“COMMERCIAL IN CONFIDENCE”

Huntly Common

Preliminary Environmental Site Assessment

Huntly Streamside Reserve, Victoria

3 December 2020

58207 - 131,111 - Rev0

JBS&G Australia Pty Ltd

www.jbsg.com.au

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Abbreviations

Term	Definition
ADWG	Australian Drinking Water Guidelines
ANZECC	Australian and New Zealand Environment Conservation Council
ANZG	Australian and New Zealand Guidelines
ASC NEPC	National Environment Protection (Assessment of Site Contamination) Measure 1999 (NEPM) (as amended 2013). National Environment Protection Council
ASC NEPM	National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013
ASLP	Australian standard leaching procedure
ASS	Acid sulphate soils
COC	Chain of custody
COPC	Contaminants of potential concern
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DBYD	Dial before you dig
DELWP	Department of Environment, Land, Water and Planning
DGV	Default guideline values
DS	Downstream
EC	Electrical conductivity
EIL	Ecological investigation levels
EPA	Environment protection authority
EPBC	Environment Protection and Biodiversity Conservation Act 1999
ESA	Environmental site assessment
EVCs	Ecological vegetation communities
FFG	Flora and Fauna Guarantee Act 1988
GDE	Groundwater dependent ecosystem
GPS	Global positioning system
HIL	Health-based Investigation Levels
JRA	Job risk analysis
LOR	Limits of reporting
mAHD	Metres Australian Height Datum
mBGL	Metres below ground level
MS	Midstream
NATA	National Association of Testing Authorities
NHMRC	National Health and Medical Research Council
NTU	Nephelometric turbidity unit
OH&S	Occupational Health and Safety
PID	Photo-ionisation detector
Ppm	Parts per million
QA/QC	Quality Assurance and Quality Control
SEPP Land	The State Environment Protection Policy - Prevention and Management of Contamination of Land 2002 (VIC)
SEPP Waters	2018 Waters of Victoria State Environmental Protection Policy
SWMS	Safe work method statements
TDS	Total dissolved solids
TOC	Total organic carbon
TOC	Total organic carbon
TP	Test pit
TSS	Total suspended solids
UCL	Upper confidence level
US	Upstream
USCS	Unified soil classification system
VOC	Volatile organic compounds
VVG	Visualising Victoria's groundwater

Executive Summary

JBS&G was engaged Huntly Common to undertake a preliminary environmental site assessment (ESA) comprising soil, sediment and water sampling at the Huntly Streamside Reserve, Huntly, Victoria. Subject to the limitations presented in **Section 9**, the key findings from the Preliminary ESA are as follows:

- Based on the results from the investigative works undertaken and exceedances of the adopted screening level assessment criteria, the tailings material in the Huntly Streamside Reserve poses a potential risk to the surrounding environment and human health, particularly with respect to arsenic and, to a lesser extent, mercury.
- There is a slight potential that the tailings material may be impacting the underlying natural material, based on the detected levels of arsenic in the underlying natural material and the leachability of arsenic in the tailings material. The level of arsenic in the natural soil may, however, reflect the naturally elevated concentrations in the region.
- The potential for mobilisation of arsenic during reclamation operations will require suitable control measures to protect the environment and human health, given:
  - the identified leachability of arsenic in soils tested
  - the correlation of higher arsenic concentrations to smaller, more erodible particle size fractions.
- Removing and appropriately managing the arsenic present in the tailings should reduce the current and future potential risks to human health and the environment, post-completion of the proposed project.

The site is an artificial landform created from the deposition of sediment derived from historic mining activity in the Bendigo area, including tailings. Huntly Common, based upon the results from previous assessments, identified that an appreciable quantity of gold is expected to be readily recoverable from the tailings material utilising elementary metallurgical techniques.

Whilst an economic incentive to reprocess the tailings is acknowledged, there is also the potential that the removal of the tailings material will also result in a net environmental gain through reduction of possible risks to human health and the environment.

To understand the current baseline environmental condition of the site and assess the potential impact of the proposed project, JBS&G, on behalf of Huntly Common, undertook the sampling program described in this document to collect soil, sediment and surface water data.

Soil data from eight test pits, data from three surface water samples and three sediment samples were compared to applicable criteria. It was found that:

- Soils contained the highest concentrations of the six identified contaminants of potential concern (COPC) of arsenic, chromium (III), copper, mercury, nickel and zinc.
- Arsenic was identified as the primary contaminant of concern as it was the only contaminant present in soil, sediment and surface water.
- Arsenic is potentially leachable from the soil but does not appear to have significantly leached into the underlying natural soil (based on limited data). There is some evidence that arsenic may be leaching into surface water but levels only marginally exceed the criteria for protection of freshwater species.
- There is no correlation between arsenic levels and location or tailings depth. This suggests arsenic is distributed fairly uniformly through the tailings.

- Arsenic appears to be preferentially associated with the smaller particle sizes.
- Mercury is also present at elevated levels in the tailings but does not appear to be in a mobile form as it was not detected in surface water (but this needs further consideration).
- There is potential that chromium (III) (found to be non-leachable), copper, nickel and zinc are reflective of background concentrations.

1. Introduction

JBS&G Australia Pty Ltd (JBS&G) were engaged by Huntly Common Pty Ltd (Huntly Common) to undertake a Preliminary ESA comprising soil, sediment and water sampling at the Huntly Streamside Reserve, Huntly, Victoria (the 'site'), see **Figure 1**.

1.1 Background

The site comprises most of the Huntly Streamside Reserve and is on Crown Land in Huntly, Victoria, located approximately 120 km north-east of Melbourne (see **Figure 1**).

The site is an artificial landform created from the deposition of sediment derived from historic mining activity in the Bendigo area. The site was the dredge deposition area from dredging undertaken upstream between 1917 and 1920 by the Bendigo Creek Trust to reclaim agricultural and urban land from the historical uncontrolled deposition of mining sludge (tailings). As result of migration of tailings downstream and the intentional deposition of tailings on-site, the original course of the Bendigo Creek (the 'Creek') has been altered and the original location is covered with up to 3 m of tailings. The average depth of tailings is estimated to be 1.8 metres below ground level (mBGL)[1], with significant undulation in tailings depth across the site. It is estimated that there is approximately 3 million m^3 of tailings present on-site.

Based on previous investigations undertaken by Huntly Common, an appreciable quantity of gold is expected to be readily recoverable from the tailings material utilising elementary metallurgical techniques. While there is an economical incentive to reprocess the tailings, there is also the potential that the removal of the tailings material will also result in a net environmental gain through reduction of possible risks to human health and the environment. Based upon JBS&G's experience at other areas with historical tailings deposits, it was anticipated that the presence of the tailings on-site may be having a detrimental environmental impact due to the elevated concentrations of arsenic and mercury, amongst other COPCs, in addition to a potential human health risk should sensitive receptors be exposed.

In the context of the above, JBS&G notes that Huntly Common holds two mining licences for the site, MIN5512 and MIN5515, which enclose a total area of 164.8 ha extending for approximately 4.2 km along Bendigo Creek between Leans Road and Millwood Road, see **Figure 2**. Huntly Common propose to reclaim the deposited tailings, re-process them offsite and then subsequently rehabilitate the Creek to its original location and natural form (collectively, the 'project').

To understand the current baseline environmental condition of the site and assess the potential impact of the proposed project, JBS&G, on behalf of Huntly Common, undertook the sampling program described in this document to collect soil, sediment and surface water data.

1.2 Objectives

The overall objective of the ESA works program was to better understand the current environmental condition of the site and assess the potential risks to human health and the environment from the existing emplaced/ deposited tailings (in the absence of the project), the potential for contaminants to be mobilised during excavation works advanced as part of the project and the likely future potential risks, post completion of the project.

To achieve the overall objective above, the following points were specifically addressed:

- The extent of potential risks posed by any existing contamination to the surrounding environment and human health, i.e. members of the public

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[1] Current surface levels.

- The potential for any site contaminants to be mobilised during excavation works as part of the project, and to identify any control measures that will be required to protect the environment and human health
- An assessment of the extent to which the surface water, the natural soil adjacent to the tailings has been impacted by leaching of contaminants from the overlying tailings and, consequently, to identify any measures that will be needed during site rehabilitation to manage this contamination
- Provide an initial appraisal of the likely future potential risks to human health and the environment, post-completion of the proposed project.

1.3 Scope of Works

To achieve the objectives outlined in **Section 1.2** above, the following scope of works was completed:

- Preparation of a Sampling Plan (**Appendix A**) for submission to the Department of Environment, Land, Water and Planning (DELWP) for approval to undertake works on Crown Land
- Liaison with DELWP and completion of Parks Victoria approval requirements
- Revision of the Sampling Plan to include specific detail regarding the sampling methodology for Huntly Common approval
- Preparation of a Job Risk Analysis (JRA)/ Safe Work Method Statements (SWMS) and undertaking Dial Before You Dig (DBYD) Searches of the site to meet relevant Occupational Health and Safety (OH&S) requirements prior to undertaking works at the site
- A soil investigation comprising an intrusive fieldworks program of eight test pit locations within the tailings material
- A sediment investigation including the collection of three sediment samples obtained from downstream, mid-stream and upstream locations
- A surface water investigation including the collection of three surface water samples, again obtained from downstream, mid-stream and upstream locations
- Submission of selected samples for laboratory analysis
- Interpretation and analysis of the field observations and laboratory results
- Documentation of findings of the above scope of works in an ESA (this document).

2. Site Description

2.1 Site Identification

A summary of the site details are presented in **Table 2.1**.

The site location is presented in **Figure 1** and site features are presented in **Figure 2**.

Table 2.1: Site Details - Huntly Streamside Reserve

Source	Description
Site Address	Huntly Streamside Reserve, Huntly, Victoria, 3551 The site is shown as a consolidated property on VicPlan under the address Leans Road Huntly 3551
Site Owner	Victorian Government
Traditional Owners	Dja Dja Wurrung
Site Manager	Parks Victoria
Current Land Use	Recreational Reserve
Proposed Land Use	Tailing Reclamation and return to Recreational Reserve
Site Area	Approximately 1.648 km^2 or 164.8 ha
Parcel details	The site is made of six parcels: Allotment 19A on Section 20 of Parish of Huntly (19A~20\PP2770) Allotment 8A on Section 17 of Parish of Huntly (8A~17\PP2770) Allotment 4F on Section 17 of Parish of Huntly (4F~17\PP2770) Allotment 4E on Section 17 of Parish of Huntly (4E~17\PP2770) Allotment 10B on Section 14 of Parish of Huntly (10B~14\PP2770) Allotment 12G on Section 16 of Parish of Huntly (2G~16\PP2770)
Land Use Zoning	Public Conservation and Resource Zone (PCRZ) Schedule to Clause 36.03 Public Conservation and Resource Zone (PCRZ)
Municipality	Greater Bendigo
Surrounding land use	Private farmland surrounding the site immediately to all directions. The Whipstick National Park is located 600 m west of the site. The Coliban Water Treatment Facility is located approximately 1 km south of Leans Road. The township of Huntly is located 1.2 km east of the site.
Overlays	Environmental Significance Overlay (ESO) Environmental Significance Overlay - Schedule 1 (ESO1) Environmental Significance Overlay - Schedule 2 (ESO2) Land Subject to Inundation Overlay (LSIO) Land Subject to Inundation Overlay - Schedule 1 (LSIO1) Land Subject to Inundation Overlay - Schedule 2 (LSIO2) Aboriginal Cultural Heritage Sensitivity Designated Bushfire Prone Areas

2.2 Current Site Condition

The site is an open recreational reserve managed by Parks Victoria. It is approximately 164.8 ha in size and has an approximately length of 4.2 km between Leans Road and Millwood Road (see **Figure 2**). It is approximately 100 m in width at the narrowest point and 550 m wide at the widest point.

The site is mainly accessed from Leans Roads and there are several unsealed and rough tracks that traverse the site. It has considerable scenic value in its current condition, due to the presence of large mature Red Gums, presence of understory tussock vegetation, open space and lush creek landscapes. The site is a popular local area used for bike riding, drone flying, four-wheel driving, horse riding and other general recreational purposes.

2.3 Environmental Setting

A summary of environmental aspects regarding the site is provided in **Table 2.2** below.

