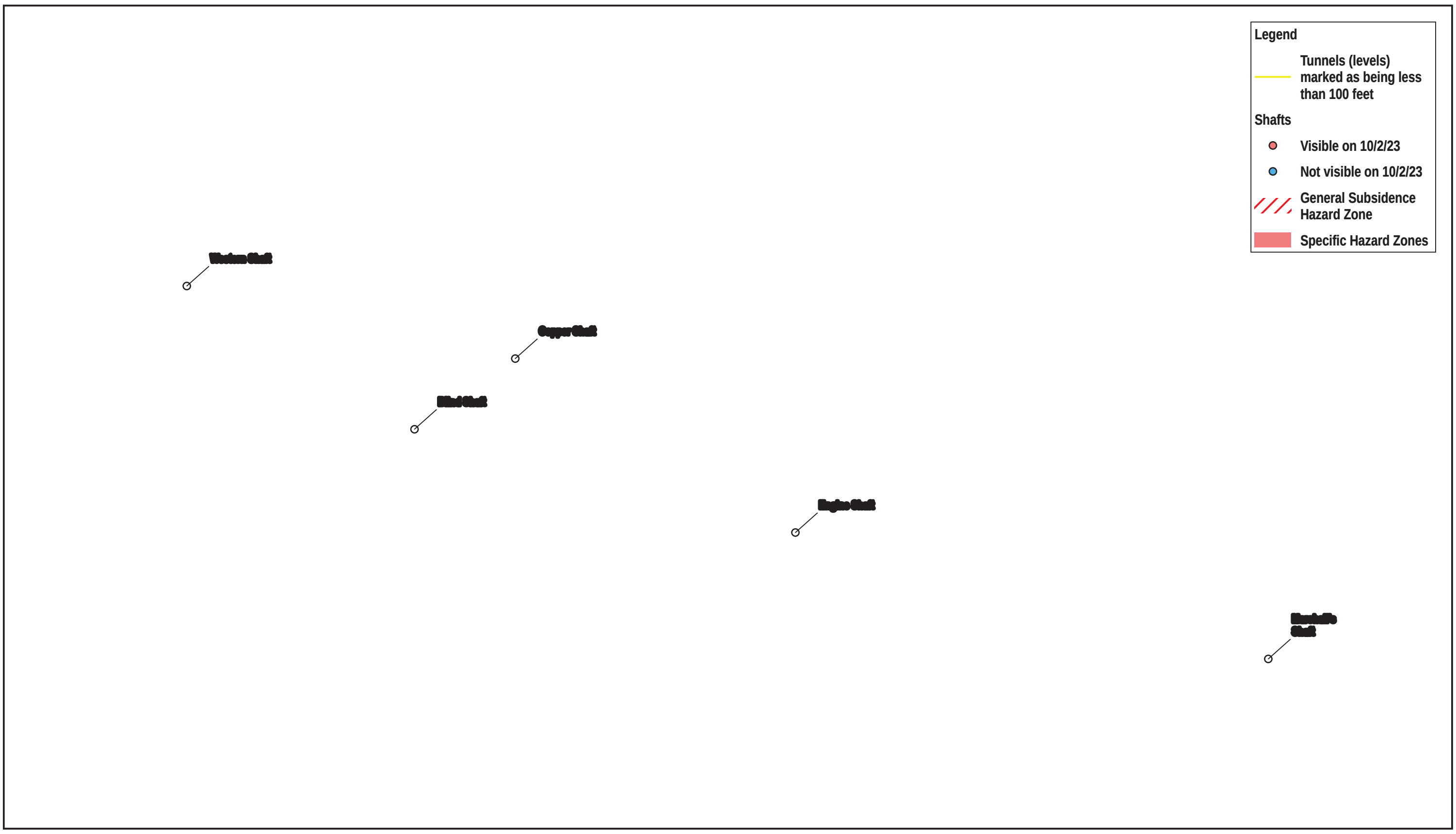

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Grid: GDA2020 MGA Zone 55

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Department of Regional NSW
Leadville Remediation Technical Oversight
Hazard Assessment Report

Mount Stewart Extended – Subsidence Hazard Zones

Project No. **12588769**
Revision No. **0**
Date **8/7/2023**

FIGURE 3

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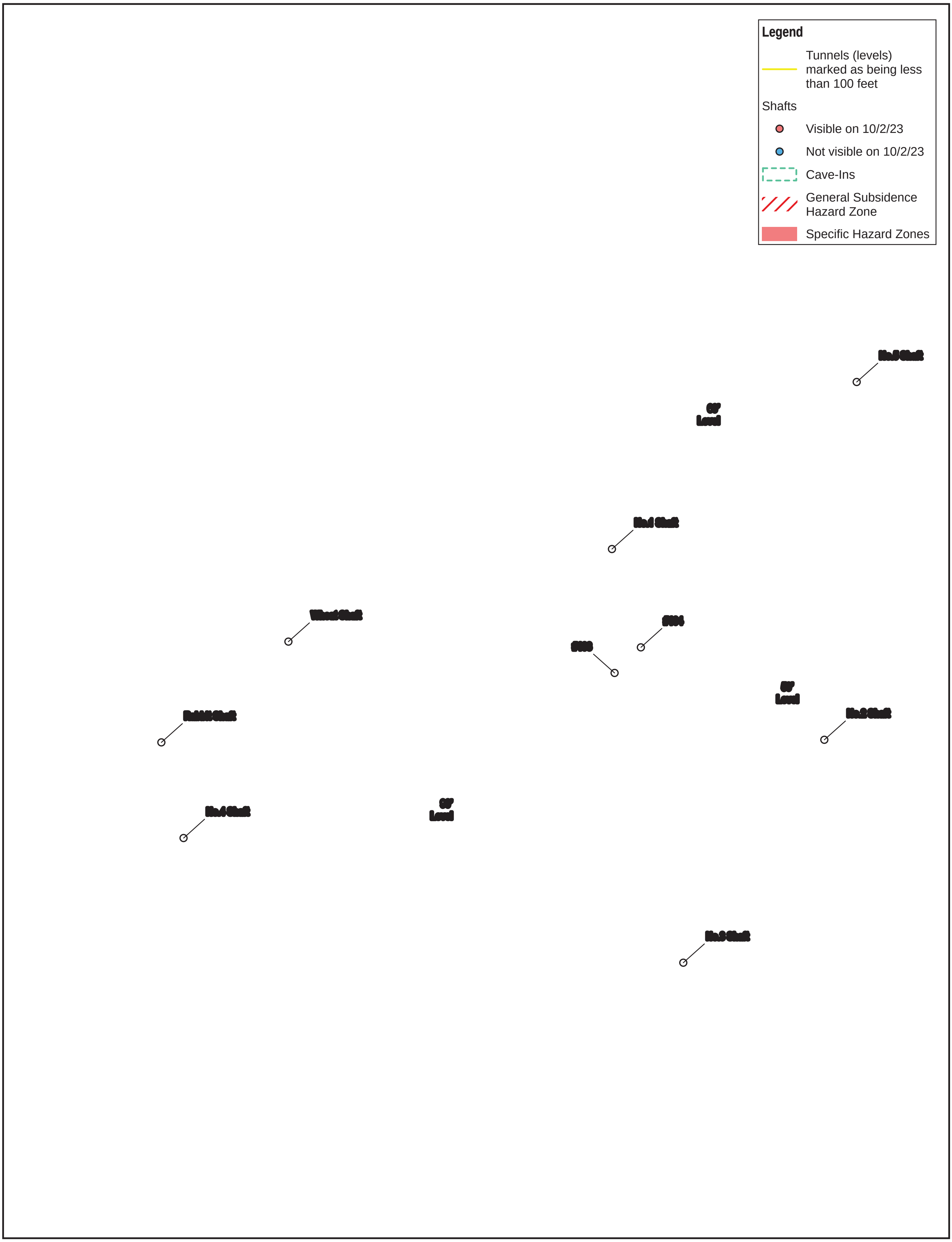

