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MEMO REPORT

COMPANY:	Saturn Metals Limited
[redacted]	
DATE:	8 March 2023
DESCRIPTION:	**Apollo Hill Gold Project – Soil Characterisation Study**

1. INTRODUCTION

Significant Environmental Services (SignificantENV) completed the pre-mine soil characterisation study for the Apollo Hill Gold Project (the Project) in March 2023. The purpose of this study was to characterise the surficial soil materials within the proposed disturbance footprint areas, and subsequently determine where the optimum volumes can be sourced as topsoil material for rehabilitation.

2. SITE DESCRIPTION

Project Location and Description

Saturn Metals Limited (STN; the Company) is the holder of mining leases M31/486, M31/496 and M39/296 which encompass the proposed mining activities for the Apollo Hill Gold Project (the Project). The Project is located approximately 650km north-east of Perth and 50km south-east of the town of Leonora, in the Eastern Goldfields district in Western Australia (refer to **Figure 1**).

The Project is currently focused on the development of a pilot heap leaching operation and associated bulk sample pit which will provide learnings to leverage larger scale development activities for the already defined 1.47Moz Apollo Hill Gold Resource. The Project includes the proposed development of a single open pit (290m long and 30m deep), x2 waste rock dumps (WRD's), run-of-mine (ROM) pad, ore crushing circuit, heap leach pad, process ponds and plant, power plant, topsoil stockpile areas and associated infrastructure areas (offices, workshops, camp, access roads, laydown areas, etc.) (refer to **Figure 2**). The current pit design allows for variable mining scenarios up to 1Mt of ore and waste which will be used to run a stacking height heap leach trial. The life of mine (LoM) for this bulk sample mining and pilot heap leach project will be approximately 1 year, with construction planned to commence in H1-2024, and mining and heap leach commissioning operations in H2-2024.

This soil characterisation study report covers the proposed disturbance footprints from which surficial soils will be harvested during ground clearing earthworks and stored within topsoil stockpile areas until reclaimed for rehabilitation at closure. The total area of the proposed disturbance footprints is 30 hectares (ha) which excludes the haul or access roads due to the surficial soil materials from these corridor disturbance footprints being pushed to the side as windrows rather than removed and stockpiled.

Regional Biophysical Environment

The Project lies within the Murchison Bioregion of the Eremaean Province of WA in a region known as the Austin Botanical District. The Murchison Bioregion is further divided into sub-regions, based on the Interim Biogeographic Regionalisation of Australia (IBRA), with the Project located within the Eastern Murchison (MUR1) sub-region.

The landscape of the Murchison Bioregion comprises low hills, mesas of duricrust separated by flat colluvium and alluvial plains. It is dominated by the Archaean (over 2500 million years ago) granite greenstone terrain of the Yilgarn Craton. Alluvial soils and sands mantle the granitic and greenstone units of the Yilgarn Craton. These soils are shallow, sandy and infertile. Underlying the soils in low areas is a red-brown siliceous hardpan (Curry et al. 1994). The soils in the eastern half of the bioregion are typically red sands, calcareous red earth soil, duplex soil and clays. There are 41 vegetation associations (hummock grasslands, succulent steppe or low woodlands) that have at least 85 per cent of their total area in the bioregion. The bioregion is rich and diverse in both its flora and fauna but most species are wide ranging and usually occur in adjoining regions (McKenzie, May and McKenna, 2002).

The Eastern Murchison sub-region comprises the northern parts of the craton's Southern Cross and Eastern

Goldfields Terrains and is characterised by internal drainage and extensive areas of elevated red desert sandplains with minimal dune development. Salt lake systems are associated with the occluded paleodrainage system. Broad plains of red-brown soils and breakaways complexes as well as red sandplains are widespread. Vegetation is dominated by Mulga woodlands and is often rich in ephemerals, hummock grasslands, saltbush shrublands and Samphire shrublands (McKenzie et. al., 2002).

Regional Soils and Landscape Systems

The Project lies within the Murchison Province of Western Australia. The Murchison Province consists of hardpan wash plains and sandplains (with some stony plains, hills, mesas and salt lakes) on the granitic rocks and greenstone of the Yilgarn Craton. This Province is located in the inland Mid-west and northern Goldfields between Three Springs, the Gascoyne River, Wiluna, Cosmo Newberry and Menzies (Tille, 2006).