Table 2.2: Environmental Description - Huntly Streamside Reserve

Aspect	Description
Topography *VicPlan*[2] *(accessed online 15 July 2020)*	The site slopes gently down towards the north-east as elevation ranges from 180 metres Australian Height Datum (mAHD) at Leans Road and decreases to 167 mAHD at Millwood Road. The site is slightly elevated above the surrounding plain, especially to the east. There is minimal overall east to west topographical pattern as the site is relatively flat. There is a high levee which has been constructed along the eastern margin of site to protect Huntly from inundation. A smaller levee bank is present on the western side of site.
Flora *Ecology Australia (2020) Huntly Streamside Reserve - Bendigo Creek Mining Licences (MIN5515 and MIN5512) - Flora and Fauna Assessment*	The site occurs within the Victorian Riverina bioregion. There are two main Ecological Vegetation Communities (EVCs) on-site, both of which are endangered. These are EVC 68 Creekline Grassy Woodland (101.7 ha with 577 large old trees) and EVC 175_61 Low Rises Grassy Woodland (4.1 ha with 25 large old trees). The large trees are mostly comprised of Red and Yellow Box with numerous large invasive Peppercorns. The ground cover species are generally invasive species such as Bermuda buttercup (aka soursob)(*Oxalis pes-caprae*), Spiny Rush and Wild Garlic.
Fauna *Ecology Australia (2020) Huntly Streamside Reserve - Flora and Fauna Assessment*	During the ecological study, a total of 49 fauna species were recorded. These comprised 41 species of birds (all native), three species of mammal (two introduced species), two species of reptile and two species of frog and one aquatic invertebrate. Several E*nvironment Protection and Biodiversity Conservation Act 1999* (Commonwealth) (EPBC) listed species and *Flora and Fauna Guarantee Act 1988* (VIC) (FFG) listed species may be present on-site.
Surface Water *Visualising Victoria's Groundwater (VVG) (accessed online 15 July 2020)*	There are two surface water receptors present on-site, these are the Bendigo Creek (the 'creek') which runs along the western margin of site and an effluent channel (the 'channel') from the Coliban Water Treatment Facility. The creek and channel merge at a point approximately 2.75 km north of Leans Road. Three Waterwatch monitoring locations are situated along the Bendigo Creek within the site at upstream, midstream and downstream locations. Downstream water quality measured on 26 March 2020 was 954 electrical conductivity (EC) µS/cm, 7.5 pH and turbidity of 10.74 nephelometric turbidity units (NTU). Midstream measurements on 30 March 2020 were 1120 EC µS/cm, 7.5 pH and turbidity of 17 NTU. Upstream measurements on 05 March 2019 were 1082 EC µS/cm, 7.6 pH and turbidity of 0 NTU.
Geology *Geological Survey of Victoria (2001) 1:50,000 Huntly Geological Map Sheet 7724-1 Zone 55*	The site is situated on a shallow Pliocene to Quaternary aged non-marine sedimentary prior stream deposits and minor alluvium of the Shepparton Formation. These deposits are situated in the low-lying floodplains surrounding the several water features including Bendigo Creek, Eaglehawk Creek, Sandy Creek and Reedy Creek. These deposits are characterised by fine to coarse-grained sand/ sandstone with quartz, mica, feldspar and ironstone inclusions with well to poorly sorted variably consolidated quartz gravel/ conglomerate. The stream deposits are underlain by Lancefieldian aged sedimentary sediments of the Castlemaine Group. These are comprised of deep-marine turbidites and hemipelagic sediments of sandstone, mudstone, black shale and minor granule quartz conglomerate. The site is immediately underlain by recent shallow tailings deposits (anthropogenic).
Hydrogeology *Visualising Victoria's Groundwater (accessed online 15 July 2020)* *DELWP Groundwater Resource Report (***Appendix B***)*	Site groundwater is anticipated to occur between 0 and 5 mBGL within an Upper Tertiary/ Quaternary aquifer that extends to approximately 7 m BGL. Regional and local groundwater flows are expected to flow in a north-easterly direction and is within the Campaspe groundwater catchment. Groundwater salinity is indicated to range from 1001 to 3500 mg/L (segment A2, B and C under the 2018 Waters of Victoria State Environmental Protection Policy (SEPP)) within the shallow watertable. There arenine bores within 2 km of the site which range from 3.8 m to 81 m in depth. One bore was registered for stock and domestic use, five for minerals - gold and the remaining two for unknown purposes.` There is a high potential that the Bendigo Creek is a Groundwater Dependent Ecosystem (GDE) according to the GDE National Atlas dataset accessed through VVG. The Bendigo Creek supports an ecosystem that is reliant on the surface expression of groundwater.
Acid Sulphate Soils *Australian Soil Resource Information System*[3] *(accessed online 15 July 2020)*	A search of the CSIRO Australian Soil Resource Information System revealed that the site has a low probability of occurrence of Acid Sulphate Soils (ASS).

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[2] VicPlan (2020) Retrieved from https://mapshare.vic.gov.au/vicplan/ accessed 15 July 2020.

[3] Australian Soil Resource Information System (2020) Retrieved from http://www.asris.csiro.au/mapping/viewer.htm accessed 15 July 2020.

2.4 Area History

The discovery of alluvial gold nuggets in the 1850s initiated the Victorian Goldrush. This saw significant migration to the Victorian goldfields that spread from Stawell, Ararat, Ballarat, Maldon, Castlemaine and Bendigo. In Bendigo, alluvial mining was a major activity along the Bendigo Creek. "Puddlers" were used to process gold-bearing clay, where gold would sink to the bottom of the puddler and surface sludge, containing soils and other unwanted residue, was discarded by being washed into nearby watercourses.

At its peak, it is estimated there were up to 2,000 puddling machines within the Sandhurst district (Bendigo). Gullies and creeks were soon filled up, and sludge from Bendigo Creek was found almost 100 miles from its source (Lovell Chen, 2013).

Between 1900 and 1906, dredging of approximately 50 million cubic yards of material (approximately 38 million m^3) from Bendigo Creek occurred (Lovell Chen, 2013), where excavated sediment was deposited along the floodplain, providing a continuing source of sediment following flood events (Grove, et al., 2019).

In 1915, the creek was further modified by the Bendigo Creek Improvement Trust who worked to straighten the creek to control water supply and protect surrounding properties. This was done through grading of floodplains and construction of levee banks, which occurred between Epsom and Huntly (Lovell Chen, 2013).

As a result of historic gold puddling activities, attempts to drain sludge with box drains, dredging, and the grading and straightening of the Bendigo Creek, the site at Huntly Streamside Reserve has been highly modified from its original state, and the natural course of the Bendigo Creek through the site has been significantly altered.

2.4.1 Background Concentrations of Arsenic

Elevated levels of arsenic are associated with gold mineralisation and gold mining activities and known to be present within the Bendigo region. Due to the known presence of mine tailings on-site, elevated levels of arsenic were expected, and the associated levels are determined by the original concentration in the parent ore material. As the material has been deposited from downstream and has naturally washed downstream, the location of the original ore material was assumed to be the Bendigo area.

Arsenic is a metalloid and known human carcinogen, with human epidemiological studies having shown skin and internal cancers associated with chronic exposures to arsenic in drinking water. Elevated levels of arsenic have also been found in biota, such as fish, where arsenic levels are high in river sediments (EPA, 2017).

Elevated concentrations of arsenic in the Bendigo region are associated with historical gold mining activities, which released arsenic from gold bearing ores. Across the Victorian goldfields, historical tailings dumps and overburden containing elevated arsenic have been linked to the contamination of the surrounding soils and waterways (EPA, 2017).

The average arsenic concentration in the Earth's crust is around 2 mg/kg, while the world soil average concentration is 6-7 mg/kg (Sultan, 2006). Background soil arsenic levels in the Victorian Goldfields are much higher than the rest of Australia and the World.

Work undertaken by Sultan (2006), in Ballarat, Creswick and Maldon, found concentrations of arsenic in soil between 1.5 to 3,618 mg/kg, sampled in state forest, farmland and mined affected areas. Approximately 98% of soils sampled had arsenic values above the world average, and 28% of soils had arsenic levels of 30 mg/kg, which is close to the background arsenic soil concentration observed in Central Victoria (Sultan, 2006).

In a natural environment, arsenic concentrations in soil are expected to occur below 50 mg/kg, with a mean concentration of approximately 5-6 mg/kg (Smith, et al., 2003). However, arsenic concentrations in former mine waste disposal areas can range from 280 to 15,000 mg/kg, and data collected from sediments of catchments close to historical mining have recorded concentrations up to 1,159 mg/kg (Smith, et al., 2003).

In Central Victoria, areas affected by mining activities recorded arsenic concentrations in excess of 1000 mg/kg in topsoils (0-10 cm), with more than 51% of soil samples recorded above 500 mg/kg (Sultan, 2006). In Bendigo and Golden Square, soil arsenic concentrations have been recorded between <5-16,800 mg/kg (Hindwood, Bannister, Shugg, & Sim, 1998). The variable concentration range for arsenic found in most studies indicates there are hotspots of contamination, attributed to historical mining activities.

Several Environmental Audits completed under the *Environment Protection Act* 1970 (VIC) undertaken nearby the site, have recorded elevated arsenic soil concentrations, as outlined in **Table 2.3** below.

Table 2.3: Reported Soil Arsenic Concentrations from Surrounding Audits

Audit Address	Proximity to Site	Arsenic Concentration Range (mg/kg)	Year	Comments	Audit Report
68 Pasley Street and 580 Midland Highway, Huntly, Vic	1.5 km east	**<5 to 1,100**	2020	Arsenic was detected in mining sands from former mining shaft	(Prensa, 2020)
CA8 Ironstone Road, Ascot, Vic	3 km south east	**22-330**	2005	The levels of arsenic are considered to be natural for the area	(Environmental & Earth Sciences, 2005)
99-111 Station Street, Epsom, Vic	3.6 km south east	**6-380**	2006-2009	70 samples	(Noel Arnold & Associates, 2009)
Woodvale Evaporation Ponds Complex	7.2 km west	**6-5,200**	2015	80 soil/sediment samples. Background concentrations were reported as 9.1-12 mg/kg	(Senversa, 2015)

A review of the surrounding Audits indicates that arsenic soil concentrations in the region are variable.

Arsenic is also noted to be dissolved in both surface and groundwater. In 1998, the recorded concentrations of arsenic in Bendigo ranged from 0.01-2.83 mg/L in surface water, and 0.02-12 mg/L in groundwater (Hindwood, Bannister, Shugg, & Sim, 1998).

A study of dissolved arsenic in the Ballarat, Creswick and Maldon areas recorded surface water concentrations between 0.0041-11.54 mg/L, with about half of samples recorded as less than 0.01 mg/L (Sultan, 2006). Under alkaline and oxidative conditions the concentration of dissolved arsenic was low (average 0.0079 mg/L), as the release of arsenic to water is slowed, and soil retention increased, under alkaline oxidising conditions (Sultan, 2006).

2.1 Contaminants of Potential Concern (COPCs)

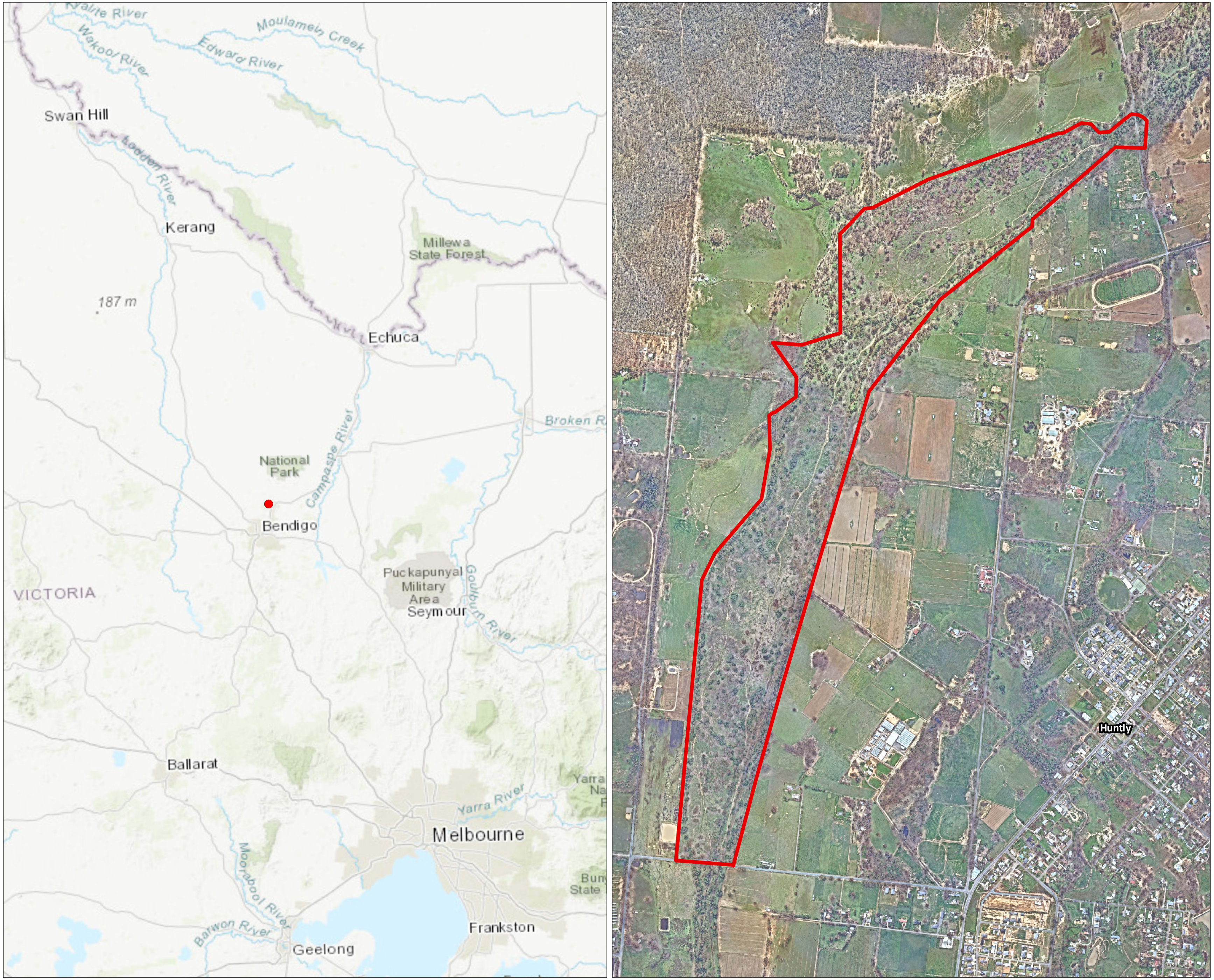
While arsenic is an indicator of potential contamination, there are also other heavy metals associated with arsenic and more broadly, historical mining, which may be present in the environment of the Bendigo region (Sultan, 2006). These include:

- **Zinc**: an essential plant nutrient in trace amounts, but toxic at high concentrations.
- **Lead**: no known biological function and can cause chronic health effects.