Paper Size ISO A4

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA2020
Grid: GDA2020 MGA Zone 55

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Leadville Remediation Technical Oversight
Hazard Assessment Report

Grosvenor – Subsidence Hazard Zones

Project No. **12588769**
Revision No. **0**
Date **8/7/2023**

FIGURE 4

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Appendix B

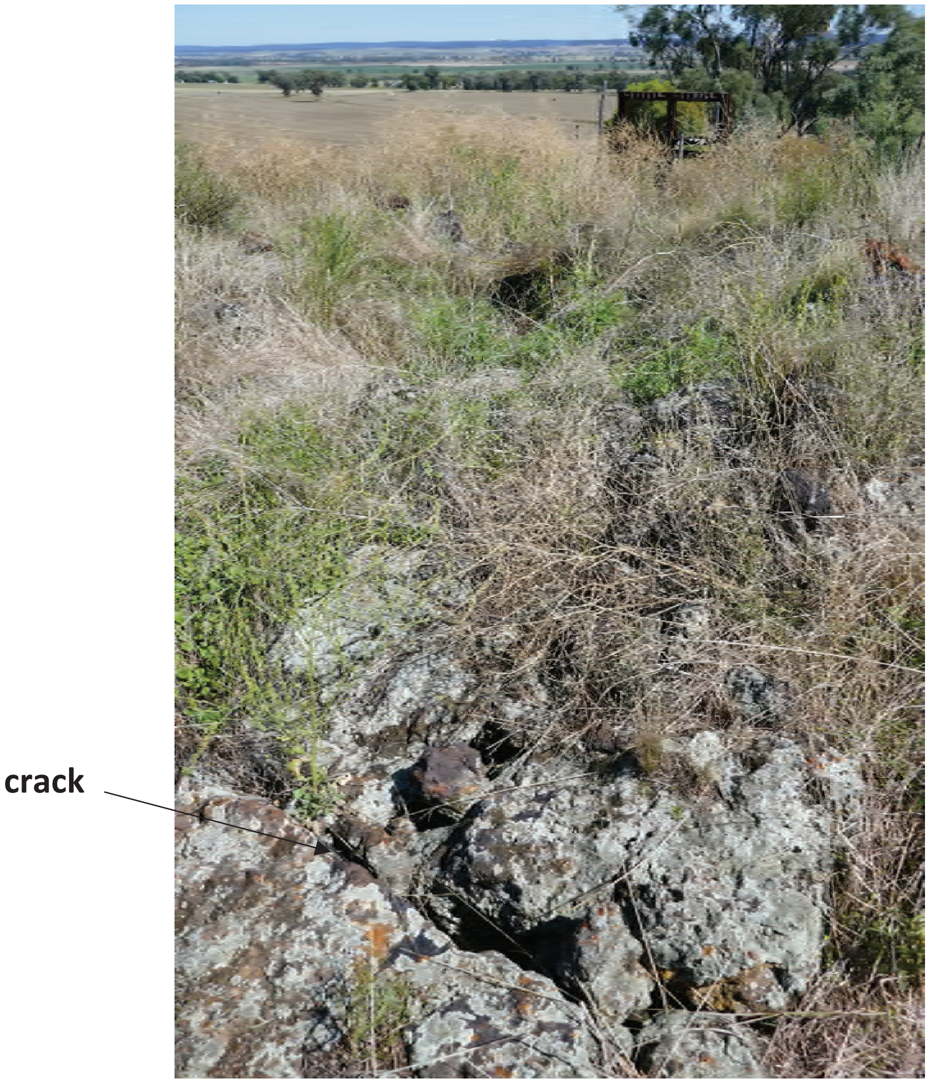
Photographs

GROSVENOR WORKINGS: **Rabbit Shaft**

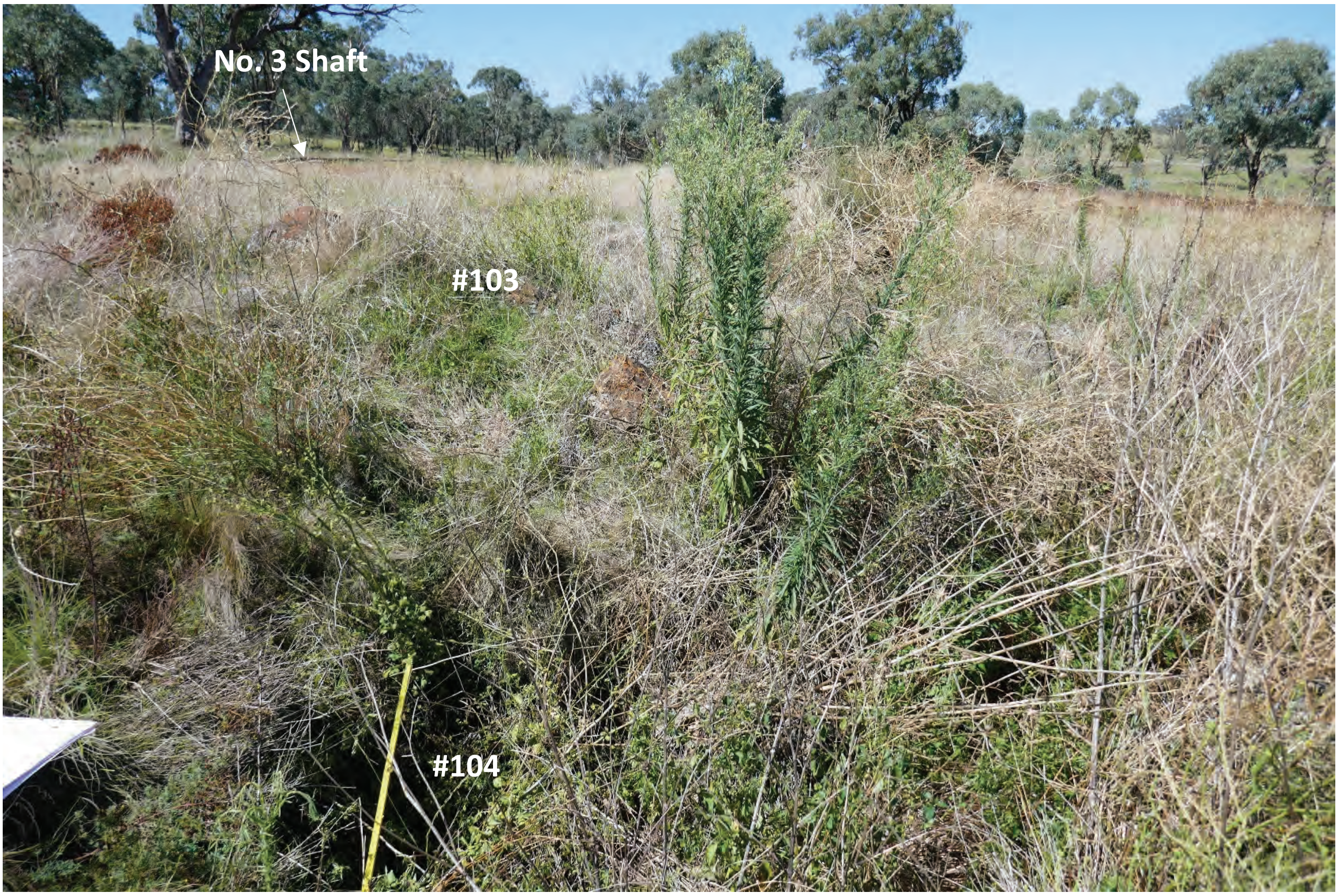
GROSVENOR WORKINGS: **No. 5 Shaft**

GROSVENOR WORKINGS: **No. 3 Shaft**

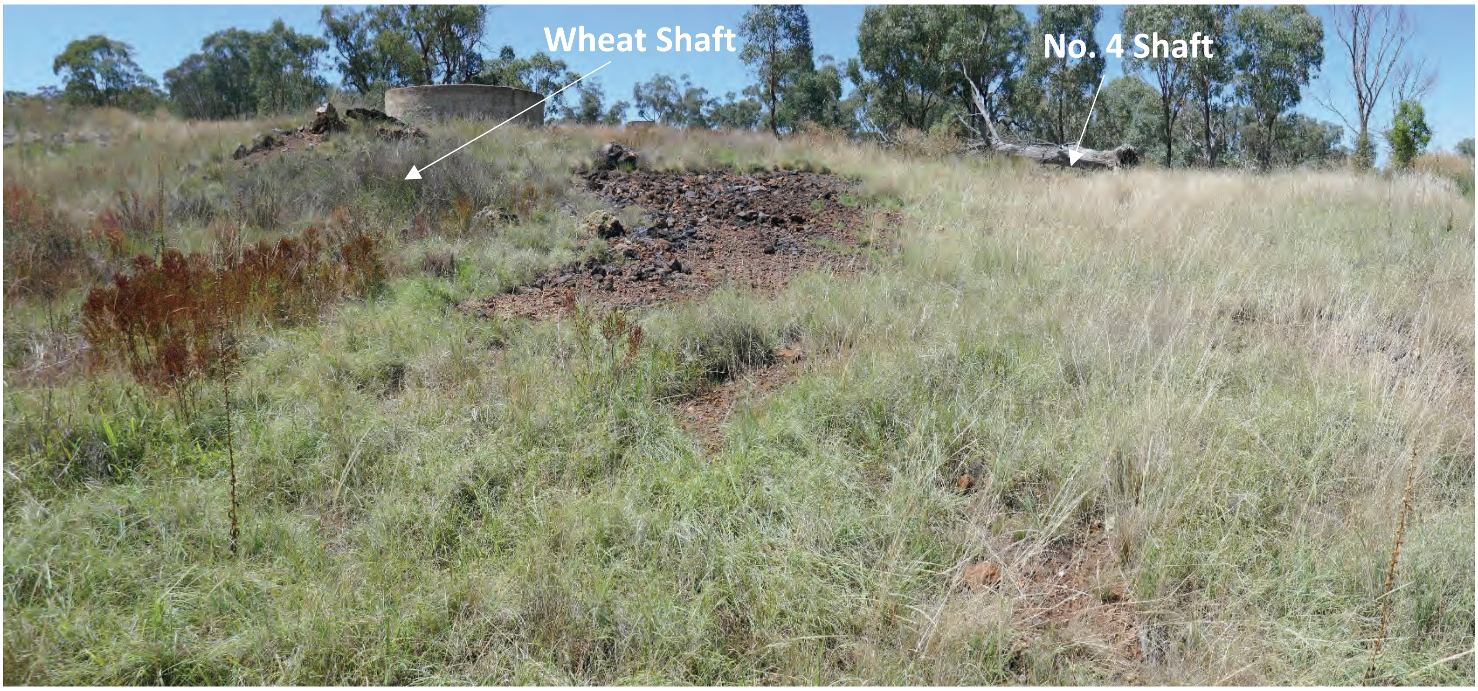
GROSVENOR WORKINGS: **No. 1 Shaft**



GROSVENOR WORKINGS: **Possible cave-in (#103)**



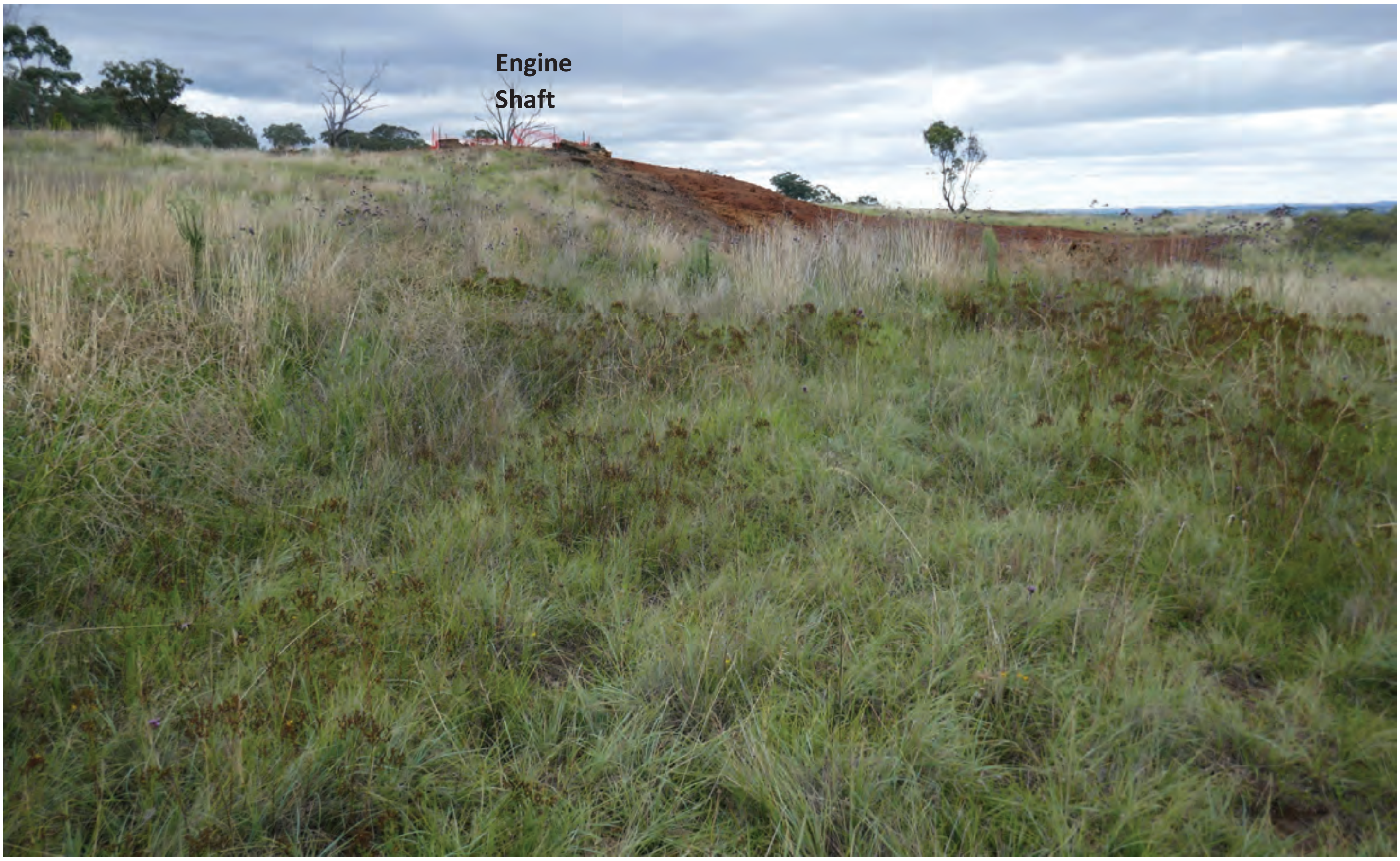
GROSVENOR WORKINGS: **Circular depression (#104)**