The Project occurs within the Salinaland Plains Zone of the Murchison Province which consists of sandplains (with hardpan wash plains and some mesas, stony plains and salt lakes) on granitic rocks (and some greenstone) of the Yilgarn Craton. Soils include red sandy earths, red deep sands, red shallow loams and red loamy earths with some red-brown hardpan shallow loams, salt lake soils and red shallow sandy duplexes. Vegetation is dominated by mulga shrublands with spinifex grasslands (and some halophytic shrublands and eucalypt woodlands). This zone is located in the northern Goldfields from Lakes Barlee and Lake Ballard to Wiluna and Laverton (Tille, 2006).

The hardpan material forming the principal subsoil material of the Project area is colloquially referred to as the Wiluna Hardpan Land System (refer to **Figure 4** for distribution map). The material varies in lithology and age (from Quaternary to recent), consisting of a colluvial/alluvial conglomerate (clays, sands, gravels, rock fragments) that have been progressively altered through clay illuviation and cementation by amorphous silica. These conditions are thought to result from bioclimatic pedogenesis; in particular, sequential wet-dry cycles associated with episodic (cyclonic) flooding and prolonged, intense dehydration (Bettenay and Churchward, 1979).

Climate

The climate is described as arid with hot dry days in summer, and mild days and cool nights in winter. The closest long-term Bureau of Meteorology (BoM) weather station with a complete dataset is Leonora (Station No: 012046), located approximately 45km north-west of the Project site. Mean daytime temperatures range from 18°C in July to 37°C in January, and mean night-time temperatures from 6°C to 22°C also in July and January, respectively.

The project area receives 236mm of rain annually, on average. Rainfall is bimodal, occurring during the summer and winter months. Summer rainfall is generally restricted to irregular thunderstorm activity associated with the inter-tropical convergence zone or by remnant tropical cyclones. These systems travel south after crossing the Pilbara coast. Rainfall in winter is related to frontal activity extending up from the Great Australian Bight. Generally winter rainfall is more reliable but has a lower intensity. Summer rainfall, especially when resulting from remnant cyclone activity, can be heavy and cause substantial flooding.

The closest station with evaporation data is Kalgoorlie-Boulder Airport (Station No: 012038), located about 200km south. Mean evaporation exceeds rainfall in all months and annually by more than an order of magnitude.

Geomorphology and Hydrology

The Project area is characterised by a subdued topography, comprising flat hardpan wash plains with scattered mantles of small pebbles and gravels (dominated by quartz). The high-point of the Project site is the Apollo hills to the north-west where the pit development exists (up to 369mAHD), and south-west and southwards from this high-point is the flat wash plains (355-357 mAHD) where rainfall runoff and drainage occurs steadily into the soils comprising of sandy clays with pebbles (refer to **Figure 3**). The proposed waste dumps and other supporting infrastructure are at least 500m from the high-point, and thus unlikely to be impacted by surface water drainage considering the gentle, subdued topography of the Project area. The Lake Raeside salt lake system exists north-east and northwards of the Apollo hills high-point.

Land Use

The dominant land uses of the Eastern Murchison sub-region include grazing native pastures (85.47%), unallocated crown reserves (11.34%), conservation (1.4%) and mining (1.79%) (Cowan, 2001). The Project is located within the Glenorn Pastoral Lease (L3114/990) which is owned by Minara Resources Pty Ltd.

The proposed post-mining land use is low intensity pastoral activities, including traditional beef cattle farming activities, as this has been the land use in this remote location for the past century and is agreed by all relevant stakeholders to remain the case.

3. STUDY METHODOLOGY

Soil Profiling and Sampling

Soil materials were investigated by shallow diggings within the proposed disturbance footprint areas in February 2023. This involved soil profiling and sampling, with the locations of the sampling sites shown in **Figure 2**.

Shallow diggings were excavated by shovel to a maximum depth of 0.5m, or until a consolidated layer (or hardpan) was reached. Photographs of the sampling site and profile cross-section were taken prior to collecting samples. Samples were collected within 2 to 15cm from the ground surface, as this top layer of soil is representative of the topsoil and subsoil that will be removed and stockpiled (for rehabilitation) when ground clearing earthworks are undertaken. Approximately 1kg of soil was collected into laboratory supplied jars and plastic bags for analysis by ALS laboratory testing services.

The soil profiles assessed in the field were described in accordance with McDonald and Isbell (2009). Soil profiles were assessed for degree of horizonation, presence and abundance of coarse fragments (i.e. gravels) and mottling, and structure, fabric and field texture of soil materials.