- **Copper**: an essential element in the normal metabolism of animals and plants.
- **Nickel**: toxic in plants containing more than 100 mg/kg.
- **Chromium**: Found in the environment as Cr(III) and Cr(VI), with Cr(III) being less toxic and more abundant. Chromium is an essential trace element in animals.
- **Selenium**: an essential nutrient for animals in trace amounts. Concentrations higher than 5 mg/kg in food causes disease in humans.
- **Cadmium**: occurs naturally in phosphate rocks and is introduced into soil through the use of fertilisers. Biologically it has no benefits, and regular consumption of plants at concentrations higher than 3 mg/kg can accumulate in the organs, causing adverse health effects (Sultan, 2006).
- **Mercury**: highly toxic in freshwater environments and capable of bioaccumulation in fish, microalgae, sediment-dwelling invertebrates, and humans. Historically used in gold mining to amalgamate small particles of gold, but entered waterways as tailings sludge and other mining debris (Davies, Lawrence, & Turnbull, 2015)

Heavy metals which have been recorded at elevated concentrations in the area and mining surrounds include:

- Copper- 160 mg/kg (Prensa, 2020)
- Zinc- 5,490 mg/kg (Prensa, 2020)
- Mercury- 4.1 mg/kg (Environmental & Earth Sciences, 2005)
- Nickel- 79 mg/kg (Environmental & Earth Sciences, 2005)
- Lead- 546 mg/kg (Noel Arnold & Associates, 2009).



Legend:

🟥 Site Boundary

● Site Location

JBS&G

Job No: 58207

Client: Huntly Common

Version: RevB	Date: 05-Aug-2020
Drawn By: SW	Checked By: AT

Scale at A4 1:25,000

0 400 800

metres

Coor. Sys. GDA 1994 MGA Zone 55

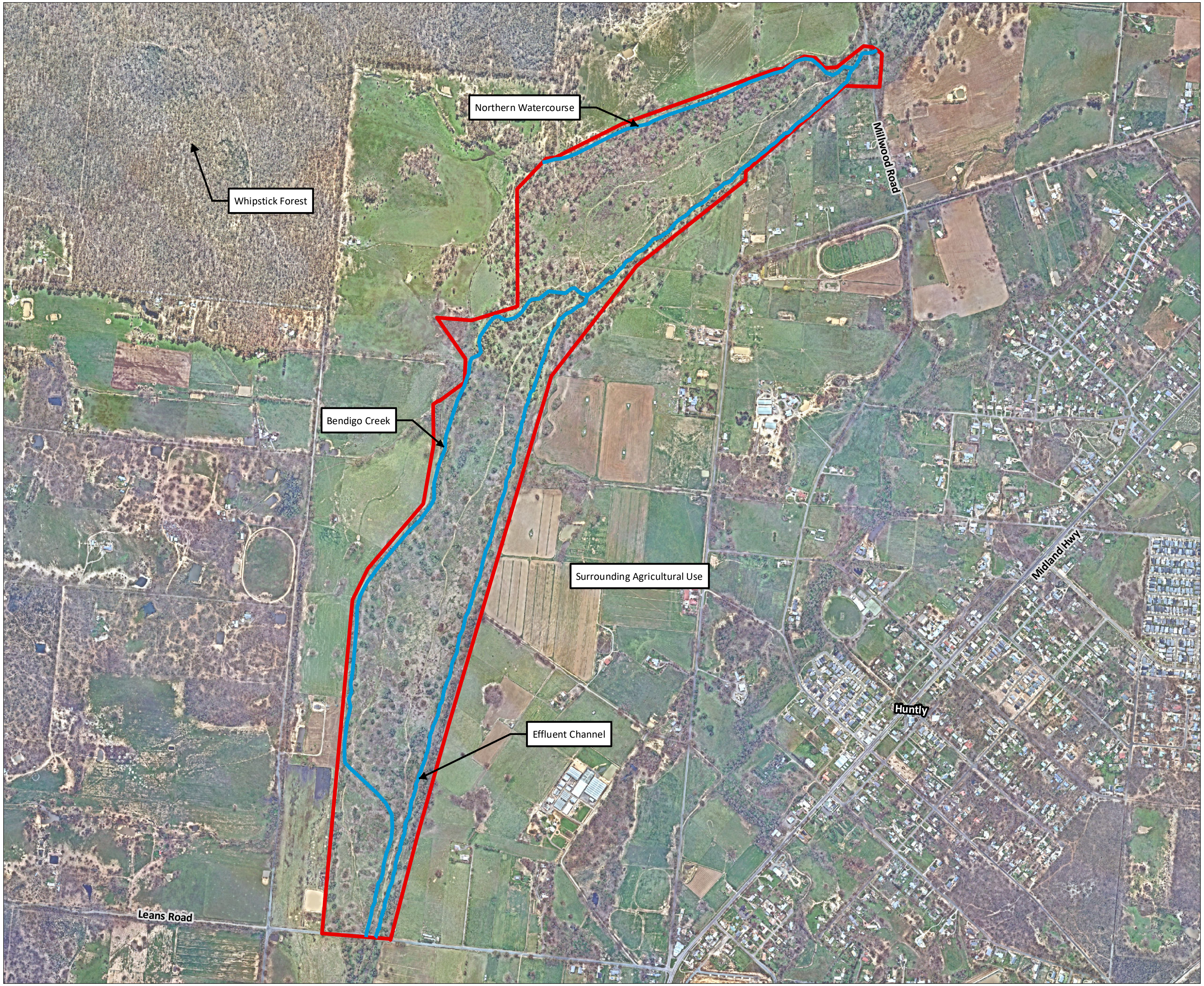
Huntly Streamside Reserve, Leans Road Huntly, Victoria

SITE LOCATION

FIGURE 1

Document Path: V:\05 Projects\Huntly Common\58207 Huntly Work Plan - Bendigo Gold\8 - ArcGIS\01_MXD\04_Contam_Study\01_58207_Site_Location_RevB_2020_08_05.mxd

Image Reference: www.nearmap.com© - Imagery Date: 6 May 2020 & Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community



Legend:

- 🟥 Site Boundary
- ▬ Watercourse

JBS&G

Job No: 58207	
Client: Huntly Common	
Version: RevB	Date: 10-Aug-2020
Drawn By: SW	Checked By: AT
Scale at A4 1:22,000	

0 300 600
metres

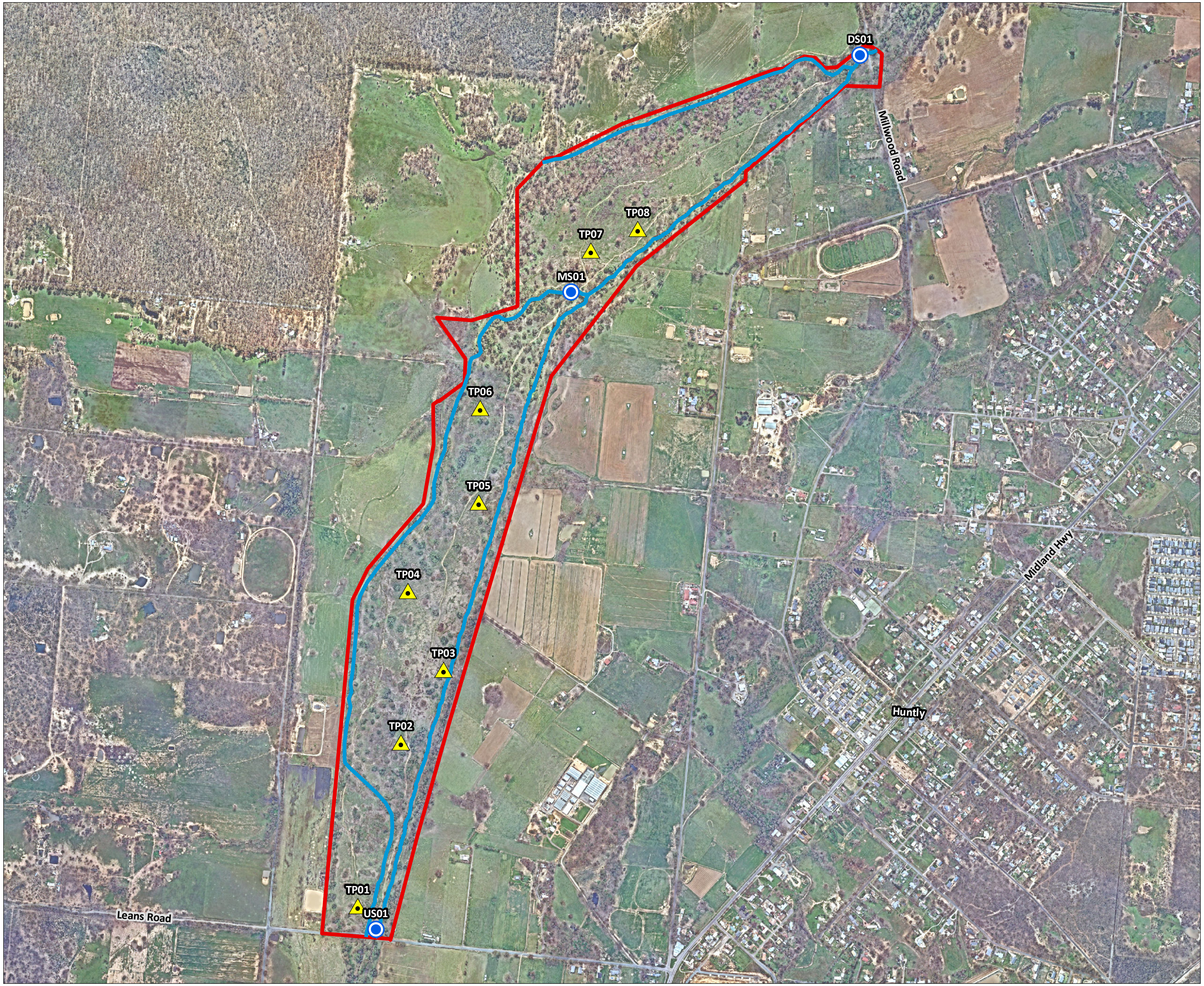
Coor. Sys. GDA 1994 MGA Zone 55

Huntly Streamside Reserve, Leans Road
Huntly, Victoria

SITE FEATURES

FIGURE 2

Document Path: V:\05 Projects\Huntly Common\58207 Huntly Work Plan - Bendigo Gold\8 - ArcGIS\01_MXD\04_Contam_Study\02_58207_Site_Features_RevB_2020_08_10.mxd
Image Reference: www.nearmap.com© - Imagery Date: 6 May 2020



Legend:

- ▭ Site Boundary
- — Watercourse
- ▲ Test Pit
- ● Surface Water & Sediment Sample

JBS&G

Job No: 58207	
Client: Huntly Common	
Version: RevB	Date: 10-Aug-2020
Drawn By: SW	Checked By: AT
Scale at A4 1:22,000	

0 300 600
metres

Coor. Sys. GDA 1994 MGA Zone 55

Huntly Streamside Reserve, Leans Road
Huntly, Victoria

SAMPLE LOCATIONS

FIGURE 3

Document Path: V:\05 Projects\Huntly Common\58207 Huntly Work Plan - Bendigo Gold\8 - ArcGIS\01_MXD\04_Contam_Study\03_58207_Sample_Locations_RevB_2020_08_10.mxd
Image Reference: www.nearmap.com© - Imagery Date: 6 May 2020

3. Soil Assessment

As discussed in **Section 1.3**, a limited soil assessment was undertaken comprising the advancement of a total of eight test pit locations (via excavator) across the site. Regulatory guidance, investigation methodologies, analytical schedules, screening criteria and results are discussed in the following sections.

3.1 Regulatory Guidance

Works conducted for the soil assessment were undertaken with consideration of the following documents:

- *National Environment Protection (Assessment of Site Contamination) Measure 1999 (NEPM) (as amended 2013).* National Environment Protection Council (ASC NEPC 1999)
- *Standards Australia (2005) Guide to the Sampling and Investigation of Potentially Contaminated Soil Part 1: Non-Volatile and Semi-Volatile Compounds. AS4482.1-2005*
- *Standards Australia (2005) Guide to the Sampling and Investigation of Potentially* Contaminated Soil Part 2: Volatile Compounds. AS4482.2-1999.

3.2 Soil Investigation Methodology

A total of eight test pits were advanced across the site to a maximum depth of 3.0 mBGL supervised by two JBS&G field scientists on 8 July 2020[4].

The locations of the test pits were selected to gain a representative north to south spread of the soil profile. In addition, the east to west location of the test pits were selected to gain a representative spread of the tailings depth laterally across site.

Test pit sampling locations are shown on **Figure 3**.

The following sampling methodology was undertaken for the assessment of site soils:

- Development of a JBS&G prepared site-specific JRA/SWMS
- The Sampling Plan was input into the ArcGIS Collector App to track and record the GPS coordinates of each test pit while on-site. The location of some test pits were altered slightly from the Sampling Plan to avoid vegetation and tree roots
- All test pit locations were assessed for underground services by review of DBYD plans, prior to excavation
- Test pits were then advanced mechanically (via 4-tonne excavator) to a maximum depth of 3.0 mBGL
- The soils encountered were logged in general accordance with the Unified Soil Classification System (USCS). The materials encountered were logged and photographed by a field scientist wearing fresh disposable nitrile gloves at the time of sampling. A photograph log is provided in **Appendix C**. Test pit logs are presented in **Appendix D**
- Samples were placed directly into Teflon sealed sample jars provided by the laboratory, with zero headspace. Samples were labelled with a unique identifier, date and sampler. Sample containers were then placed in a pre-cooled insulated box for sample preservation prior to and during shipment to the testing laboratory

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[4] Whilst JBS&G had originally aimed to complete up to 10 test pit locations, only 8 were able to be completed during the fieldworks program due to both timing and light constraints.

- Three bulk samples were collected at three test pits for fractionation by particle size. The bulk samples included material from all points of the soil profile and were homogenised to ensure a representative sample of the soil profile
- A duplicate soil sample was collected at each sample location interval for field screening of potential volatile contaminants using a photo-ionisation detector (PID). The PID was calibrated using isobutylene to 100 parts per million (ppm) prior to use. Soil sample details and PID measurements are included in the test pit logs presented in **Appendix D**
- Collected samples were transported under standard JBS&G chain-of-custody (COC) protocols within specified holding times for relevant analytes to National Association of Testing Authorities (NATA) accredited laboratories for the required analyses (as discussed in **Section 3.3**).

3.3 Soil Analytical Program

Selected soil samples were submitted to NATA accredited laboratories for COPCs which were identified during the historical desktop review and via field observations.