Wheat Shaft
No. 4 Shaft

GROSVENOR WORKINGS: **No. 4 Shaft**

MOUNT STEWART WORKINGS: **Engine Shaft**

MOUNT STEWART WORKINGS: **No. 1 Shaft**



MOUNT STEWART WORKINGS: **No. 2 Shaft**

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Leadville Remediation Project
Subsidence hazard assessment

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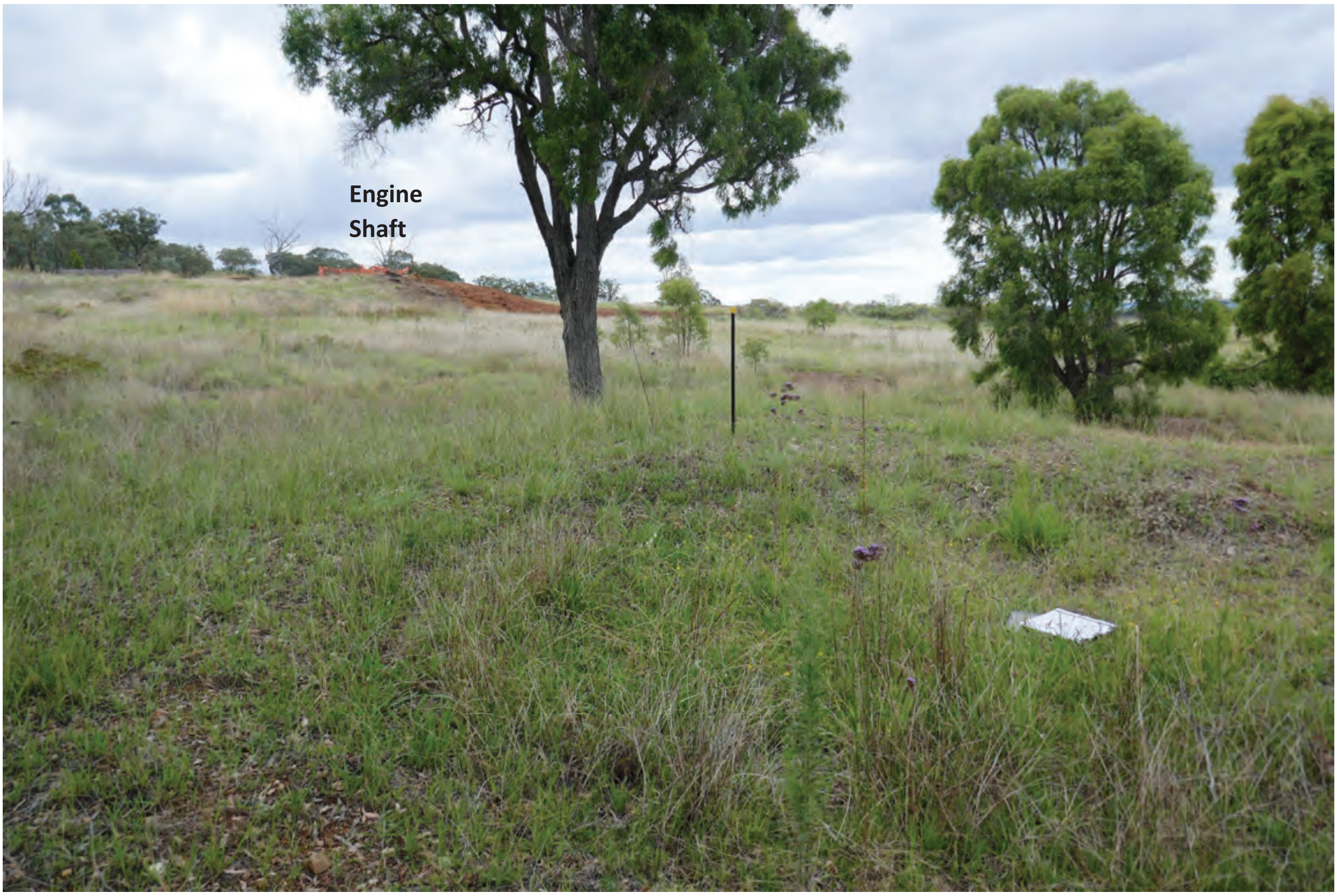
file ref	
scale	N/A
date	9th, 10th February 2023



MOUNT STEWART WORKINGS: **No. 3 Shaft / No. 2 Cave-in**

MOUNT STEWART WORKINGS: **No. 4 Shaft**

MOUNT STEWART WORKINGS: **Underlay Shaft**

MOUNT STEWART WORKINGS: **Western Shaft**

MOUNT STEWART WORKINGS: **No.1 Paddock Shaft**

MOUNT STEWART WORKINGS: **No.2 Paddock Shaft**

MOUNT STEWART WORKINGS: **No.3 Paddock Shaft**

MOUNT STEWART WORKINGS: **No.3 Paddock Shaft**

Department of Regional NSW (Legacy Mines Program)
Leadville Remediation Project
Subsidence hazard assessment

job no	12581924
file ref	
scale	N/A
date	9th, 10th February 2023

MOUNT STEWART WORKINGS: **No.3 Paddock Shaft**

Department of Regional NSW (Legacy Mines Program)
Leadville Remediation Project
Subsidence hazard assessment

job no	12581924
file ref	
scale	N/A
date	9th, 10th February 2023

MOUNT STEWART WORKINGS: **Shaft to 50' level**

MOUNT STEWART WORKINGS: **No.1 South Shaft**

Department of Regional NSW (Legacy Mines Program)
Leadville Remediation Project
Subsidence hazard assessment

job no	12581924
file ref	
scale	N/A
date	9th, 10th February 2023

MOUNT STEWART WORKINGS: **unnamed shaft (#65)**

MOUNT STEWART EXTENDED WORKINGS: **Engine Shaft**

MOUNT STEWART EXTENDED WORKINGS: **Copper Shaft**

MOUNT STEWART EXTENDED WORKINGS: **Blind Shaft**

MOUNT STEWART EXTENDED WORKINGS: **Marshalls Shaft**

MOUNT STEWART EXTENDED WORKINGS: **Western Shaft and adjacent lineation** ghd.com