Photographs for each of the twelve (12) sampling sites, representative of the surficial soil materials covering the proposed disturbance footprint areas, are provided in **Figure 5** to **Figure 16**. The coordinates of each sampling site, landscape descriptions and depth to consolidated layer (i.e. digging effort) are provided in **Table 1**.

Laboratory Analysis of Soil Materials

The soil samples were assessed for the physical and chemical properties listed in **Table 2**.

Table 1: Soil sampling locations and basic field descriptions

Site ID	Coordinates (GDA94, Zone 51)		Landform	Soil Surface	Soil Type	Digging Depth to Consolidated Layer (cm)
	Easting	Northing				
S1 – Pit (NW)	371,388.93	6,774,097.98	Rocky Rise	Sand, Pebbles and Cobbles-Stone	Sandy clay with pebbles-cobbles	15 cm (to rocky layer)
S2 – Pit (SE)	371,465.79	6,773,991.45	Rocky Rise	Sand, Pebbles and Cobbles-Stone	Sandy clay with pebbles-cobbles	10-15 cm (to rocky layer)
S3 – WRD1 (N)	369,567.41	6,774,352.43	Flat Plain	Pebbles	Sandy clay with pebbles	10-15 cm (to hardpan layer)
S4 – WRD1 (S)	369,579.63	6,774,276.05	Flat Plain	Pebbles	Sandy clay with pebbles	10 cm (to hardpan layer)
S5 – WRD2	370,970.39	6,773,676.39	Flat Plain	Pebbles	Sandy clay with pebbles	15 cm (to hardpan layer)
S6 – Heap Leach Pad (NE)	370,845.14	6,773,535.86	Flat Plain	Pebbles	Sandy clay with pebbles	15 cm (to hardpan layer)
S7 – Heap Leach Pad (SW)	370,716.83	6,773,465.59	Flat Plain	Pebbles	Sandy clay with pebbles	10 cm (to hardpan layer)
S8 – Crushing Pad	370,802.28	6,773,345.39	Flat Plain	Pebbles	Sandy clay with pebbles	15 cm (to hardpan layer)
S9 – Office Admin	371,391.66	6,773,269.02	Flat Plain	Pebbles	Sand with pebbles	15-20 cm (to hardpan layer)
S10 – Magazine	370,765.71	6,772,158.04	Flat Plain	Clay	Sandy clay with pebbles	20-25 cm (to hardpan layer)
S11 – Camp (N)	368,963.24	6,773,407.55	Flat Plain	Pebbles	Sandy clay with pebbles	15-20 cm (to hardpan layer)
S12 – Camp (S)	369,048.79	6,773,230.35	Flat Plain	Sand, Pebbles and Cobbles	Sandy clay with pebbles-cobbles	10 cm (to hardpan layer)

Table 2: Laboratory Analysis Results – physical and chemical properties of surficial soil materials

Parameter	Unit	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
		Pit(NW)	Pit(SE)	WRD1(N)	WRD1(S)	WRD2	HLP(NE)	HLP(SW)	CrushP	OfficeA	Mag	Camp(N)	Camp(S)
pH Value	pH Unit	8.9	9.0	8.0	6.9	6.7	6.5	6.7	6.2	6.7	5.7	5.7	6.1
Electrical Conductivity	µS/cm	52	66	157	65	58	9	294	37	9	362	53	20
Bulk Density	kg/m^3	1220	1200	1320	1430	1380	1290	1370	1490	1340	1220	1390	1380
Moisture Content	%	4.6	3.5	3.2	3.5	3.3	1.9	3.5	2.8	3.2	2.7	2.8	3.7
Particle Sizing													
+75µm	%	80	70	88	86	81	88	70	78	86	53	70	68
+150µm	%	66	57	83	73	68	78	60	68	77	44	62	62
+300µm	%	53	46	65	51	51	60	47	53	63	34	53	53
+425µm	%	50	43	52	39	40	48	40	43	53	29	48	49
+600µm	%	47	42	43	30	30	37	33	35	44	25	44	45
+1180µm	%	43	39	26	15	12	19	21	23	26	17	35	36
+2.36mm	%	34	34	7	4	3	6	11	11	10	10	18	22
+4.75mm	%	18	26	<1	<1	<1	<1	5	2	2	6	4	11
+9.5mm	%	<1	<1	<1	<1	<1	<1	<1	<1	<1	6	<1	7
+19.0mm	%	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
+37.5mm	%	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
+75.0mm	%	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Soil Classification (Particle Size)													
Clay (<2 µm)	%	8	17	11	9	11	8	15	15	10	30	18	21
Silt (2-60 µm)	%	9	9	1	3	7	5	14	8	2	14	10	9
Sand (0.06-2 mm)	%	46	38	75	80	76	77	57	62	73	44	49	43
Gravel (>2mm)	%	37	36	13	8	6	10	14	15	15	12	23	27
Cobbles (>6cm)	%	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Exchangeable Cations													
Exchangeable Calcium	meq/100g	17.9	20.7	0.5	0.4	0.5	0.4	1.6	0.7	0.7	1.3	2.1	2.1
Exchangeable Magnesium	meq/100g	1.0	1.5	1.0	0.8	0.9	0.5	3.4	1.5	0.8	1.9	2.0	3.2
Exchangeable Potassium	meq/100g	0.3	0.3	0.4	0.2	0.3	0.2	0.6	0.3	0.3	0.6	0.5	0.5