Selected samples were analysed in accordance with the analytical schedule presented in **Table 3.1.**

Table 3.1: Selected Laboratory Analysis

Sample Type	No. of Sampling Locations	Analyses
Soil	8 test pits	pH and extended heavy metal suite (M32) – 9 primary samples, 3 bulk samples split into three particle sizes These samples represent the following layers of the soil profile: • Damp brown coarse silty sand x 2 • Lighter coarse silty sand x 2 • Very fine and soft sandy silt x 2 • Natural orange sandy silt with clay inclusions x 3. Australian Standard Leaching Procedure (ASLP) Leachability Testing for As: • TP07(<100 um) • TP07(100-250 um) • TP07(>250 um) • TP03 – 0.4 • TP02 – 2.4 • TP02-3.0 • TP04-2.1 Chromium speciation and ASLP Leachability Testing: • TP08-0.7 • TP05(<100 um) • TP05(100-250 um) • TP05(>250 um) Total Organic Carbon (TOC) analysis: • TP08-0.7 • TP03-0.4 • TP06-0.5 • TP07(<100 um) • TP07(100-250 um) • TP07(>250 um) • TP05(<100 um) • TP05(100-250 um) • TP05(>250 um)

Notes: The M32 Extended Metals Suite includes: aluminium, antimony, arsenic, barium, beryllium, bismuth, boron, cadmium, calcium, chromium, cobalt, copper, iron, potassium, mercury, magnesium, manganese, molybdenum, nickel, lead, phosphorus, selenium, silicon, silver, sodium, sulphur, tin, thallium, titanium, uranium, vanadium and zinc.

3.4 Assessment Criteria

The intention of this Preliminary ESA was not to classify the material on the site, nor assess the nature and extent of identified impacts. Rather the scope of the works undertaken was intended to provide an initial understanding of the condition of the existing environment and to provide initial insights into potential sources of identified contamination that the proposed project may assist in remediating/ mitigating, in addition to the potential for contaminant mobilisation during the reprocessing of the tailings. Therefore, a varied approach was adopted to understand the material on-site. Instead of using criteria to “classify” material, the closest relevant assessment criteria were selected to evaluate the potential risks to human health and the environment associated with the current and proposed future works/ land-uses.

In the context of the above, the adopted approach to consider the results from the testing of soil samples collected from the site generally utilised the risk-based framework presented in the *National Environment Protection (Assessment of Site Contamination) Measure 1999*, as amended May 2013 (ASC NEPM), to identify COPCs through application of initial screening level criteria. Any potential exceedances of adopted screening level criteria does not necessarily mean that the potential risks to human health and/ or the environment are unacceptable, rather that further consideration is required. This is described further in **Section 3.4.1** below.

3.4.1 Adopted Soil Assessment Criteria

The State Environment Protection Policy - Prevention and Management of Contamination of Land 2002 (VIC) (Land SEPP) applies to the management of soil contamination issues in Victoria. The goal of this policy is:

> *“To maintain and where appropriate and practicable improve the condition of the land environment sufficient to protect current and future beneficial uses of land throughout Victoria”.*

Indicators and objectives for protection of beneficial uses of land are set out in the Land SEPP which applies to the management of soil contamination issues in Victoria.

Beneficial uses of the land environment required to be protected for specified land uses, defined in the Land SEPP, are as indicated in **Table 3.2** below.

Table 3.2: Protected Beneficial Use of the Land Environment

Beneficial Uses	Land Use						
	Parks & Reserves	Agricultural	Sensitive Use		Recreation/ Open Space	Commercial	Industrial
			High Density	Other			
Maintenance of ecosystems – natural ecosystems	✓						
Maintenance of ecosystems – modified ecosystems	✓	✓		✓	✓		
Maintenance of ecosystems – highly modified ecosystems		✓	✓	✓	✓	✓	✓
Human health	✓	✓	✓	✓	✓	✓	✓
Buildings and structures	✓	✓	✓	✓	✓	✓	✓
Aesthetics	✓		✓	✓	✓	✓	

Beneficial Uses	Land Use						
	Parks & Reserves	Agricultural	Sensitive Use		Recreation/ Open Space	Commercial	Industrial
			High Density	Other			
Production of food, flora & fibre	✓	✓		✓	▨		

Notes: Reproduced from Table 1 of Land SEPP.
✓ Indicates land use to be protected for the nominated beneficial use.
Grey shading denotes beneficial use to be protected applicable to the proposed land use setting.

The site is currently open space land-use and the project objective is to restore the landscape, noting for a period of time it will be utilised for commercial/ industrial purposes for the reclamation/ reprocessing of tailings material. It was considered appropriate to adopt screening level criteria for the protection of beneficial uses related to recreation/ open land-use as this represents a conservative approach to beneficial use protection, given it is currently realised (as noted in **Section 2.2**).

Given a recreation/ open space land-use, the following beneficial uses of land are considered to require protection and as such the relevant screening criteria have been adopted:

- Maintenance of Modified Ecosystems;
- Maintenance of Highly Modified Ecosystems;
- Human Health;
- Building and Structures; and
- Aesthetics.

JBS&G notes that the beneficial use of Buildings and Structures is not considered applicable to the proposed project, as no buildings and structures are proposed on-site. As such, this beneficial use is not considered further in this document.

A description of the applicable criteria selected to assess the beneficial uses is provided below for reference purposes.

Schedule B1 of the ASC NEPM provides guidelines regarding investigation levels for soil. Investigation levels are based on generic land uses that are described in Schedule B7 of the ASC NEPM. Based on the land-use of the site, the site falls within the “recreational/ open space” exposure setting C – and hence Health-based Investigation Levels (HIL C) are applicable. This is also consistent with the land use under the Land SEPP. Therefore, the HIL C screening level criteria have been adopted as a conservative criteria to assess the potential risks to the protected beneficial use of “Human Health” by site conditions.

To evaluate the possible extent that ecosystem function may be impacted, the ASC NEPM General Ecological Investigation Levels (EIL) for Areas of Ecological Significance criteria were adopted for assessment of the potential risks to the protected beneficial uses of maintenance of modified and highly modified ecosystems.

With respect to the beneficial use of “aesthetics”, the Land SEPP states that the indicators include: *“Any chemical substance or waste that may be offensive to the senses”*, with the objectives that *“Contamination must not the land to be offensive to the senses of human beings”*.

The two criteria described above, HIL C and EIL were applied to the laboratory results. The outcomes of these are described further in **Section 3.5.2** below.

3.5 Soil Results

3.5.1 Field Observations

The surface conditions were fairly consistent throughout the eight test pits. The surface was low-lying grass underlain by a shallow organic layer, damp brown coarse silty sand, lighter coarse silty sand, very fine and soft sandy silt and then natural orange sandy silt with clay inclusions.

The typical stratigraphic profile encountered during intrusive investigations at the site is summarised in **Table 3.3** below.

Table 3.3: Generalised On-site Soil Profile

Approximate Depth (m BGL)	Description
0 to 0.1 m (depth is variable across the site)	Shallow organic layer, damp rich brown clayey silt
0.1 m to 0.8 m (depth is variable across the site)	Damp brown coarse silty sand with variable clay content, moderate plasticity, soft and loose with clayey clumps
0.8 m to 1.6 m (depth is variable across the site)	Lighter brown coarse silty sand of low plasticity, soft and loose
1.6 m to 2.0 m (depth is variable across the site)	Non-plastic, very fine and very soft dry light brown/ yellow sandy silt The southern test pits also included a 400 mm band of gravel at approximately 1.8 – 2.2 mBGL
Depth to top of natural varied 0.7- 3.0 m	Natural material included a 5cm layer of darker silt with the underlying natural material comprising orange/ red sandy silt with mottled clayey clumps

A photograph log is provided in **Appendix C**. A copy of the test pit logs from the soil assessment is provided in **Appendix D.**

3.5.1.1 Field Screening

During soil investigation works, soil samples were routinely inspected in the field for the potential presence of visible contamination and potential odours. Soil samples were also screened in the field for potential volatile organic compounds (VOCs) using a PID.

PID readings were all 0 ppm, which indicated that it is unlikely that VOCs were present in the soils tested.

JBS&G notes that the PID was calibrated prior to the commencement of sampling with 100 ppm isobutylene calibration gas, as per standard operating procedures.

The PID readings, together with other field observations, are included in the test pit logs provided in **Appendix D**.

3.5.2 Soil Laboratory Results

The laboratory results were compared against the relevant criteria as discussed in **Section 3.4.1**.

Presented below is the initial results of the analysed heavy metal COPCs. Based on the results of the initial results, further investigation was undertaken by analysing the trends related to:

- Particle size
- Leachability
- Correlation with Total Organic Carbon (TOC) concentrations.

Laboratory transcripts and CoC forms are presented in **Appendix E**. All results have been tabulated against the adopted assessment criteria for a recreation/ open space land-use and are presented in appended **Summary Table 1** at the end of this report. Results of the 18 samples including primary soil samples and three bulk samples split into three particle size groups are described below.

Following evaluation of the analytical dataset, JBS&G identified that six metals reported elevated concentrations. These were: arsenic, chromium (III + IV), copper, mercury, nickel and zinc. For each of these six analytes, as well as other analytes with results but no criteria, summary statics and the criteria exceeded are provided in **Table 3.4** below. The calculated 95% Upper Confidence Level (UCL) is provided to demonstrate with 95% confidence that the average contaminant concentration of the soil represented by the dataset is at or below the concentration stated. The statistical significance of the data was assessed using ProUCL software to calculate 95% UCL values, consistent with Environment Protection Authority Victoria (EPA) guidelines. The data provided below is based on statistical analysis of the 18 soil and bulk soil samples. The number of the 18 samples that exceeded each of the adopted screening level criteria is also provided in **Table 3.4**.

Table 3.4: Summary of Soil Results

Analyte	Unit	Criteria Exceeded	HIL C Limit	EIL Limit	Statistics			
					Min	Average	Max	95% UCL
Aluminium	mg/kg	No criteria	-	-	1,800	5,222	13,000	6,465
Arsenic	mg/kg	HIL C (**7**/18) EIL (**17**/18)	300	40	**32**	**342.2**	**1,100**	**463.1**
Barium	mg/kg	No criteria	-	-	17	45	120	55.9
Chromium (III+VI)	mg/kg	All elevated	300	60	**5.7**	**11.3**	**20**	**13.2**
Copper	mg/kg	EIL (**7**/18)	17,000	20	**7**	**16.4**	**29**	**19.3**
Lead	mg/kg	None	600	470	12	25.2	100	35.5
Manganese	mg/kg	None	19,000	-	37	215.5	1,100	311.2
Mercury	mg/kg	Some elevated levels recorded	80	-	**0.2**	**1.2**	**4.1**	**1.6**
Nickel	mg/kg	EIL (**18**/18)	1,200	5	**5.2**	**10.2**	**18**	**11.7**
Zinc	mg/kg	EIL (**18**/18)	30,000	15	**16**	**37.4**	**79**	**44.3**
Sulphur as S	mg/kg	No criteria	-	-	33	186.4	1,200	298.9
Calcium	mg/kg	No criteria	-	-	490	1,896	3,700	2,324
Potassium	mg/kg	No criteria	-	-	200	621.1	1,400	772.8
Magnesium	mg/kg	No criteria	-	-	800	1,872	3,500	2,187
Sodium	mg/kg	No criteria	-	-	20	112.6	580	176.2
Phosphorus	mg/kg	No criteria	-	-	82	185.5	350	217.8
pH (aqueous extract)	pH Units	No criteria	-	-	5.7	7.5	8.4	7.8
Silicon	mg/kg	No criteria	-	-	200	303.1	480	333.6
Moisture Content	%	No criteria	-	-	3.5	9.3	23	12.1

The exceedances described above are shown in **Figure 4**.

Arsenic was the main contaminant of concern as it exceeded both adopted criteria for the protection of human health (HIL C) and also ecosystem function (EIL). The reported concentrations of chromium and mercury also required further consideration as these are not expected to be naturally derived and are likely present due to historical mining activities. The other elevated results for copper, nice and zinc all exceeded EIL criteria and suggest ecosystem function may be possibly impacted, however the exceedances are not significantly above the EIL criteria. For example, the EIL criteria for copper is 20 mg/kg and the highest result was 29 mg/kg, for nickel the EIL is 5 mg/kg and the highest result was 18 mg/kg and lastly the EIL for zinc is 15 and the highest result was 79 mg/kg.

In general, the samples where arsenic exceeded HIL C criteria, also contained elevated levels of chromium, copper, mercury, nickel and zinc.

Notwithstanding the above, it is known that heavy metals are naturally present within soils. In this context, the reported concentrations of copper, nickel and zinc are not considered to be inconsistent with naturally occurring background conditions and hence were not considered further. This is not necessarily the case, however, for chromium and mercury, which are less prevalent in the naturally occurring background conditions.

Based on the range of arsenic levels at numerous depths and locations, there is no apparent correlation between depth or spatial location and reported arsenic levels. The two highest arsenic concentrations were from test pits TP02 and TP03, however these occurred at the shallowest and deepest points sampled. In addition, evidence that arsenic levels are not concentrated around the TP02 and TP03 area was that a high arsenic concentration was also identified in TP07. As will be discussed in further detail below, the presence of variably elevated concentrations of arsenic is likely related to the heterogeneous nature of the historical tailings within the creek.

Three samples of the natural material were analysed (TP08-0.7, TP04-2.1 and TP02-3.0), the natural samples had generally lower levels of the six identified COPC. The detected arsenic level in the natural samples of 32 mg/kg, 47 mg/kg and 70 mg/kg while two still exceeded EIL criteria, were the lowest arsenic concentrations out of the 18 soil samples. This suggests that the detected arsenic levels in the underlying natural material can likely be attributed to naturally elevated prevailing background levels.

An exception to the general trend that the natural sample had lower concentrations of COPC is chromium. The detected chromium in two of the natural sample was 20 mg/kg, which was the highest detected level out of the 18 soil samples. In addition, aluminium in the natural sample was also significantly higher than the levels detected in the tailings material. Aluminium in the natural material was 13,000 mg/kg whereas the closest aluminium level in the tailings material was 8,500 mg/kg. It is known that aluminium and chromium are both naturally occurring elements and there is potential that the detected levels may be naturally derived.