The Power of Commitment

Appendix C

Bill of Quantities

Bill of Quantities

ROC ENGINEERING DESIGN | Terra Tech CONSULTING

Leadville Mine - Remediation Works

Date	**Revision 26/03/2024**	**Job Ref: 23293**

Item	Description	Qty	Unit
1	**Site Establishment/Preliminaries**		
1.01	Preliminaries. Note: Preliminaries to include preparation and management of Project Plans including but not limited to: - Construction Program - Quality Plan - Construction Environmental Management Plan including SECP - Inspection and Test Plan - Verification and Monitoring Plan	1	item
1.02	Establish site including all amenities and construction site fencing as necessary	1	item
1.03	Restore site at completion of works and remove all temporary structures	1	item
1.04	Geotechnical Testing and Inspections	1	item
1.05	Survey and Setting out	1	item
1.06	Verification survey and Works As Executed Survey as required	1	item
2	**Soil & Water Management Measures** **Contractor is to ensure the site is managed at all times for sediment an erosion control and provide appropriate measures to ensure sediment does not leave the site.**		
2.01	Establish & maintain sediment fencing	1	item
2.02	Establish & maintain temporary diversion measures	1	item
3	**Clearing and Grubbing**		
3.01	Remove and relocate trees, roots and trunks in vicinity of works as required.	1	item
4	**Bulk Earthworks**		
4.01	Stripping including reinstating topsoil onto distrubed areas	2950	BCM
4.02	Cut to fill from borrow areas (Contractor to allow for cut to stockpile, cut to fill if required by construction methodology)	3000	BCM
4.03	Removal and disposal of contaminated material to a licensed waste facility	475	BCM
4.04	Removal and relocation of contaminated material to a location on site	150	BCM
5	**Drainage works**		
5.01	Rock armour to channels, dams and spillway	1100	m^2
5.02	Class C non-woven geotextile	1400	m^2
6	**Fencing**		
6.01	Supply and Install hinged joint mesh fencing	1240	m
6.02	Supply and Install 1.8m high chain-link fence	2680	m
6.03	Demolish and dispose of existing fencing	2160	m
6.04	Demolish and dispose of existing gates	2	item
6.05	Supply and install gates to suit hinged joint fencing	2	item
6.06	Supply and install gates to suit chain-link fencing	4	item
7	**Revegatation**		
7.01	Seed and maintain disturbed areas	14800	m^2
P	**Provisional Items**		
P1	Topsoil and seed disturbed areas outside of immediate works, on completion and maintian till grass established (Provisional)		m^2

Bill of Quantities

ROC ENGINEERING DESIGN

Terra Tech CONSULTING

Leadville Mine - Remediation Works

Date	Revision 26/03/2024	Job Ref: 23293	
Item	**Description**	**Qty**	**Unit**
P2	Excavate and relocate contaminated sediment and soft material from base of dam construction		m^3
P3	Pump out and temporarily store existing dam water		Item
P3	Cut to stockpile		BCM
P4	Stockpile to fill		BCM
P5	Cut to fill		BCM

Appendix D

UCL Calculations

UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	ProUCL 5.19/03/2024 3:52:20 PM
From File	WorkSheet_b.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

As

General Statistics

Total Number of Observations	91	Number of Distinct Observations	47
		Number of Missing Observations	0
Minimum	0.114	Mean	70.67
Maximum	835	Median	48.68
SD	94.63	Std. Error of Mean	9.92
Coefficient of Variation	1.339	Skewness	6.289

Normal GOF Test

Shapiro Wilk Test Statistic	0.475	**Shapiro Wilk GOF Test**
5% Shapiro Wilk P Value	0	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.253	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.0931	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	87.15	95% Adjusted-CLT UCL (Chen-1995)	93.97
		95% Modified-t UCL (Johnson-1978)	88.24

Gamma GOF Test

A-D Test Statistic	2.546	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.772	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.117	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.0955	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.479	k star (bias corrected MLE)	1.438
Theta hat (MLE)	47.77	Theta star (bias corrected MLE)	49.15
nu hat (MLE)	269.2	nu star (bias corrected)	261.7
MLE Mean (bias corrected)	70.67	MLE Sd (bias corrected)	58.93
		Approximate Chi Square Value (0.05)	225.2
Adjusted Level of Significance	0.0474	Adjusted Chi Square Value	224.7

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	82.11	95% Adjusted Gamma UCL (use when n<50)	82.3

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.835	**Shapiro Wilk Lognormal GOF Test**

	A	B	C	D	E	F	G	H	I	J	K	L
53					5% Shapiro Wilk P Value	1.044E-14	Data Not Lognormal at 5% Significance Level					
54					Lilliefors Test Statistic	0.134	**Lilliefors Lognormal GOF Test**					
55					5% Lilliefors Critical Value	0.0931	Data Not Lognormal at 5% Significance Level					
56	**Data Not Lognormal at 5% Significance Level**											
57												
58	**Lognormal Statistics**											
59					Minimum of Logged Data	-2.172					Mean of logged Data	3.883
60					Maximum of Logged Data	6.727					SD of logged Data	0.961
61												
62	**Assuming Lognormal Distribution**											
63					95% H-UCL	96.37					90% Chebyshev (MVUE) UCL	103.9
64					95% Chebyshev (MVUE) UCL	116.2					97.5% Chebyshev (MVUE) UCL	133.4
65					99% Chebyshev (MVUE) UCL	167.2						
66												
67	**Nonparametric Distribution Free UCL Statistics**											
68	**Data do not follow a Discernible Distribution (0.05)**											
69												
70	**Nonparametric Distribution Free UCLs**											
71					95% CLT UCL	86.98					95% Jackknife UCL	87.15
72					95% Standard Bootstrap UCL	86.56					95% Bootstrap-t UCL	104.7
73					95% Hall's Bootstrap UCL	157.8					95% Percentile Bootstrap UCL	87.87
74					95% BCA Bootstrap UCL	95.6						
75					90% Chebyshev(Mean, Sd) UCL	100.4					95% Chebyshev(Mean, Sd) UCL	113.9
76					97.5% Chebyshev(Mean, Sd) UCL	132.6					99% Chebyshev(Mean, Sd) UCL	169.4
77												
78	**Suggested UCL to Use**											
79					95% Chebyshev (Mean, Sd) UCL	113.9						
80												
81	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
82	Recommendations are based upon data size, data distribution, and skewness.											
83	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
84	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
85												
86												
87	Pb											
88												
89	**General Statistics**											
90					Total Number of Observations	91					Number of Distinct Observations	80
91											Number of Missing Observations	0
92					Minimum	1.501					Mean	152.5
93					Maximum	732.2					Median	124.5
94					SD	114.7					Std. Error of Mean	12.02
95					Coefficient of Variation	0.752					Skewness	2.013
96												
97	**Normal GOF Test**											
98					Shapiro Wilk Test Statistic	0.849	**Shapiro Wilk GOF Test**					
99					5% Shapiro Wilk P Value	2.861E-13	Data Not Normal at 5% Significance Level					
100					Lilliefors Test Statistic	0.141	**Lilliefors GOF Test**					
101					5% Lilliefors Critical Value	0.0931	Data Not Normal at 5% Significance Level					
102	**Data Not Normal at 5% Significance Level**											
103												
104	**Assuming Normal Distribution**											