Parameter	Unit	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
		Pit(NW)	**Pit(SE)**	**WRD1(N)**	**WRD1(S)**	**WRD2**	**HLP(NE)**	**HLP(SW)**	**CrushP**	**OfficeA**	**Mag**	**Camp(N)**	**Camp(S)**
Exchangeable Sodium	meq/100g	0.2	0.1	1.7	0.4	0.7	0.2	1.5	0.4	0.2	0.1	0.2	0.2
Cation Exchange Capacity	meq/100g	19.4	22.6	3.5	1.9	2.4	1.3	7.0	2.9	2.0	3.9	4.7	6.0
Exchangeable Sodium	%	0.8	0.4	48.0	22.9	28.6	18.5	21.0	12.7	8.6	2.7	3.9	3.0
Soluble Major Anions													
Sulfur as S	mg/kg	<10	<10	<10	<10	<10	<10	30	<10	<10	40	<10	<10
Soluble Major Cations													
Potassium	mg/kg	<10	<10	<10	<10	<10	<10	10	<10	<10	70	20	<10
Nutrients													
Nitrite + Nitrate as N (Sol.)	mg/kg	1.2	2.8	0.8	0.6	0.9	0.7	2.4	2.3	0.7	5.2	5.6	1.9
Total Kjeldahl Nitrogen as N	mg/kg	260	640	60	90	90	100	250	170	90	280	140	240
Total Nitrogen as N	mg/kg	260	640	60	90	90	100	250	170	90	280	140	240
Total Phosphorus as P	mg/kg	141	195	157	232	202	223	162	205	191	188	152	167
Organic Matter													
Organic Matter	%	0.5	1.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Organic Carbon	%	<0.5	0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

4. SOIL CHARACTERISATION RESULTS

The soil characterisation results (field notes in Table 1, photographs in Figure 5 to Figure 16, and laboratory analysis in Table 2) indicate that the surficial soils are relatively uniform across the proposed disturbance footprint areas. The proposed pit development footprint is within the Apollo hills high-point (up to 369 mAHD) which is rocky with gravel-pebbles mixed in with sandy clay loam soils, and the proposed waste dumps and other supporting infrastructure exist at least 500m south-west and southwards in the flat wash plains (355-357 mAHD) where rainfall runoff and drainage occurs steadily into the soils comprising of sandy clays with pebbles. Besides the Apollo hills, the Project site is characterised by a subdued topography, comprising flat hardpan wash plains with scattered mantles of small pebbles and gravels (dominated by quartz). This aligns with the exploration drilling geological/ lithological data for the Project site whereby the surficial soil layer is consistently about 0.2m deep, existing above hard, indurated duricrust layer that is approximately 2m thick and made up of calcareous and ferruginous pisolitic gravels with puggy clays.

As shown in the photographs (attached) and the particle size analysis results (Table 2) for each of the twelve sampling locations, the surficial soils through the Project site are red loamy earths, consisting of sandy clay loam mixed with gravel-pebbles. The soil classification results based on particle size analysis indicates loosely consolidated material containing 40-80% sands make up the balance, with the rocky Apollo hills high-point (pit development footprint) having the greatest content of gravel-pebbles (35%) and the flat wash plain areas the greatest content of silt-clays (up to 40%). The lack of variability in soil characteristics across the Project site is expected considering the relatively flat terrain across the project area whereby the surficial soil layer is transported cover material, generated by weathering and surface water (sheet flow) runoff processes.