3.5.2.1 Arsenic

Arsenic levels in 17 samples exceeded the EIL criteria and seven samples exceeded HIL C.

The five highest arsenic concentrations occurred at:

- TP03-0.4 – 1,100 mg/kg (upper clayey silt)
- TP02-2.4 – 890 mg/kg (fine silt)
- TP07 (<100 um) – 730 mg/kg (mixed bulk sample)
- TP02 (<100 um) – 470 mg/kg (mixed bulk sample)
- TP02 (100-250 um) - 440 mg/kg (mixed bulk sample).

3.5.2.2 Particle Size

In order to evaluate whether there was a potential correlation between contaminant level and particle size, six of the elevated contaminants listed above: arsenic, chromium, copper, mercury, nickel and zinc are provided in **Table 3.5** for reference purposes.

Table 3.5: Arsenic Level (mg/kg) and Other Heavy Metal Concentrations with Particle Size

Sample	Particle Size	Arsenic Level	Chromium (III+VI) Level	Copper Level	Mercury Level	Nickel Level	Zinc Level
TP02	(<100 µm)	470	9.1	21	1.4	12	49
	(100-250 µm)	440	9	18	1.5	11	43
	(>250 µm)	290	10	21	1	11	34
TP05	(<100 µm)	330	13	22	1.4	12	37
	(100-250 µm)	270	14	19	1.1	13	35
	(>250 µm)	120	18	23	0.4	14	29
TP07	(<100 µm)	730	8.6	29	1.5	12	60
	(100-250 µm)	350	5.7	15	0.9	8.5	39
	(>250 µm)	290	5.7	13	0.7	7.8	35

From the table above, there appears to be a correlation between arsenic and zinc and particle size and to a lesser extent mercury. The recorded levels of arsenic, zinc and mercury tend to decrease with increasing particle size, in most cases. This pattern is less apparent with mercury and no obvious correlation between chromium, copper and nickel and particle size is shown. The trend highlighted above suggests that arsenic, zinc and potentially mercury are preferentially associated with these smaller particle sizes.

3.5.2.3 Leachability

Preliminary leachability testing of select samples was undertaken to gain a greater understanding of the potential mobility of arsenic and chromium in particular. Certain species of arsenic and chromium can be highly mobile in the environment and may pose a greater potential risk to human health and the environment and hence these metals were selected by JBS&G for this initial evaluation.

The results from the leachability undertaken indicated that arsenic is potentially leachable from the site soil. All sediment samples subject to ASLP testing were found to have a leachate with detectable level of arsenic. The highest leachate result was found from TP07 (<100 um), with an arsenic leachate concentration of 0.59 mg/L. The highest degree of leachability was from TP07 (100 – 250 um) (at pH 5).

Plate 1 below indicates there is no particular trend between arsenic concentration and arsenic leachability in the select samples test, however all samples had some degree of reported leaching.

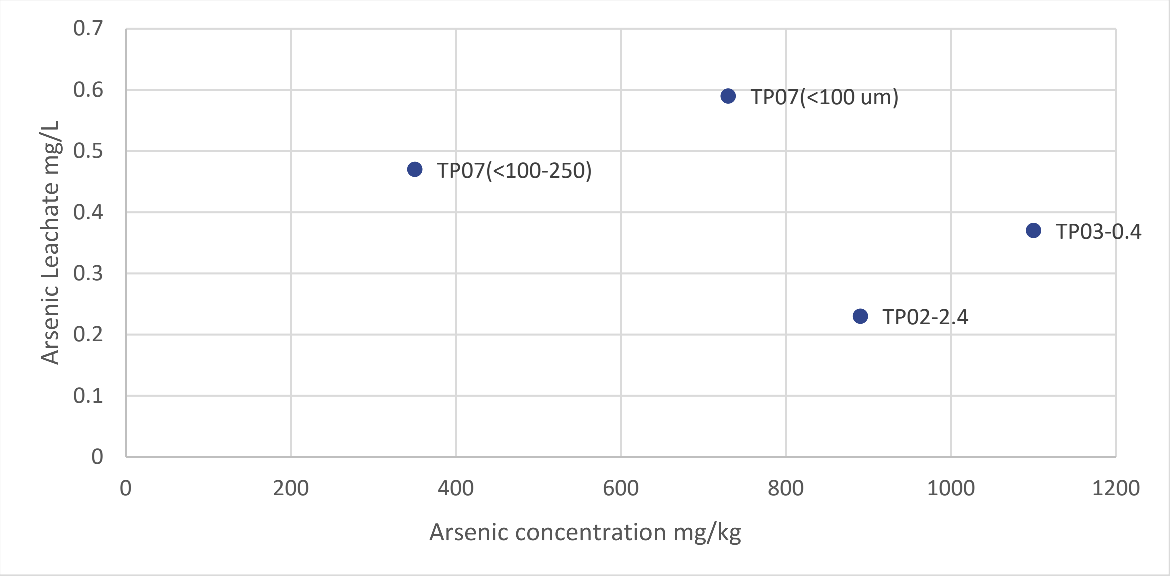


Plate 1: Correlation between arsenic concentration in soil and arsenic leachate level

Leachate results for arsenic in natural material were all reported to be below the LOR, indicating arsenic is not likely to be leachable from the natural material, from the soils tested.

Leachate results for chromium were all reported to be below the LOR, indicating chromium is not likely to leachable from the tailings material, from the soils tested.

3.5.2.4 Chromium Speciation

Due to the reported elevated levels of total chromium in soil samples, chromium speciation testing was undertaken to evaluate what species of chromium might be present. This was because total chromium includes both Cr(III) (not toxic) and also Cr(VI) (highly toxic) species. Whilst these elevated concentrations are below adopted screening level human health and environmental risk criteria, they warranted further consideration whilst the soil samples were still held by the laboratory.

In the context of the above, four samples were subsequently submitted for chromium speciation testing to confirm our expectations that the reported total chromium concentrations were associated with the presence of Cr(III) (not toxic).

The subsequent laboratory results confirmed the speciation of chromium to be solely Cr(III).

3.5.2.5 Total Organic Carbon (TOC)

The correlation between TOC and potential retardation of contaminants in the environment is well established.

To evaluate whether there was a potential correlation between TOC and arsenic concentrations, 12 samples were submitted for TOC analysis, with nine sourced from the soil assessment and three sourced from the sediment assessment (which is described in further detail in **Section 5**).

It was found that the highest TOC level in the soil assessment was 0.5 % and occurred at TP03-0.4, which is the location of the highest arsenic concentration of 1,100 mg/kg. TOC levels (expressed as a percentage) and arsenic concentrations were subsequently plotted to evaluate whether this potential trend further, and this is shown in **Plate 2** below.

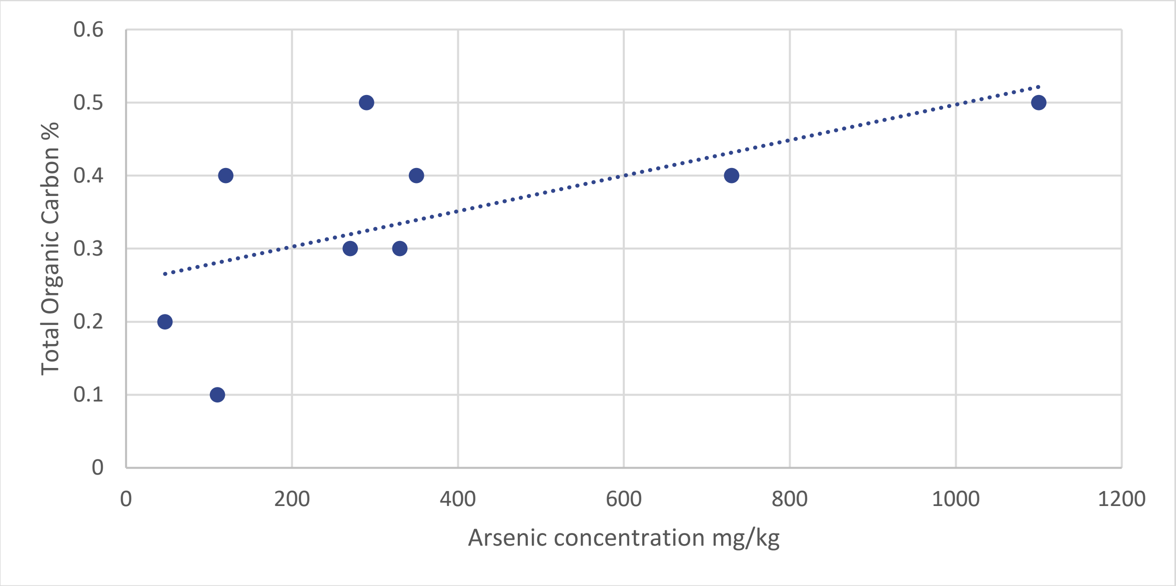


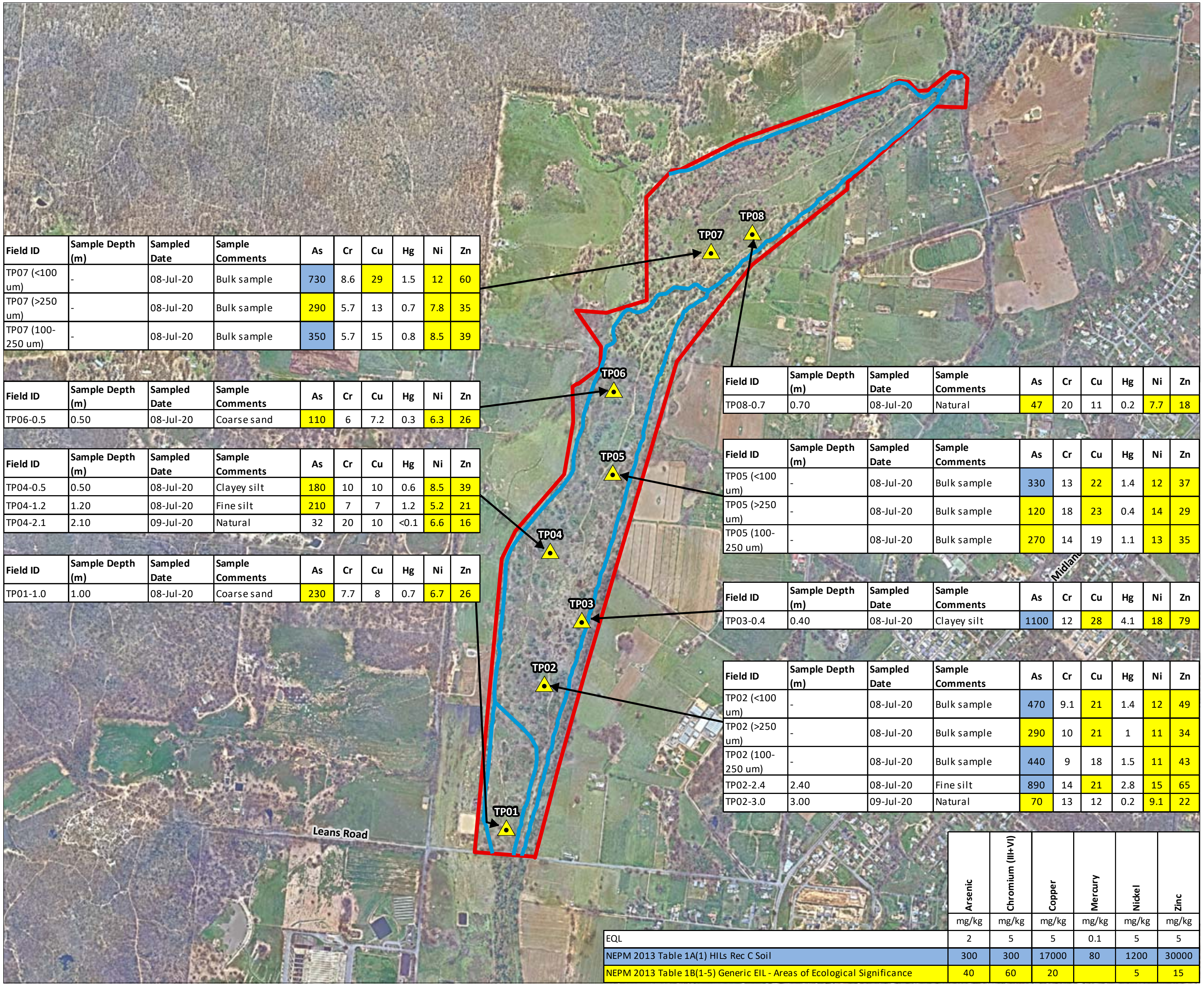
Plate 2: Correlation between arsenic concentrations in select soil samples and total organic carbon levels.

As indicated by **Plate 2** above, and acknowledging that there is only limited data available, there appears to be a slight positive correlation between arsenic concentrations in soil and TOC levels, suggesting that elevated arsenic concentrations are associated with higher TOC levels.

3.5.2.6 Major Cations and Anions

There does not appear to be any clear trends between arsenic or other metals of concern and major anions and cation levels.

The only comment to be made is that it appears that sodium levels were potentially higher in the natural material compared to the tailings material. Conversely, phosphorous levels appeared to be lower in the natural material compared to the tailings material. This was based on a comparison between TP08-0.7, TP04-2.1 and TP02-3.0 and the other 15 samples of the tailings material.