	A–E	F	G–K	L
105	**95% Normal UCL**		**95% UCLs (Adjusted for Skewness)**	
106	95% Student's-t UCL	172.4	95% Adjusted-CLT UCL (Chen-1995)	175
107			95% Modified-t UCL (Johnson-1978)	172.9
108				
109	**Gamma GOF Test**			
110	A-D Test Statistic	0.329	**Anderson-Darling Gamma GOF Test**	
111	5% A-D Critical Value	0.765	Detected data appear Gamma Distributed at 5% Significance Level	
112	K-S Test Statistic	0.06	**Kolmogorov-Smirnov Gamma GOF Test**	
113	5% K-S Critical Value	0.095	Detected data appear Gamma Distributed at 5% Significance Level	
114	**Detected data appear Gamma Distributed at 5% Significance Level**			
115				
116	**Gamma Statistics**			
117	k hat (MLE)	1.982	k star (bias corrected MLE)	1.924
118	Theta hat (MLE)	76.94	Theta star (bias corrected MLE)	79.26
119	nu hat (MLE)	360.6	nu star (bias corrected)	350.1
120	MLE Mean (bias corrected)	152.5	MLE Sd (bias corrected)	109.9
121			Approximate Chi Square Value (0.05)	307.7
122	Adjusted Level of Significance	0.0474	Adjusted Chi Square Value	307.1
123				
124	**Assuming Gamma Distribution**			
125	95% Approximate Gamma UCL (use when n>=50)	173.5	95% Adjusted Gamma UCL (use when n<50)	173.8
126				
127	**Lognormal GOF Test**			
128	Shapiro Wilk Test Statistic	0.927	**Shapiro Wilk Lognormal GOF Test**	
129	5% Shapiro Wilk P Value	3.4123E-5	Data Not Lognormal at 5% Significance Level	
130	Lilliefors Test Statistic	0.0813	**Lilliefors Lognormal GOF Test**	
131	5% Lilliefors Critical Value	0.0931	Data appear Lognormal at 5% Significance Level	
132	**Data appear Approximate Lognormal at 5% Significance Level**			
133				
134	**Lognormal Statistics**			
135	Minimum of Logged Data	0.406	Mean of logged Data	4.754
136	Maximum of Logged Data	6.596	SD of logged Data	0.834
137				
138	**Assuming Lognormal Distribution**			
139	95% H-UCL	197.4	90% Chebyshev (MVUE) UCL	212.4
140	95% Chebyshev (MVUE) UCL	234.6	97.5% Chebyshev (MVUE) UCL	265.4
141	99% Chebyshev (MVUE) UCL	325.8		
142				
143	**Nonparametric Distribution Free UCL Statistics**			
144	**Data appear to follow a Discernible Distribution at 5% Significance Level**			
145				
146	**Nonparametric Distribution Free UCLs**			
147	95% CLT UCL	172.2	95% Jackknife UCL	172.4
148	95% Standard Bootstrap UCL	172	95% Bootstrap-t UCL	175.8
149	95% Hall's Bootstrap UCL	177.6	95% Percentile Bootstrap UCL	172.6
150	95% BCA Bootstrap UCL	174.8		
151	90% Chebyshev(Mean, Sd) UCL	188.5	95% Chebyshev(Mean, Sd) UCL	204.9
152	97.5% Chebyshev(Mean, Sd) UCL	227.6	99% Chebyshev(Mean, Sd) UCL	272.1
153				
154	**Suggested UCL to Use**			
155	95% Approximate Gamma UCL	173.5		
156				

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Mn

General Statistics

Total Number of Observations	91	Number of Distinct Observations	90
		Number of Missing Observations	0
Minimum	-110.3	Mean	629.1
Maximum	2004	Median	613.7
SD	398.4	Std. Error of Mean	41.77
Coefficient of Variation	0.633	Skewness	0.763

Normal GOF Test

Shapiro Wilk Test Statistic	0.959	**Shapiro Wilk GOF Test**
5% Shapiro Wilk P Value	0.0246	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.0941	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.0931	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	698.5	95% Adjusted-CLT UCL (Chen-1995)	701.4
		95% Modified-t UCL (Johnson-1978)	699.1

Gamma Statistics Not Available

Lognormal Statistics Not Available

Nonparametric Distribution Free UCL Statistics

Data do not follow a Discernible Distribution (0.05)

Nonparametric Distribution Free UCLs

95% CLT UCL	697.8	95% Jackknife UCL	698.5
95% Standard Bootstrap UCL	697	95% Bootstrap-t UCL	704.1
95% Hall's Bootstrap UCL	703.4	95% Percentile Bootstrap UCL	695.6
95% BCA Bootstrap UCL	699.6		
90% Chebyshev(Mean, Sd) UCL	754.4	95% Chebyshev(Mean, Sd) UCL	811.2
97.5% Chebyshev(Mean, Sd) UCL	889.9	99% Chebyshev(Mean, Sd) UCL	1045