As shown in Table 2, the soils are relatively low-moderate in mineral nutrients (Nitrogen 60-640mg/kg; Phosphorus 141-232mg/kg), have equally low-moderate electrical conductivity (9-362µS/cm) and cation exchange capacity (CEC; 1.3-22.6meq/100g) levels, and the pH ranges from moderately acidic to moderately alkaline (5.7-9.0 pH units). This indicates that the soils have low-moderate fertility for plant growth, whereby CEC is a useful indicator of soil fertility because it shows the soil's ability to supply important plant micro-nutrients (calcium, magnesium and potassium). Soil pH is important for CEC because as pH increases (becomes less acid), the number of negative charges on the colloids increase, thereby increasing CEC. Moderate levels of clay and organic matter content also add value to the chemical structure of the soil and in turn the fertility and water holding capacity.

5. CONCLUSIONS AND RECOMMENDATIONS

This section outlines management considerations for the handling and utilisation of the surficial soil materials covering the Project area. These management considerations will assist in achieving the following aims:

- Maintaining optimal soil properties during the mining and rehabilitation process.
- Appropriate handling of soil materials based on physical and/or chemical properties.
- Minimising environmental impacts through appropriate handling and placement of soil materials.

Soil Harvesting and Stockpiling Considerations

- Surficial soils within the Project site are relatively uniform whereby 40-80% sands make up the balance, with the rocky Apollo hills high-point (pit development footprint) having the greatest content of gravel-pebbles (35%) and the flat wash plain areas the greatest content of silt-clays (up to 40%). Therefore, the surficial soils can be treated the same when harvested and stored within the topsoil stockpile areas during ground clearing earthworks.
- The depth of surficial soils through the Project site are 10-25cm, existing above hard, indurated duricrust layer that is approximately 2m thick and made up of calcareous and ferruginous pisolitic gravels with puggy clays. Therefore, the harvesting depth of topsoil during ground clearing earthworks shall be to this hardpan layer (i.e. an effort should be made to harvest surficial soils to at least 20cm depth from all the proposed disturbance footprint areas, and appropriately store all of it within the topsoil stockpile areas for rehabilitation.
- Based on the proposed total disturbance footprint being approximately 30 hectares, and soil harvesting depth of 20cm, this equates to a total volume of 60,000m^3 that could be harvested and stored within the topsoil stockpile areas during ground clearing earthworks.

- The soils within the Project site are of a reasonable quality for rehabilitation purposes, having a balanced proportion of sands, gravels and fine clays to avoid erosion issues, and being moderately fertile for plant growth. It is important to maintain the seed viability and biotic activity of the harvested soil by appropriately storing it within the topsoil stockpile areas. The topsoil stockpiles shall be limited to a maximum of two metres in height and the storage time kept to a practicable minimum (i.e. utilise for progressive rehabilitation of the WRD landforms and other disturbed areas which are no longer required).

WRD Landform Design and Rehabilitation Considerations

- Due to the majority of the waste rock material proposed to be mined from the pit being weathered (oxidised) material, the WRD landforms should have gentle slope angles of 15° to prevent erosion and maintain soil stability over the long-term. Furthermore, to minimise runoff from the top surface of the WRD landforms, the upper surface should be slightly concave with bund set back from the crest; to minimise runoff down the walls/faces, a berm should be constructed every 10m height; and to minimise runoff from the base, a toe bund should be constructed.
- To ensure stabilisation of the outer waste rock material of the WRD landforms, it is worthwhile harvesting the underlying indurated duricrust layer (hardpan) within the pit development footprint in addition to the surficial soils layer; and this hardpan material should then be stockpiled separately to the topsoil material. This indurated duricrust layer is approximately 2m thick and made up of calcareous and ferruginous pisolitic gravels, thus being considered a stabilisation resource for cladding the outer surface of the WRD landforms during rehabilitation earthworks. Based on the pit development footprint being 2.6ha, approximately 50,000m^3 of this hardpan material could be harvested, which would adequately cover the WRD landforms (approximately 3.5ha).
- During the staged closure of the WRD landforms, the stockpiled hardpan material should be applied 1m thick on the outer surface (cladding layer), and the topsoil material then respread to depth of 10cm (growth medium layer), contour ripped and seeded with native species.

I trust this report deliverable meets your requirements. Please contact me with any queries.