Field ID	Sample Depth (m)	Sampled Date	Sample Comments	As	Cr	Cu	Hg	Ni	Zn
TP07 (<100 um)	-	08-Jul-20	Bulk sample	730	8.6	29	1.5	12	60
TP07 (>250 um)	-	08-Jul-20	Bulk sample	290	5.7	13	0.7	7.8	35
TP07 (100-250 um)	-	08-Jul-20	Bulk sample	350	5.7	15	0.8	8.5	39

Field ID	Sample Depth (m)	Sampled Date	Sample Comments	As	Cr	Cu	Hg	Ni	Zn
TP06-0.5	0.50	08-Jul-20	Coarse sand	110	6	7.2	0.3	6.3	26

Field ID	Sample Depth (m)	Sampled Date	Sample Comments	As	Cr	Cu	Hg	Ni	Zn
TP04-0.5	0.50	08-Jul-20	Clayey silt	180	10	10	0.6	8.5	39
TP04-1.2	1.20	08-Jul-20	Fine silt	210	7	7	1.2	5.2	21
TP04-2.1	2.10	09-Jul-20	Natural	32	20	10	<0.1	6.6	16

Field ID	Sample Depth (m)	Sampled Date	Sample Comments	As	Cr	Cu	Hg	Ni	Zn
TP01-1.0	1.00	08-Jul-20	Coarse sand	230	7.7	8	0.7	6.7	26

Field ID	Sample Depth (m)	Sampled Date	Sample Comments	As	Cr	Cu	Hg	Ni	Zn
TP08-0.7	0.70	08-Jul-20	Natural	47	20	11	0.2	7.7	18

Field ID	Sample Depth (m)	Sampled Date	Sample Comments	As	Cr	Cu	Hg	Ni	Zn
TP05 (<100 um)	-	08-Jul-20	Bulk sample	330	13	22	1.4	12	37
TP05 (>250 um)	-	08-Jul-20	Bulk sample	120	18	23	0.4	14	29
TP05 (100-250 um)	-	08-Jul-20	Bulk sample	270	14	19	1.1	13	35

Field ID	Sample Depth (m)	Sampled Date	Sample Comments	As	Cr	Cu	Hg	Ni	Zn
TP03-0.4	0.40	08-Jul-20	Clayey silt	1100	12	28	4.1	18	79

Field ID	Sample Depth (m)	Sampled Date	Sample Comments	As	Cr	Cu	Hg	Ni	Zn
TP02 (<100 um)	-	08-Jul-20	Bulk sample	470	9.1	21	1.4	12	49
TP02 (>250 um)	-	08-Jul-20	Bulk sample	290	10	21	1	11	34
TP02 (100-250 um)	-	08-Jul-20	Bulk sample	440	9	18	1.5	11	43
TP02-2.4	2.40	08-Jul-20	Fine silt	890	14	21	2.8	15	65
TP02-3.0	3.00	09-Jul-20	Natural	70	13	12	0.2	9.1	22

	Arsenic	Chromium (III+VI)	Copper	Mercury	Nickel	Zinc
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
EQL	2	5	5	0.1	5	5
NEPM 2013 Table 1A(1) HILs Rec C Soil	300	300	17000	80	1200	30000
NEPM 2013 Table 1B(1-5) Generic EIL - Areas of Ecological Significance	40	60	20		5	15

Legend:

- 🟥 Site Boundary
- ▬ Watercourse
- ▲ Test Pit

Job No: 58207

Client: Huntly Common

Version: RevB	Date: 03-Dec-2020
Drawn By: SW	Checked By: AT

Scale at A4 1:25,000

0 300 600
metres

Coor. Sys. GDA 1994 MGA Zone 55

Huntly Streamside Reserve, Leans Road Huntly, Victoria

SOIL EXCEEDANCES- METALS

FIGURE 4

Document Path: V:\05 Projects\Huntly Common\58207 Huntly Work Plan - Bendigo Gold\8 - ArcGIS\01_MXD\04_Contam_Study\04_58207_Soil_Exceedances_RevB_2020_12_03.mxd
Image Reference: www.nearmap.com© - Imagery Date: 6 May 2020

4. Surface Water Assessment

A limited surface water assessment was undertaken comprising the collection of a surface water sample from three locations: downstream, midstream and upstream. Regulatory guidance, investigation methodologies, analytical schedules and screening criteria are discussed in the following sections.

4.1 Regulatory Guidance

All works conducted for the surface water assessment considered the following documents:

- Standards Australia (1998) Water quality - Sampling - Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples. AS5667.1-1998
- State Environment Protection Policy (Waters), October 2018, (SEPP, October 2018)
- Australian and New Zealand Environment Conservation Council, 2000, Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Volume 1, (ANZECC, 2000)
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG) (2018) Australian and New Zealand Governments and Australian State and Territory Governments, Canberra ACT, Australia.

4.2 Surface Water Investigation Methodology

A total of three surface water samples were collected. These were collected from a downstream, upstream and location across the site. There are two surface water bodies on-site, these are the Bendigo Creek (the 'creek') and the Effluent Channel (the 'channel'). Two samples were collected from the creek and one was collected from the channel.

The sample locations are shown on **Figure 3**.

The following sampling methodology was undertaken for the assessment of site surface water:

- Development of a JBS&G prepared site-specific JRA/ SWMS;
- The Sampling Plan was input into the ArcGIS Collector App to track and record the GPS coordinates of each sample location while on-site. The location of some sample locations were altered slightly from the Sampling Plan due to access restrictions;
- The depth of the water source in the location of the sample was recorded and photographs were taken of the sample location and surroundings;
- A Water Quality Meter was fastened to a swing sampler and held in a stationary position halfway up the water column;
- Field water quality parameters were recorded after 10 minutes or after reading had stabilised;
- The Water Quality Meter was removed from the swing sampler and a 500 mL laboratory supplied sample bottle without preservatives was attached to collect the surface water sample. This sample was collected into the direction of water flow;
- A second 500 mL sample bottle was used to collect water for field metals filtering. Field filtering included pouring approximately 100 mL into a stericup, which was pushed through a filter through vacuum suction by a hand pump. The filtered sample was placed in a 50 mL laboratory suppled metal bottle with preservatives;

- A second 50mL sample was collected by pouring the unfiltered surface water into a 50 mL preserved inorganics sample bottle;
- Samples were placed directly into sealed sample bottles provided by the laboratory, with zero headspace. Samples were labelled with a unique identifier, date and sampler. Sample containers were then placed in a pre-cooled insulated box for sample preservation prior to and during shipment to the testing laboratory;
- Collected samples were transported under standard JBS&G COC protocols within specified holding times for relevant analytes to NATA accredited laboratories for the required analyses (as discussed in **Section 4.3**).

4.3 Surface Water Analytical Program

The three surface water samples were submitted to NATA accredited laboratories for COPCs which were identified during the historical desktop review and via field observations.

Selected samples were analysed in accordance with the analytical schedule presented in **Table 4.1.**

Table 4.1: Selected Laboratory Analysis

Sample Type	No. of Sampling Locations	Analyses
Water	3: Downstream (DS-01) Midstream (MS-01) Upstream (US-01)	Conductivity (at 25°C) pH (at 25°C) Total Suspended Solids Dried at 103–105°C Suite B11 M32 Extended Metals Suite filtered Total Dissolved Solids Dried at 180°C ± 2°C

Notes:

The B11 Suite includes: Na, K, Ca, Mg, Hardness, Cl, SO_4, Alkalinity (CO_3, HCO_3, OH^-, Total Alkalinity)

4.4 Adopted Surface Water Assessment Criteria

According to the SEPP (Waters), October 2018 (Water SEPP), the site is within the Murray and Western Plains surface water segment. Table 3 of the SEPP describes the beneficial uses to be protected within the Murray and Western Plains surface water segment:

- Slightly to moderately modified water dependent ecosystems and species
- Agriculture and irrigation
- Human consumption of aquatic foods
- Aquaculture
- Industrial and commercial
- Water-based recreation (primary contact)
- Water-based recreation (secondary contact)
- Water-based recreation (aesthetic enjoyment)
- Traditional Owner cultural values
- Cultural and spiritual values.

The Water SEPP sets out Environmental Quality Indicators according for the Murray and Western Plains segment. **Table 4.2** below describes the environmental quality indicators for the lowlands of Campaspe, Loddon, Avoca, Wimmera and Mallee basins under the Murray and Western Plains segment.

Table 4.2: Murray and Western Plains (Slightly to moderately modified) Environmental Quality Indicators

Total phosphorus (µg/L)	Total nitrogen (µg/L)	Dissolved oxygen (percent saturation)		Turbidity (NTU)	Electrical conductivity (µS/cm@ 25°C)	pH (pH units)		Toxicants Water
75th percentile	75th percentile	25th percentile	Maximum	75th percentile	75th percentile	25th percentile	75th percentile	% protection
≤50	≤900	≥65	130	≤40	≤2,000	≥6.8	≤7.8	95

As the Murray and Western Plains segment is determined to have slightly to moderately modified water dependent ecosystems and species, the level of ecosystem protection in the ANZECC Guidelines adopted was 95%.

The beneficial use of Buildings and Structures is not applicable in this context as there will be no buildings or structures on-site, therefore no criteria for this use was included, nor this beneficial use considered further.

Based on the beneficial uses to be protected, the following criteria were adopted:

- Recreation / Aesthetics
    - National Health and Medical Research Council (NHMRC) (2011 updated 2018) ADWG: Health x10
    - NHMRC (2011 updated 2018) ADWG: Aesthetics
    - NHMRC (2019): Recreational water.
- Aquatic Ecosystems
    - ANZG (2018) Freshwater, 95% DGVs
    - ANZECC (2000) Freshwater, 95% species protection.
- Primary Industries
    - ANZECC (2000) Aquaculture
    - ANZECC (2000) Irrigation, long term
    - ANZECC (2000) Livestock.

4.5 Surface Water Results

Observations made and field parameters collected are summarised in **Section 4.5.1** below and laboratory results are summarised in **Section 4.5.2**.

4.5.1 Surface Water Observations

One sample was collected from the channel in the upstream location, and two were collected from Bendigo Creek in the midstream and downstream locations. There was a significant difference observed between the creek and channel sampling locations. This is shown in the surface water photograph log provided in **Appendix F**.

The downstream and midstream locations were within moderately steeply incised banks that were densely vegetated with soursob and large trees. The water quality was observed to be very good, with very low visible levels of turbidity as the creek bed was visible. No anthropogenic inclusions, staining, odours or other features were noted of concern. At both locations, and especially at the downstream location, very high flood levels were noted greater than 2 m above the water level due to presence of debris in the branches of trees above. This suggests that the creek is susceptible to flash flooding.

In contrast, the channel was observed to be considerably disturbed compared to the creek. The sample located was just upstream of the Leans Road bridge, where water flows through two levees before entering the site from the Coliban Water Treatment Facility. The water had very high levels of turbidity and was murky brown in appearance. The channel also appeared to have experienced a recent flash flood due to the observation of flattened bank vegetation, scoured and incised channel bank and presence of debris. The channel exhibited a number of disturbance indicators including; presence of invasive species, presence of rubbish including tyres, concrete pipes and general rubbish and presence of iron oxide precipitates.

The field water quality parameters from the various sampling locations are provided in **Table 4.3** below.

Table 4.3: Water Quality Field Parameters

Parameter	Downstream (DS-01)	Midstream (MS-01)	Upstream (US-01)
Depth (cm)	40	50	20
Measurement depth (cm)	20	20	10
Temperature (˚C)	9.1	10.1	9.0
Conductivity (µs/cm)	980	1,119	690
pH (pH units)	8.12	8.20	8.08
Redox Potential (ORP mV)	74	63	43.3
Dissolved Oxygen (mg/L)[5]	13	12.05	12.72

The field parameters indicate that redox potential, dissolved oxygen and conductivity were generally potentially higher at the downstream and midstream sample location compared to the upstream sample location, however, the limited amount of data considered is acknowledged.

4.5.2 Surface Water Laboratory Results

The laboratory results were compared against the relevant criteria as discussed in **Section 4.4**.

Laboratory transcripts and COC forms are presented in **Appendix G**. All results were tabulated against the adopted criteria and are presented in appended **Summary Table 2** at the end of this report. Results of the three surface water samples are described below.

The analytes that exceeded any of the criteria are described in further detail in **Table 4.4**.

Table 4.4: Summary of Surface Water Results

Analyte	Unit	Criteria Exceeded	Result
Aluminium (Filtered)	mg/L	ANZG (2018) Freshwater 95% toxicant DGVs	DS-01: **0.06** MS-01: **0.06** US-01: **0.12**
Arsenic (Filtered)	mg/L	ANZECC (2000) Freshwater, 95% species protection	MS-01: **0.013**
Copper (Filtered)	mg/L	ANZG (2018) Freshwater 95% toxicant DGVs	DS-01: **0.002** MS-01: **0.002**
Iron (Filtered)	mg/L	ANZECC (2000) Irrigation, long term NHMRC (2011 updated 2018) ADWG: Aesthetics	US-01: **0.52**
Zinc (Filtered)	mg/L	ANZG (2018) Freshwater 95% toxicant DGVs	DS-01: **0.014** MS-01: **0.016** US-01: **0.014**
Nitrate (as N)	mg/L	ANZECC (2000) Freshwater, 95% species protection ANZECC (2000) Irrigation, long term	DS-01: **3.1** MS-01: **3.3**
Sodium	mg/L	NHMRC (2011 updated 2018) ADWG: Aesthetics	DS-01: **210** MS-01: **240**
Chloride	mg/L	NHMRC (2011 updated 2018) ADWG: Aesthetics	DS-01: **260** MS-01: **290**

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[5] JBS&G notes that there were some field issues with the stablisation of DO measurements. Oxygen concentrations well above 8 mg/L are considered to be saturated conditions.

Analyte	Unit	Criteria Exceeded	Result
Total Dissolved Solids	mg/L	NHMRC (2011 updated 2018) ADWG: Aesthetics	DS-01: **850** MS-01: **950** US-01: 6**00**

Similar contaminants as identified in the soil assessment, i.e. arsenic, copper and zinc, had reported elevated concentrations above applicable water quality criteria. The reported concentration of metals and metalloids were all marginal and did not exceed any criteria by more than a magnitude of two.