Suggested UCL to Use

95% Chebyshev (Mean, Sd) UCL	811.2

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Appendix E

XRF data supplied by the Principal

Date	SAMPLE DESCRIPTION	Ag ppm	As ppm	Be ppm	Bi ppm	Ca %	Cd ppm	Co ppm	Cr ppm	Cu ppm	Fe %	Hg ppm	K %	Mn ppm	Mo ppm	Nb ppm	Ni ppm	P ppm	Pb ppm	Rb ppm	S %	Sb ppm	Se ppm	Sn ppm	Sr ppm	Th ppm	Ti %	U ppm	V ppm	W ppm	Y ppm	Zn ppm	Zr ppm	Ag ppm	Pb %	Zn %
3/11/2020	TP3-0.0-0.1	>100	367	1.58	331	0.7	11.85	9.1	36	194	14.8	0.787	1	735	9.17	5.6	6.6	190	>10000	78.9	>10.0	15.2	7	66	42.8	3.55	0.267	1.5	60	73.8	10.4	3290	59.2	152	1.47	
3/11/2020	13	92	682	#N/A	175	1449	12	-1038	594	136	18.0834	-7	6889	716	4	0	12	-1963	8211	67	13275	11	8	385	27	4	2291	-1	191	55	29	1418	154	92	8211	1418
3/11/2020	TP3-1.3-1.4	67.9	482	1.59	156	0.12	83	6.2	42	115.5	13.85	0.124	1.61	3860	5.7	7.2	11.9	280	6780	101	4.4	5.87	3	24.3	54	5.45	0.216	1.5	86	31.7	9.9	15350	69.7			1.535
3/11/2020	16	19	855	#N/A	88	52	-6	-1152	250	114	19.0194	-7	14201	813	10	13	7	-2212	6070	99	31488	16	-4	146	43	6	3322	-7	86	18	29	2139	289	19	6070	2139
3/11/2020	TP4-0.6-0.7	>100	486	0.73	548	0.13	17.75	20.1	25	362	14.25	1.575	0.43	1500	2.48	2.7	10	150	>10000	43	>10.0	18.05	12	149.5	20.4	3.47	0.104	1.2	43	32.7	6.7	3400	40.4	144	2.8	
3/11/2020	32	333	18314	#N/A	1197	-529	31	-1977	785	1306	31.0508	-36	9466	1191	4	47	9	-2939	11588	108	36983	22	17	1679	28	17	8707	4	216	146	45	4966	609	333	11588	4966
3/11/2020	TP4a-0.2-0.3	85.6	1040	1.71	152.5	0.08	5.68	2.7	44	407	14.75	0.448	1.48	1280	14.05	6.7	8.6	250	>10000	104.5	2.53	22.8	4	35.5	45.8	5.52	0.255	1.3	98	26.3	10.1	2810	70.9		1.075	
3/11/2020	39	56	1717	#N/A	144	0	40	0	-258	45	60.9069	26	0	2385	17	7	-200	0	10034	67	0	41	11	188	25	9	4819	-13	461	-17	13	9109	129	56	10034	9109
4/11/2020	TP5-1.3-1.4	51.8	535	4.86	203	1.61	81.2	13.4	30	581	22.5	0.534	0.68	17300	3.38	4.3	13.7	410	>10000	52.9	3.43	18.25	3	47.1	81.5	8.09	0.147	2.5	48	47.6	13.3	15700	44.2		3.41	1.57
4/11/2020	6	-5	141	#N/A	2	255	7	-452	79	142	6.0608	7	13215	4074	4	12	21	-1188	32134	95	7708	-34	2	23	25	13	3525	-3	36	-7	28	4881	338	-5	32134	4881
4/11/2020	TP6-0-0.1	>100	406	2.08	67.8	9.97	12.1	4.9	47	1095	28.2	0.042	0.38	5800	23.8	8.9	5	730	>10000	24.5	0.74	11.95	2	436	201	7.98	0.388	6.9	80	141	24.8	6250	171.5	105	3.79	
4/11/2020	7	6	1454	#N/A	71	171273	-28	-9190	303	1223	59.517	-12	6131	2931	35	0	66	-2601	18417	22	27492	39	8	1261	200	17	3015	9	65	92	94	7004	177	6	18417	7004
4/11/2020	TP8-0-0.1	>100	1130	4.7	1425	0.61	24.5	9.1	25	1010	19.4	0.178	0.74	4330	4.21	5.5	9	520	>10000	44.6	0.57	31.3	12	59	69.1	8.1	0.221	2.7	63	117.5	19.9	6100	60.8	153	4.8	
4/11/2020	20	98	2148	#N/A	826	1574	20	-3505	170	781	28.5986	-17	8611	2162	12	19	29	-2154	35377	63	21587	66	19	200	27	17	1939	-16	57	14	-98	8598	124	98	35377	8598
4/11/2020	TP08-0.6-0.7	27.4	243	4.12	134.5	2.66	8.23	8.5	28	328	10.1	0.126	0.48	2960	2.2	6.3	11.4	280	>10000	37.2	0.66	7.36	2	18	238	7.54	0.195	2.9	49	50.5	18.7	2550	56.6		1.23	
4/11/2020	23	9	9	#N/A	-15	2239	7	104	931	111	4.201	-13	1627	1457	2	5	24	-389	16479	8	2356	-2	-2	18	187	9	9524	-1	338	41	37	3485	131	9	16479	3485
6/11/2020	TP16-0.1-0.2	36.4	707	5.1	107.5	0.96	55.9	9.6	34	289	20.9	0.368	0.31	31100	1.96	6.1	11.2	500	>10000	22.9	0.61	11.7	2	38	101	6.87	0.203	2.3	57	42.7	13.6	8070	57.5		1.29	
6/11/2020	2	28	1465	#N/A	85	9691	89	915	58	428	68.7736	-3	7942	16258	-3	#N/A	-79	2182	15101	37	14974	39	1	212	80	#REF!	3757	#REF!	56	-63	18	10170	129	28	15101	10170
6/11/2020	TP18-0.2-0.4	79.4	541	3.95	334	1.66	13.1	11	32	676	12.4	0.185	0.61	6130	3.34	6.4	12.7	390	>10000	54.7	1.23	15.45	5	41.8	180	8.07	0.248	2.2	64	75.9	18.9	3170	63.8		5.18	
6/11/2020	11	42	73	#N/A	183	8772	2	96	47	492	12.072	-1	8038	1371	1.3	#N/A	-13	847	41111	56	10238	7	-3	82	101	#REF!	3242	#REF!	58	11	24	2448	136	42	4.1111	2448
6/11/2020	TP18-D	45.3	309	4.95	136.5	2.03	15.1	24	34	535	11.3	0.14	0.53	10100	1.91	6	18.1	310	>10000	43.3	0.74	7.41	3	22.3	115	6.81	0.223	1.7	55	48.4	17.9	3450	53.7		1.925	
6/11/2020	11	42	73	#N/A	183	8772	2	96	47	492	12.072	-1	8038	1371	1.3	#N/A	-13	847	11111	56	10238	7	-3	82	101	#REF!	3242	#REF!	58	11	24	2448	136	42	11111	2448

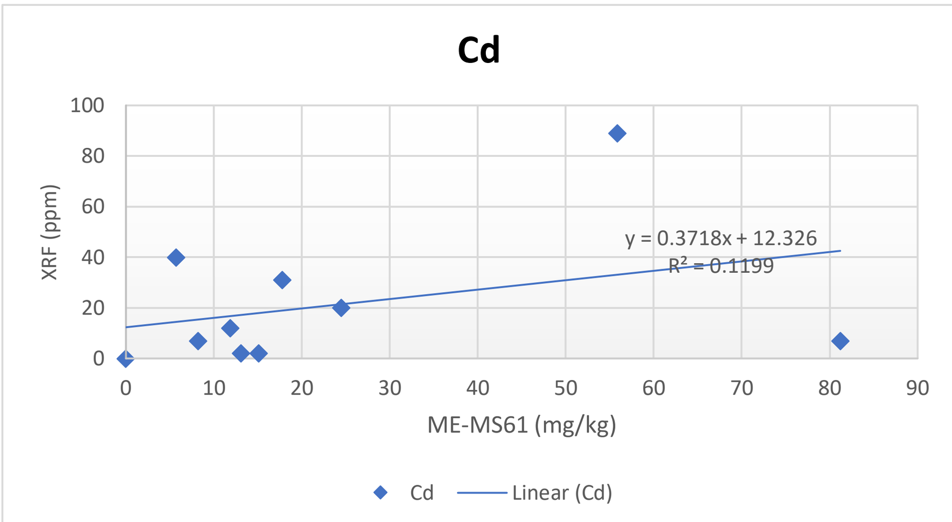
Pb	
%	
Pb-OG62	XRF
0	0
1.47	0.8211
2.8	1.1588
1.075	1.0034
3.41	3.2134
3.79	1.8417
4.8	3.5377
1.23	1.6
1.29	1.5101
5.18	4.1111
1.925	1.1111

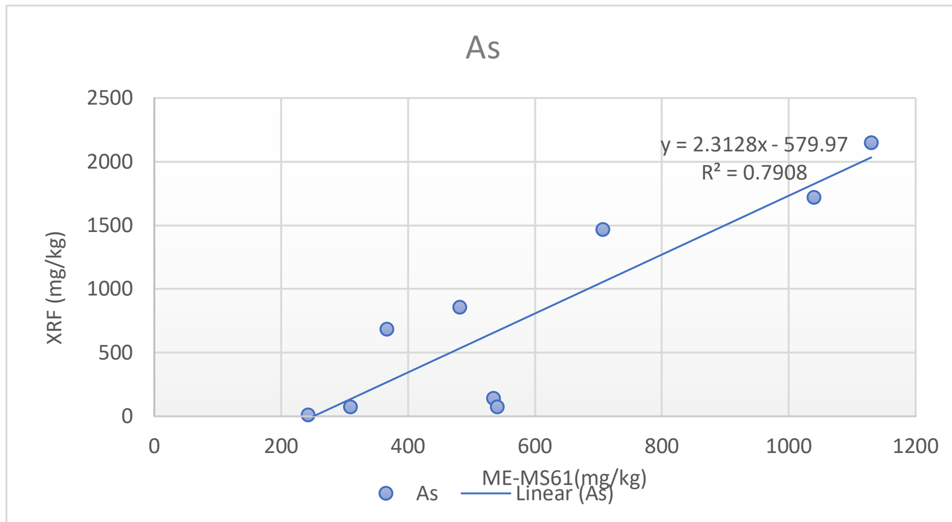
As	
ppm	
ME-MS61	XRF
367	682
482	855
1040	1717
535	141
	1454
1130	2148
243	9
707	1465
541	73
309	73