Yours sincerely

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FIGURES

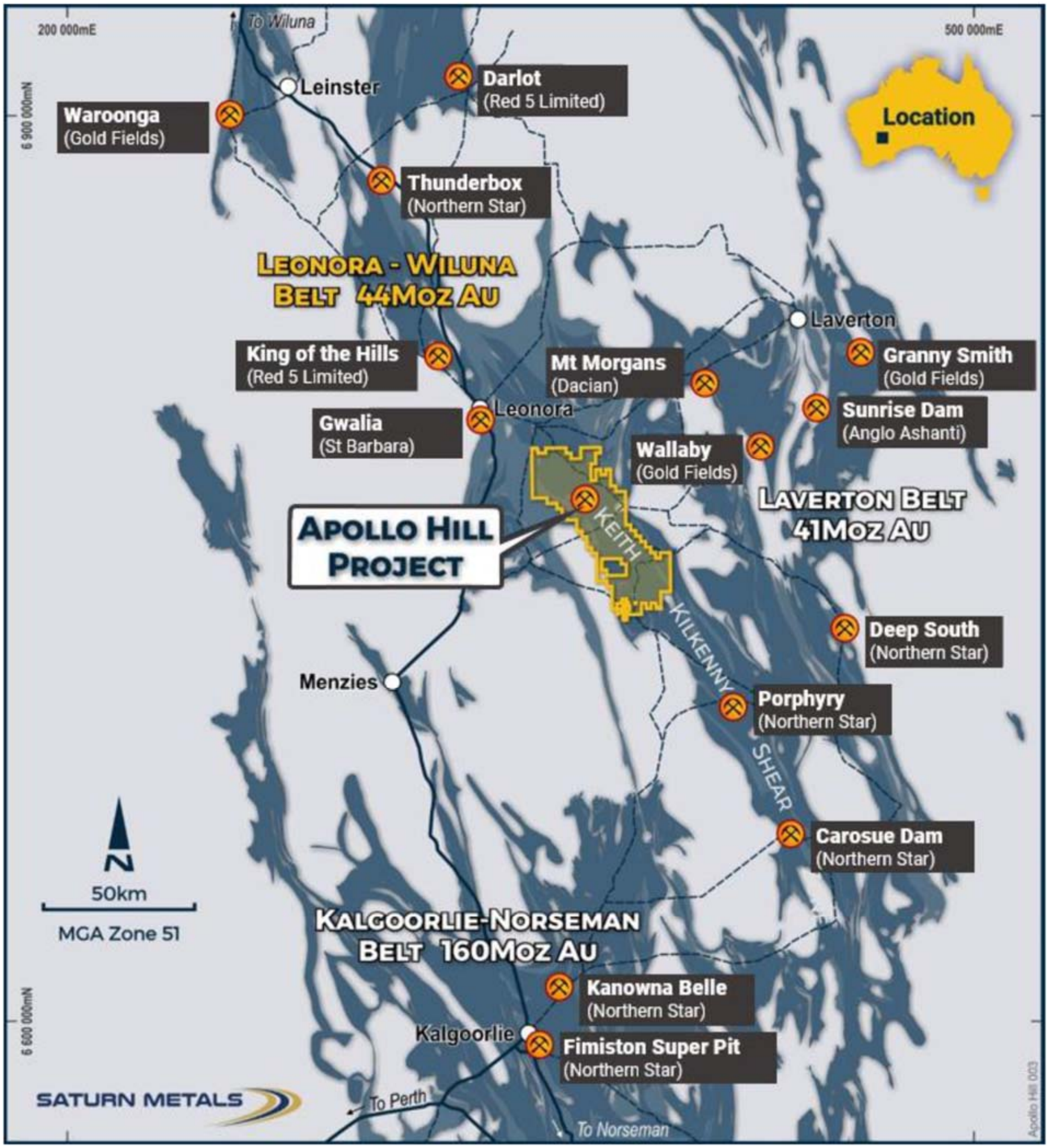

Figure 1: Project Location Map