4.5.2.1 Major Cations and Anions

Sulphur, nitrate, calcium, potassium, magnesium, sodium, alkalinity, chloride, sulphate and total dissolved solids (TDS), were all higher at the downstream location compared to the upstream location. In addition, the midstream location had the highest levels compared to the downstream location, albeit marginally. The cations and anions with the greatest level of change were:

- Sulphur increased from 18 mg/L upstream to 32 mg/L downstream (33 mg/L midstream)
- Nitrate increased from 0.44 mg/L upstream to 3.1 mg/L downstream (3.3 mg/L midstream)
- Potassium increased from 7.3 mg/L upstream to 20 mg/L downstream (22 mg/L midstream)
- Sodium increased from 150 mg/L upstream to 210 mg/L downstream (240 mg/L midstream)
- Chloride increased form 190 mg/L upstream to 260 mg/L downstream (290 mg/L midstream)
- Sulphate increased from 43 mg/L upstream to 80 mg/L downstream (88 mg/L midstream)
- Electrical Conductivity increased from 970 µS/cm upstream to 1,300 µS/cm downstream (1,600 µS/cm midstream)
- TDS increased from 600 mg/L upstream to 850 mg/L downstream (950 mg/L midstream)

Total suspended solids (TSS) however were higher at the upstream location compared to the downstream and midstream locations.

5. Sediment Assessment

A limited sediment assessment was undertaken comprising the collection of a sediment sample from three locations, downstream, midstream and upstream. Investigation methodologies, analytical schedules and regulatory guidance and screening criteria are discussed in the following sections

5.1 Regulatory Guidance

All works conducted for the sediment assessment considered the following documents:

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG) (2018) Australian and New Zealand Governments and Australian State and Territory Governments, Canberra ACT, Australia

5.2 Sediment Investigation Methodology

A total of three sediment samples were collected. These were collected from a downstream, upstream and location across the site. As noted above, there are two surface water bodies on-site, these are the Bendigo Creek and the Effluent Channel. Two samples were collected from the creek and one was collected from the channel as discussed previously.

The sample locations are shown on **Figure 3**.

The following sampling methodology was undertaken for the assessment of site surface water:

- Development of a JBS&G prepared site-specific JRA/ SWMS;
- The Sampling Plan was input into the ArcGIS Collector App to track and record the GPS coordinates of each sample location while on-site. The location of some sample locations were altered slightly from the Sampling Plan due to access restrictions;
- The depth of the water source in the location of the sample was recorded and photographs were taken of the sample location and surroundings;
- A decontaminated AMS Multi-Stage Sediment Sampler (hand core sampler) was used to collect a sediment core of 10 cm depth from within the creek and channel using waders;
- Sediment disturbance was limited as far as practicable by disturbing the sediment for the least amount of time practicable and by selecting an area to core that was relatively free of rocks;
- Samples were placed directly into Teflon sealed sample jars provided by the laboratory, with zero headspace. Samples were labelled with a unique identifier, date and sampler. Sample containers were then placed in a pre-cooled insulated box for sample preservation prior to and during shipment to the testing laboratory; and
- Collected samples were transported under standard JBS&G COC protocols within specified holding times for relevant analytes to NATA accredited laboratories for the required analyses (as discussed in **Section 4.3)**.

5.3 Sediment Analytical Program

Selected sediment samples were submitted to NATA accredited laboratories for COPCs which were identified during the historical desktop review and via field observations.

Selected samples were analysed in accordance with the analytical schedule presented in **Table 5.1.**

Table 5.1: Selected Laboratory Analysis

Sample Type	No. of Sampling Locations	Analyses
Sediment	3: Downstream (DS-01) Midstream (MS-01) Upstream (US-01)	pH and M32 extended heavy metal suite – 3 primary samples Total Organic Carbon (TOC) analysis: • DS-01 • MS-01 • US-01

Notes: The M32 Extended Metals Suite includes: Al, Sb, As, Ba, Be, Bi, B, Cd, Ca, Cr, Co, Cu, Fe, K, Hg, Mg, Mn, Mo, Ni, Pb, P, Se, Si, Ag, Na, S, Sn, Tl, Ti, U, V, Zn

5.4 Adopted Sediment Assessment Criteria

Toxicant default guideline values (DGVs) for sediment quality are provided under the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG) (2018). These guidelines have been adopted as the relevant assessment criteria as these guidelines have been specifically designed for sediment within water bodies. In addition, it was considered inappropriate to apply NEPM HIL or EIL criteria in this context.

Two sets of criteria under these DGVs have been adopted, these are:

- ANZG (2018) Sediment DGVs
- ANZG (2018) 'upper' guideline values (GV-high).

The sediment DGVs are used to protect aquatic ecosystems by indicating the concentrations below which there is a low risk of unacceptable effects occurring. In contrast, the 'upper' guideline values (GV-high), provide an indication of concentrations at which the presence of toxicity-related adverse effects are anticipated to already occur. In the context of the site, the GV-high are used as an indicator of potential high-level toxicity problems and the sediment DGVs are used to indicate the risk of unacceptable effects occurring.

5.5 Sediment Results

5.5.1 Sediment Field Observations

Photographs taken during the collection of sediment samples are provided as **Appendix F.**

As described in **Section 4.5.1** above, there was a significant difference between the apparent condition of the creek and channel sample locations. The two creek samples (DS-01 and MS-01) appeared to be much less disturbed compared to the channel sample location (US-01). The sediment condition at DS-01 and MS-01 were largely consistent, comprising coarse sandy silt with smooth pebbly inclusions. The sediment at MS-01 had a higher proportion of coarse sand to silt compared to DS-01. DS-01 had softer sediment and less larger rock inclusions compared to MS-01. The channel sample location comprised very soft sediment between a mostly rocky base. It was difficult to advance the sediment sampler in this location due to the presence of large rocks at the base of the creek.

5.5.2 Sediment Laboratory Results

The laboratory results were compared against the relevant criteria as discussed in **Section 5.4**.

Laboratory transcripts and COC forms are presented in **Appendix E**. All results have been tabulated against the adopted criteria and are presented in appended **Summary Table 3** at the end of this report. Results of the three sediment samples are described below.

The analytes with concentrations considerably above the LORs are described in further detail in **Table 5.2**. Analytes where criteria were exceeded are highlighted orange.

Table 5.2: Summary of Sediment Results

Analyte	Unit	Criteria Exceeded	Result		
			DS-01	MS-01	US-01
Aluminium	mg/kg	No criteria	4,500	1,900	7,600
Arsenic (Filtered)	mg/kg	ANZG (2018) - Sediment Quality DGV	**43**	**39**	**59**
Barium	mg/kg	No criteria	25	26	65
Manganese	mg/kg	No criteria	56	35	160
Mercury	mg/kg	ANZG (2018) - Sediment Quality DGV	<0.1	<0.1	**0.2**
Zinc	mg/kg	None	16	26	40
Sulphur as S	mg/kg	No criteria	21	52	230
Calcium	mg/kg	No criteria	340	470	1,000
Potassium	mg/kg	No criteria	560	220	1,200
Magnesium	mg/kg	No criteria	470	420	1,200
Sodium	mg/kg	No criteria	110	110	170
Phosphorus	mg/kg	No criteria	110	210	150
pH (aqueous extract)	pH Units	No criteria	7.1	7.2	8
Silicon	mg/kg	No criteria	400	430	330
Moisture Content	%	No criteria	16	19	21

The main contaminant of concern in the sampled sediment as indicated by the summary table is arsenic, as all other exceedances did not approach the GV-High level. The arsenic level in all three sediment samples exceeded the sediment quality DGV criteria of 20 mg/kg by at least two orders of magnitude. The arsenic level reported in US-01 was 59 mg/kg, which was noted by JBS&G to be approaching the upper GV for this contaminant.

In addition, mercury levels in US-01 also exceeded the sediment quality DGV, albeit marginally. This suggests that it is likely that the presence of arsenic and to a lesser extent mercury, in the environment may be detrimentally impacting the health of the surrounding aquatic environment. The remainder of analytes indicated a low potential risk of unacceptable effects occurring according to the available screening level criteria under the ANZG (2018) Sediment Quality DGVs. The remaining analytes had no available screening level criteria. Further consideration of internationally sourced assessment criteria was considered to be beyond the scope of this Preliminary ESA.

5.5.2.1 Major Cations and Anions

Sulphur, calcium, potassium, magnesium, sodium, pH and moisture content were highest at the upstream location compared to the midstream or downstream locations. This is the opposite trend compared to the surface water assessment results. The cations and anions with the greatest level of change were:

- Sulphur decreased from 230 mg/kg upstream to 21 mg/kg downstream (33 mg/L midstream)
- Calcium decreased from 1,000 mg/kg upstream to 340 mg/kg downstream
- Potassium decreased from 1,200 mg/kg upstream to 560 mg/kg downstream (220 mg/L midstream)
- Magnesium decreased from 1,200 mg/kg upstream to 470 mg/kg downstream (420 mg/L midstream)
- Sodium decreased from 170 mg/kg upstream to 110 mg/kg downstream
- pH decreased from 8 upstream to 7.1 downstream
- Moisture content decreased from 21 % upstream to 16 % downstream.

5.5.2.2 Total Organic Carbon

As noted in **Section 3.5.2.5**, correlations between TOC and potential retardation of contaminants in the environment are well established.

Of the 12 samples were submitted for TOC testing, nine were part of the soil assessment and three were part of the sediment assessment.

The sediment sample results for arsenic, mercury and TOC are summarised below, with other analytes shown in **Summary Table 3 – Sediment Assessment** (and laboratory certificates) at the end of this report:

- US-01 – Arsenic (59 mg/kg); Mercury (0.2 mg/kg); and TOC (0.6%)
- MS-01 – Arsenic (39 mg/kg); Mercury (<0.1 mg/kg); and TOC (0.7%)
- DS-01 – Arsenic (43 mg/kg); Mercury (<0.1 mg/kg); and TOC (0.5%).

Given there is only quite limited data available, no clear trends are apparent, bar a general comment that elevated arsenic concentrations were reported, along with relatively consistent TOC levels.

6. Quality Assurance/ Quality Control

Quality Assurance and Quality Control (QA/ QC) activities were undertaken throughout the soil, surface water and sediment sampling program to ensure the requested integrity of the data collected. QA and QC performed have been summarised in **Table 6.1** below and provided in **Appendix H**.

Table 6.1: Quality Assurance and Quality Control undertaken

QA/QC Item	Detail
QA	
Field Procedures	Field procedures were undertaken in accordance with relevant guidelines outlined in ASC NEPC (1999) and in accordance with JBS&G standard operating procedures.
Decontamination of Equipment	The excavator bucket was cleaned thoroughly prior to use on-site, with sample material collection conducted in the middle of the bucket to avoid potential cross contamination between sampling locations. Sediment and surface water sampling equipment was decontaminated between each sampling location. Samples were transferred into the sample jar using fresh disposable nitrile glove for each sample.
Laboratories used and NATA accreditation	Eurofins (primary) and Envirolab (secondary) are NATA accredited for the analyses undertaken.
Sample Tracking	CoC documentation was used for the transport of all soil, surface water and sediment samples to the laboratory.
Sample Preservation and Storage	Samples were collected in laboratory supplied jars and bottles with specific preservation for the chemicals of interest (where applicable) and were kept in a chilled insulated box and transported to the laboratory under COC protocols.
Holding Times	Samples were analysed within specified holding times.
Data Transcription	Results are supplied by the laboratory as CSV files, which minimises the chance of transcription errors. In addition, a random 10% data check of the laboratory results, indicated no anomaly within the generated electronic data by JBS&G.
Laboratory Limits of Reporting (LORs)	The laboratory limits of reporting (LORs) are presented in the laboratory certificates of analysis (**Appendix E** and **Appendix G**). The LORs are below adopted screening levels for soil, surface water and sediment.
QC	
Intra-laboratory Duplicate Samples	One intra-laboratory duplicate samples were collected during the soil sampling program as follows: • DUP01 was collected with primary sample TP02-2.4; Results: Some variability was noted in the intra-laboratory duplicate samples, with elevated RPDs (above 30%) reported for the following: • DUP01 – Iron (45%), Lead (99%), Manganese (36%), Mercury (33%), Sulphur (34%), Potassium (34%) and Silicon (63%). This variability is considered likely associated with minor heterogeneity of the soil samples and the low concentrations of analytes reported and in combination are not considered to represent any systemic issues with the environmental assessment undertaken.
Inter-laboratory Duplicate Samples	One inter-laboratory duplicate samples were collected during soil sampling program, as follows: • SPLIT01 was collected with primary sample TP02-2.4; Results: Similar to the above commentary, some variability was also noted in the inter-laboratory duplicate samples, with elevated RPDs (above 30%) reported for the following: • SPLIT01 – Lead (90%) and Silicon (63%). The variability noted in the elevated RPDs are not considered material and are likely associated with minor heterogeneity of the soil samples and the low concentrations of analytes reported and hence don’t indicate any systemic issues with the assessment.
Rinsate Blank Samples	No rinsate samples were collected as part of this investigation. The absence of such samples is not considered to affect the overall quality of results, as proposed for the purpose of this investigation.

QA/QC Item	Detail
Trip Blank Samples	No trip blank samples were collected as part of this investigation. The absence of such samples is not considered to affect the overall quality of results, as proposed for the purpose of this investigation
Laboratory Internal QC	Internal laboratory quality control procedures conducted by the primary and secondary laboratories included the analysis of laboratory blanks, internal duplicates and spikes. Internal duplicates measure the repeatability of the results. The laboratory blanks measure the potential cross contamination from laboratory equipment, and spike samples measure the degree of recovery of the samples. JBS&G conducted a review of the laboratory generated quality data, inclusive of: • Frequency of quality control testing; • Method blanks; • Internal laboratory duplicates; • Matrix spikes; and • Surrogate spikes. The review noted the following non-compliances: **Soil** Matrix spikes Matrix spikes recovery above the laboratory limits are reported for Beryllium (Sediment sample MS-01) and Aluminium (TP03-0.4). The laboratories indicated that these non-compliances were attributed to sample matrix interference. JBS&G considers that the above non-conformances are unlikely to affect the overall interpretation of results. Internal laboratory duplicates Elevated RPDs associated with the internal laboratory duplicates are reported for Sulphur (Sediment sample US-01) and Lead (TP02-2.4) The laboratories indicated that these internal duplicate RPDs outside of the initial screening of >30% still passed their laboratory acceptance criteria. JBS&G considers that the above non-conformances are unlikely to affect the overall interpretation of results.