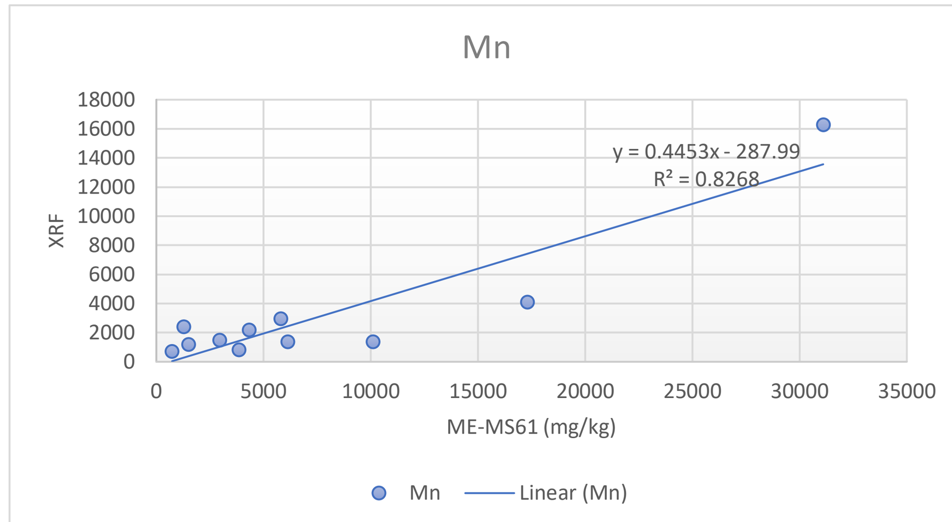
Mn	
ppm	
ME-MS61	XRF
735	716
3860	813
1500	1191
1280	2385
17300	4074
5800	2931
4330	2162
2960	1457
31100	16258
6130	1371
10100	1371

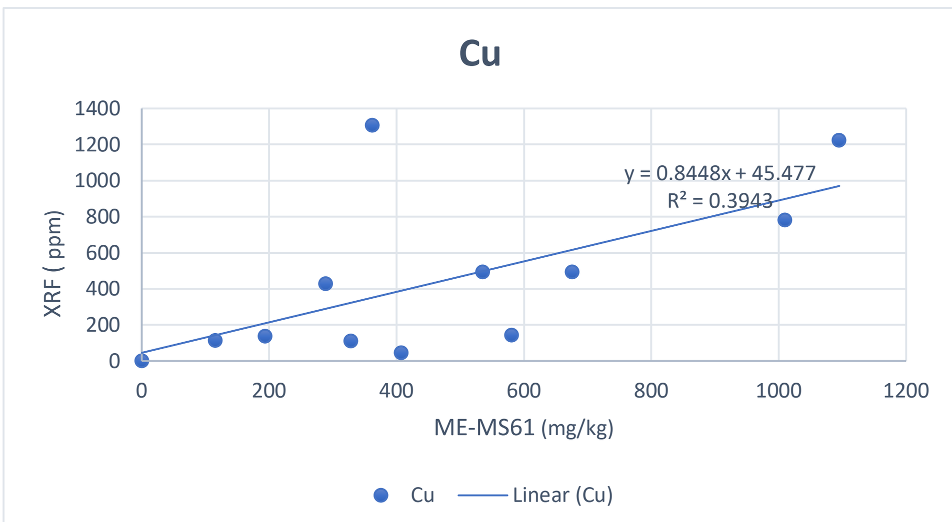
Zn	
ppm	
ME-MS61	XRF
3290	1418
15350	12139
3400	4966
2810	2109
15700	14881
6250	7004
6100	8598
2550	3485
8070	10170
3170	2448
3450	2448

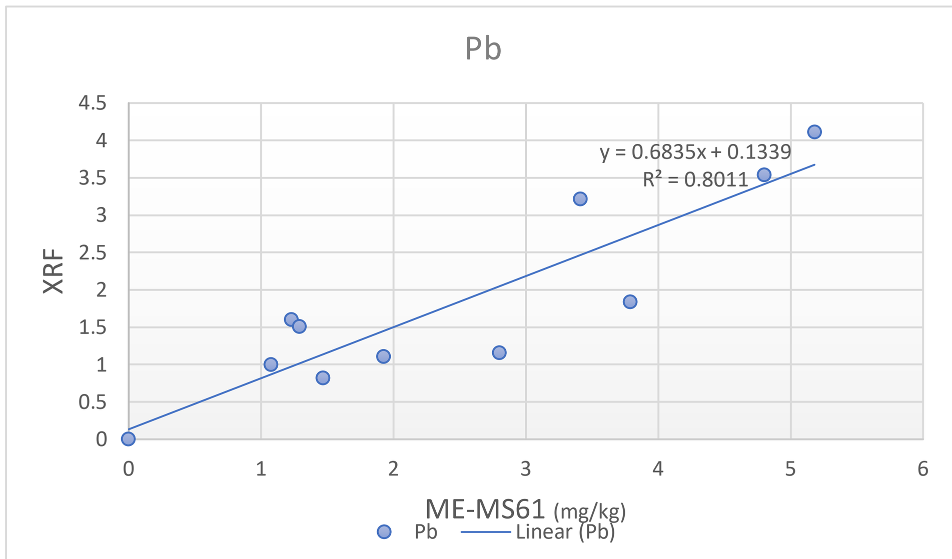
Cd	
ppm	
ME-MS61	XRF
11.85	12
17.75	31
5.68	40
81.2	7
24.5	20
8.23	7
55.9	89
13.1	2
15.1	2
0	0
Cu	
ppm	
ME-MS61	XRF
194	136
115.5	114
362	1306
407	45
581	142
1095	1223
1010	781
328	111
289	428
676	492
535	492
0	0

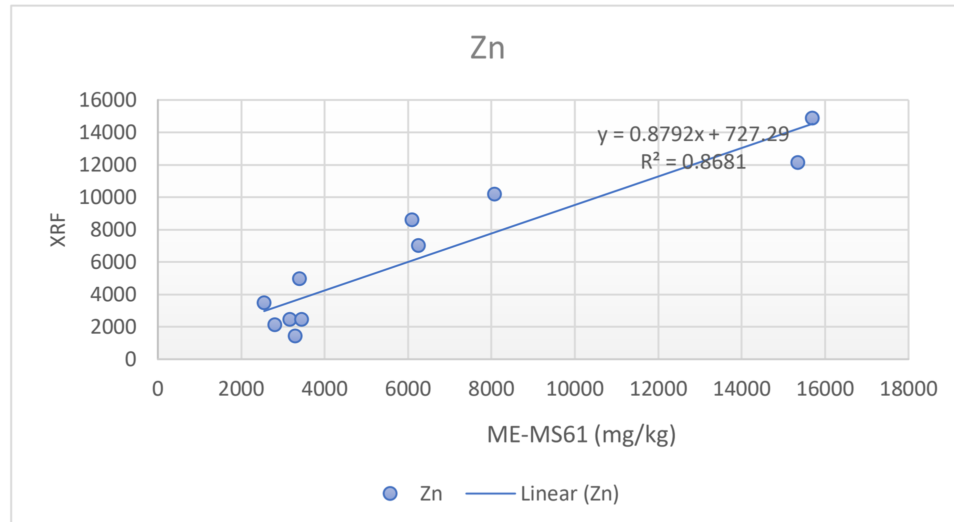












Full XRF Dataset in excel: This dataset are the paired results for ICP-MS

Terra Tech

CONSULTING

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