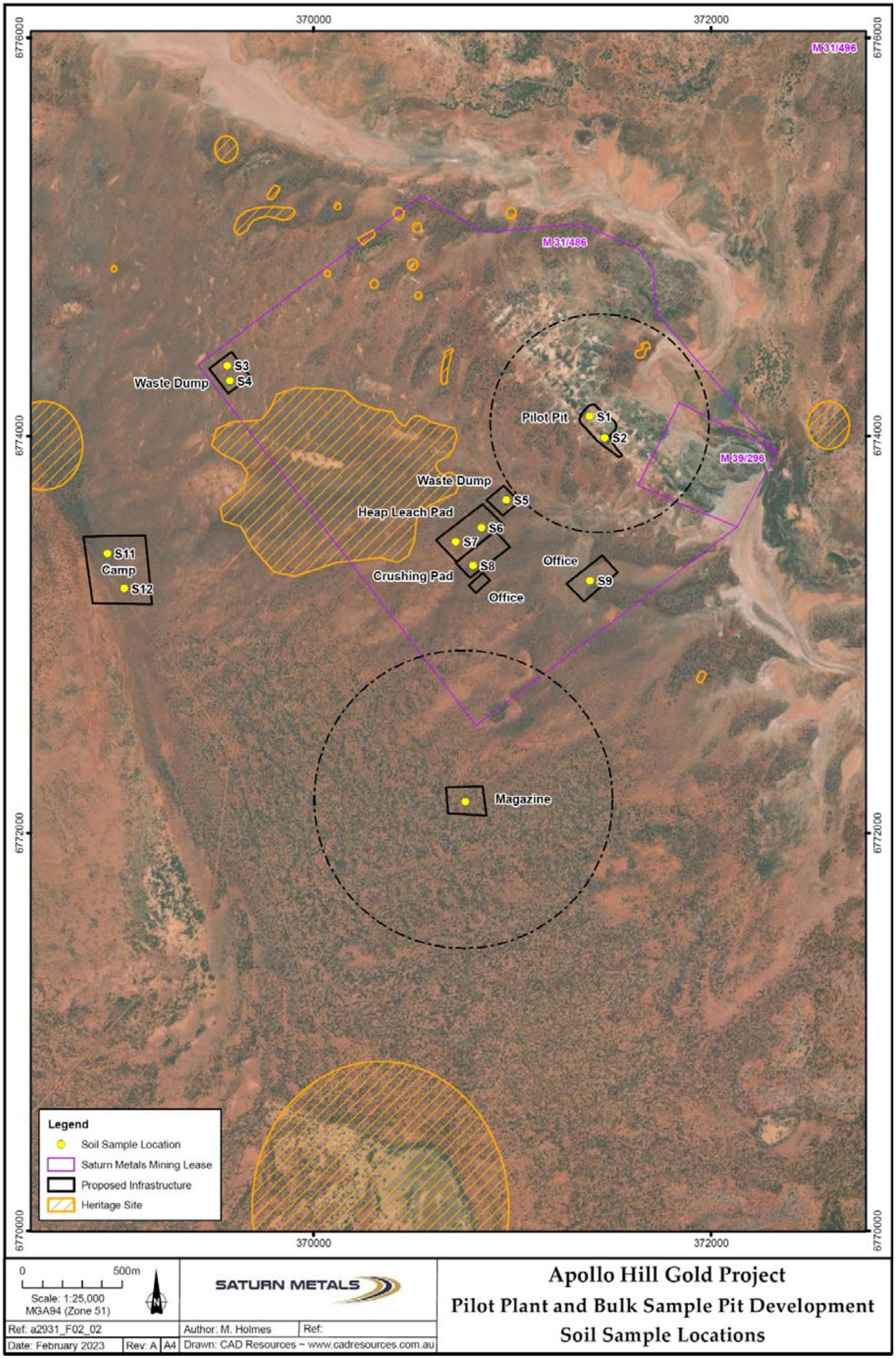

Figure 2: Site Layout Plan, displaying soil sampling locations (on aerial imagery map)

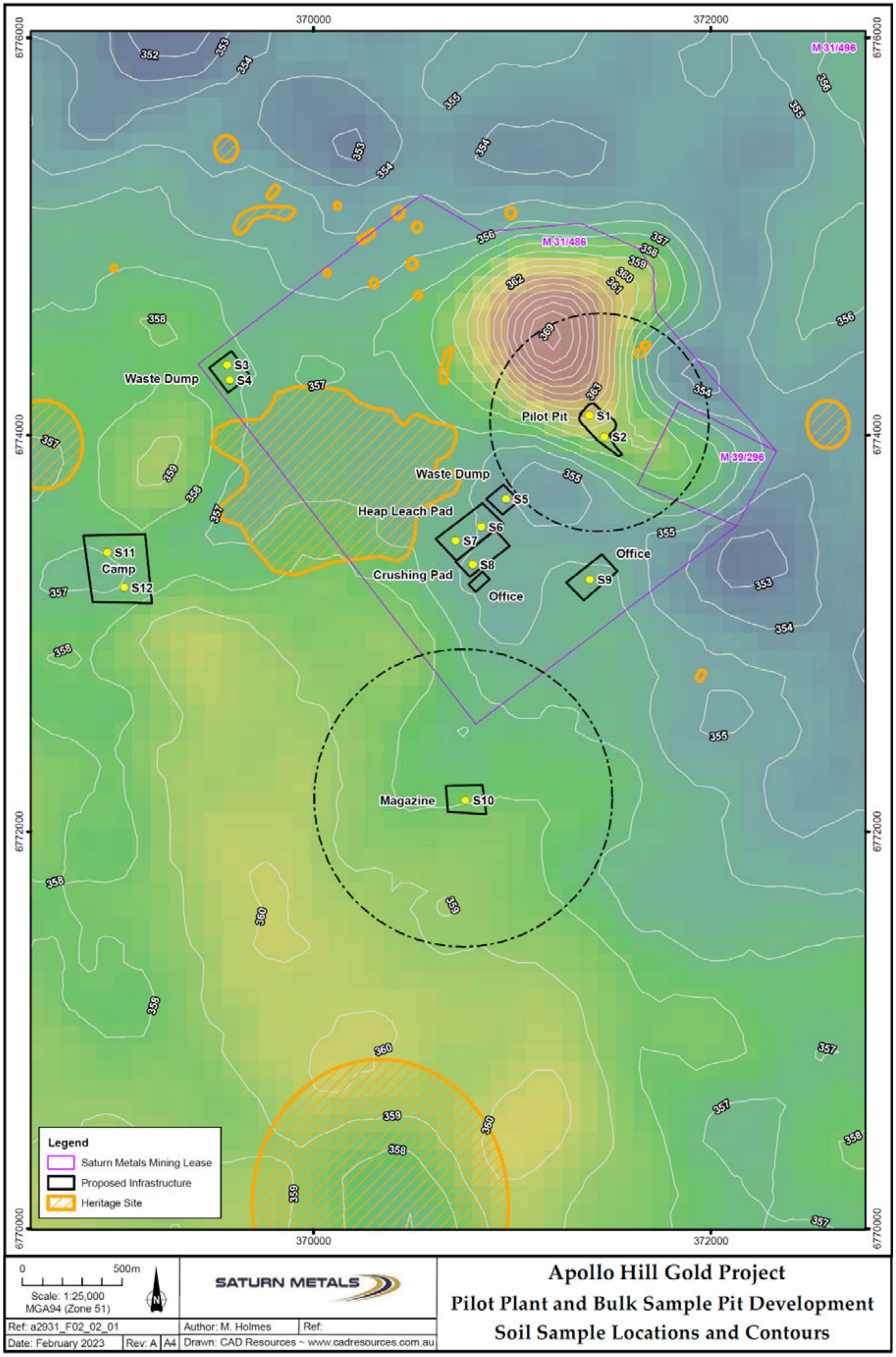

Figure 3: Site Layout Plan, displaying soil sampling locations (on topographic contours map)

Figure 4: Distribution of Wiluna Hardpan Land System, showing the Study Areas of Bettenay and Churchward (1979)

Figure 5: S1 soil sampling location – Pit (north-west end), looking north direction on rocky rise of Apollo hills

Figure 6: S2 soil sampling location – Pit (south-east end), looking north direction on rocky rise of Apollo hills

Figure 7: S3 soil sampling location – WRD1 (north end), looking north direction on flat wash plain

Figure 8: S4 soil sampling location – WRD1 (south end), looking north direction on flat wash plain

Figure 9: S5 soil sampling location – WRD2, looking north direction on flat wash plain

Figure 10: S6 soil sampling location – Heap Leach Pad (north-east end), looking north direction on flat wash plain

Figure 11: S7 soil sampling location – Heap Leach Pad (south-west end), looking north direction on flat wash plain

Figure 12: S8 soil sampling location – Crushing Pad, looking north direction on flat wash plain

Figure 13: S9 soil sampling location – Office Admin, looking north direction on flat wash plain


Figure 14: S10 soil sampling location – Magazine, looking north direction on flat wash plain

Figure 15: S11 soil sampling location – Camp (north end), looking north direction on flat wash plain

Figure 16: S12 soil sampling location – Camp (south end), looking north direction on flat wash plain