Based on the results of the evaluation of the QA/ QC data, it is considered that:

- The field and laboratory quality assurance measures implemented provide an acceptable level of confidence that the data collected and reported was appropriately complete, comparable and representative
- The field and laboratory quality control measures implemented provide an acceptable level of confidence that the data collected and reported was appropriately accurate and precise.

Therefore, the data collected for the soil, sediment and surface water investigation is considered to be reliable and suitable for the assessment of the condition of the site, relative to the scope of work agreed with the Client.

7. Discussion

The laboratory results from the soil, surface water and sediment testing completed as part of this assessment identified a number of exceedances of the adopted screening level criteria, primarily heavy metals. This is described in further detail below.

7.1 Soil

As detailed in **Section 3.5.2** above, laboratory testing of the samples collected highlighted elevated concentrations of arsenic, chromium, copper, mercury, nickel and zinc.

7.1.1 Arsenic

Arsenic was present in elevated concentrations in the soil, with all but one sample exceeding the EIL criteria and seven out of 18 samples exceeding HIL C criteria. Unlike mercury, arsenic is highly leachable and mobile in the environment. Arsenic can represent a potential human health risk as it is a known human carcinogenic (Martinez et al. 2011), in this context, the risk to human health from arsenic is flagged by the exceedance of NEPM HIL C (300 mg/kg) by almost an order of four, and a potential risk to the environment is indicated by the exceedance of EIL criteria (40 mg/kg) by almost 30 times. The recorded levels of arsenic in the tailings material are associated with mining activity and are not considered to comprise background concentrations. Due to the elevated arsenic concentrations reported, leachability testing was undertaken, and it was found that arsenic is leachable. For this assessment, arsenic was identified as the primary COPC.

The detected arsenic level in the natural samples (TP08-0.7, TP04-2.1 and TP02-3.0) were the lowest arsenic concentrations out of the 18 soil samples. This suggests that the detected arsenic levels in the underlying natural material can likely be attributed to naturally elevated prevailing background levels.

There was no apparent correlation between sample depth or spatial location in arsenic level, instead the results suggest widespread high arsenic levels, commensurate with heterogeneous presence of historical tailings with the creek.

Through fractionation of three bulk samples into the three following particle sizes, <100 µm, 100-250 µm and >250 µm, a trend was observed that suggests that arsenic may be preferentially associated with smaller particle sizes.

Total Organic Carbon testing found that there is a slight positive correlation between arsenic concentrations in soil and TOC.

7.1.2 Mercury

Mercury concentrations were up to 40 times the LOR and therefore can be considered significant exceedances. The two highest mercury recordings were 2.8 mg/kg and 4.1 mg/kg, located at TP02-2.4 and TP03-0.4 respectively, also the location of the highest arsenic concentrations. The concentrations of mercury are not considered reflective of background conditions and instead are the likely result of the tailings deposition on-site.

Tailings are known to have elevated levels of heavy metals, especially arsenic and mercury. Mercury was used among artisanal miners to extract gold from crushed ore from approximately 1850s to the 1930s. The reported concentrations of mercury in the soils demonstrates the persistence of mercury in the environment.

Mercury is relatively immobile within soil (O'Connor et al. 2019). In contrast bioavailable forms of mercury can represent a significant risk to the aquatic environment as well as human health due to the concentration of mercury up the food chain (EPA 2017).

Whilst mercury was detected in site soil, it was at a diminished concentration in sediment and was not detected in surface water. Due to the undetected levels of mercury in the surface water assessment, it is possible the mercury detected in soil has possibly transformed to the stable but highly toxic form, methylmercury (Miller, Northey and Yellishetty 2017), but this would require further consideration/ assessment. This is further supported as the samples of natural material (TP08-0.7, TP04-2.1, TP02-3.0) had the lowest level of detected mercury of <0.1 mg/kg and 0.2 mg/kg. While mercury is toxic, the stable form is anticipated to adsorb to soil particles and not result in concentrated mercury levels up the food chain. For this reason, it is possible that the presence of mercury does not pose a significant risk to the environment or human health, but this would need further investigation to confirm.

7.1.3 Chromium

Chromium was also identified in elevated concentrations. The highest concentrations was 20 mg/kg and was located in TP08-0.7 and TP04-2.1 which were samples of the natural material. While this result is only four times the LOR, chromium is highly mobile even in small quantities, depending on the speciation. Speciation testing was undertaken on chromium (III + IV). It was found that the exceedances present were chromium (III) and therefore were unlikely to be mobile in the environment and not likely to pose a mobilisation risk to human health or the environment. In addition, as the highest level of chromium was detected in the natural material underlying the tailings material, it is possible that the detected levels may be reflective of background concentrations.

7.1.4 Copper, Nickel and Zinc

The concentrations of copper, nickel and zinc were not significantly elevated and were in general less than ten times the LOR. In addition, copper, nickel and zinc are known to occur in elevated concentrations in the Bendigo area and in the Goldfields Region as discussed in **Section 2.1** above. Copper is known to occur in the region at 160 mg/kg compared the highest concentration recorded of 29 mg/kg. Nickel is known to occur in the region at 79 mg/kg, compared the highest concentration recorded of 18 mg/kg. Zinc is known to occur in the region at 5,490 mg/kg, compared the highest concentration recorded of 79 mg/kg.

In the context of the above, it is considered likely that elevated concentrations of copper, nickel and zinc are primarily associated with prevailing regional background concentrations. As such, these exceedances are not considered to be "pollution", as per the *Environment Protection Act 1970,* the Act.

7.2 Surface Water

The results of the surface water assessment indicate there may be an existing issue with water quality due to the presence of contaminants that exceed the criteria regarding the beneficial uses of maintenance of ecosystems, irrigation and aesthetics.

The reported concentration of metals and metalloids were all marginal and did not exceed any criteria by more than a magnitude of two. As mentioned above, mercury and chromium were not detected in any surface water samples which suggests these contaminants might be present within the tailings material in stable and relatively non-leachable forms, however the limited nature of the preliminary ESA works undertaken is acknowledged. Arsenic marginally exceeded the ANZECC (2000) Freshwater, 95% species protection at the mid-stream sample location (MS-01) and was detected but below the criteria in upstream (US-01) and downstream (DS-01) locations. This suggests that there is a slight potential that the aquatic environment may be impacted by arsenic identified in the site soil as it flows through site. This is indicated as arsenic levels in surface water were higher at the midstream and downstream locations compared to the upstream location.

Potential changes in water quality indicators of major cation and anions as surface waters travelled through the site were more apparent compared to metals in surface water. The site may be influencing surface water sulphur, nitrate, major cations and major anions, electrical conductivity and TDS concentrations, as all apparently increase when passing through the site. This is indicated in the comparison of upstream water quality compared to downstream water quality.

The change in major cations and anions from the upstream location compared to downstream location could be attributed to a number of factors. Firstly, the stream may be receiving runoff from different locations at differing rates as determined by the surrounding topography and landuse. Secondly, the increase in major anions and cations in surface water from the upstream location to the downstream location may be associated with variations in the underlying stratigraphy and soil horizons which may alter soil ionic capacities and soil chemistry and therefore surface water. Lastly, the change in major cations and anions may indicate a groundwater-surface water interaction. This may indicate that the creek may receive groundwater or may feed groundwater. Due to the lack of groundwater data at this time, further comments are not able to be made.

The identified elevated analytes are provided below:

- Aluminium (Filtered) in all samples exceeded ANZG (2018) Freshwater 95% toxicant DGVs
- Arsenic (Filtered) in MS-01 Marginally exceeded ANZECC (2000) Freshwater, 95% species protection
- Copper (Filtered) in DS-01 and MS-01 exceeded ANZG (2018) Freshwater 95% toxicant DGVs
- Iron (Filtered) in US-01 exceeded ANZECC (2000) Irrigation, long term AND NHMRC (2011 updated 2018) ADWG: Aesthetics
- Zinc (Filtered) in all samples exceeded ANZG (2018) Freshwater 95% toxicant DGVs
- Nitrate in DS-01 and MS-01 exceeded ANZECC (2000) Freshwater, 95% species protection and ANZECC (2000) Irrigation, long term
- Sodium in DS-01 and MS-01 exceeded NHMRC (2011 updated 2018) ADWG: Aesthetics
- Chloride in DS-01 and MS-01 exceeded NHMRC (2011 updated 2018) ADWG: Aesthetics
- TDS in all samples exceeded NHMRC (2011 updated 2018) ADWG: Aesthetics

7.3 Sediment

Arsenic and mercury were the two contaminants of concern that exceeded the ANZG Sediment Quality criteria.

Arsenic levels in all three sediment samples exceeded the sediment quality DGV criteria of 20 mg/kg by at least two orders of magnitude. The arsenic level recorded in US-01 was 59 mg/kg which is approaching the upper GV. As the arsenic level was recorded to be approaching the GV-High criteria, this indicates that toxicity-related adverse effects in the aquatic and benthic environment may be already occurring.

The marginal exceedance of mercury detected in US-01 suggests that while mercury is present in the aquatic environment, it is at low levels and is unlikely to significantly impact ecosystem function or human health through bioaccumulation, however further assessment/ consideration would be required.

Sulphur, calcium, potassium, magnesium, sodium, pH and moisture content were highest at the upstream location compared to the midstream or downstream locations. This is the opposite trend compared to the surface water assessment results. This is likely influenced by the inflows of water from the Coliban Water Treatment Plant at the upstream location. In addition, the environmental condition at the upstream location was observed to be significantly more disturbed compared to the downstream and midstream locations, respectively.

There is potential that the disturbance factors observed at the upstream location have impacted sediment at a greater extent compared to surface water as the disturbed sediment is more likely to settle closer to the origin source rather than travel downstream.

7.4 Bioavailability

As arsenic levels in soil samples except one exceeded the NEPM Health Investigation Level (HIL), an initial consideration into the potential bioavailability of the detected arsenic in soils was undertaken.

JBS&G notes that bioavailability is a generic term defined as the fraction of a contaminant that is absorbed into the body following dermal contact, ingestion or inhalation (CRCCARE 2009). Exposure pathways where contaminated soil may impact human health are dermal contact, ingestion or inhalation.

Available data from the Bendigo region suggests that the bioavailability of arsenic in soil derived from mine tailings in this region commonly ranges from 10−20% and is generally less than 30%. Therefore, the value of 25% that is adopted by the US EPA might be appropriate for the site (ASC NEPM). Notwithstanding this, further more detailed assessment of arsenic concentrations in soil, sediment and surface water would likely be required to better understand the nature and extent of arsenic contamination at the site to prepare a quantitative human health risk assessment (HHRA) that rigorously evaluates bioavailability in the context of human receptors.

Similarly, an ecological risk assessment (ERA) would be needed to better understand contaminant bioavailability in the context of relevant ecological (i.e. flora and fauna) receptors.

In the interim, JBS&G makes the following comments:

- Arsenic mobility has been demonstrated at the site, through soil, sediment and surface water reported concentrations, in addition to leaching from site soils
- The presence of increasing levels of TOC tends to be associated with elevated concentrations of arsenic in site soils. Absorption/ adsorption of arsenic with organic carbon will likely reduce its bioavailability, however TOC levels are relatively low within the site soils.

8. Conclusions

Subject to the limitations presented in **Section 9**, the key findings from the Preliminary ESA were as follows:

- Based on the results from the investigative works undertaken and exceedances of the adopted screening level assessment criteria, the tailings material in the Huntly Streamside Reserve poses a potential risk to the surrounding environment and human health, particularly with respect to arsenic and, to a lesser extent, mercury.
- There is a slight potential that the tailings material may be impacting the underlying natural material, based on the detected levels of arsenic in the underlying natural material and the leachability of arsenic in the tailings material. The level of arsenic in the natural soil may, however, reflect the naturally elevated concentrations in the region.
- The potential for mobilisation of arsenic during reclamation operations will require suitable control measures to protect the environment and human health, given:
    - the identified leachability of arsenic in soils tested
    - the correlation of higher arsenic concentrations to smaller, more erodible particle size fractions.
- Removing and appropriately managing the arsenic present in the tailings should reduce the current and future potential risks to human health and the environment, post-completion of the proposed project.

9. Limitations

This report has been prepared for use by the client who has commissioned the works in accordance with the project brief only, and has been based in part on information obtained from the client and other parties.

The advice herein relates only to this project and all results conclusions and recommendations made should be reviewed by a competent person with experience in environmental investigations, before being used for any other purpose.

JBS&G accepts no liability for use or interpretation by any person or body other than the client who commissioned the works. This report should not be reproduced without prior approval by the client, or amended in any way without prior approval by JBS&G, and should not be relied upon by other parties, who should make their own enquires.

Sampling and chemical analysis of environmental media is based on appropriate guidance documents made and approved by the relevant regulatory authorities. Conclusions arising from the review and assessment of environmental data are based on the sampling and analysis considered appropriate based on the regulatory requirements.

Limited sampling and laboratory analyses were undertaken as part of the investigations undertaken, as described herein. Ground 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 subsurface 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 based on the information obtained at the time of the investigations.

This report does not provide a complete assessment of the environmental status of the site, and it is limited to the scope defined herein. Should information become available regarding conditions at the site including previously unknown sources of contamination, JBS&G reserves the right to review the report in the context of the additional information.

10. References

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Summary Table 1 - Soil Assessment
Project Number: 58207
Project Name: Huntly Common

JBS&G

					Metals and Metalloids																								
					Aluminium	**Antimony**	**Arsenic**	**Barium**	**Beryllium**	**Bismuth**	**Boron**	**Cadmium**	**Chromium (III+VI)**	**Cobalt**	**Copper**	**Iron**	**Lead**	**Manganese**	**Mercury**	**Molybdenum**	**Nickel**	**Selenium**	**Silver**	**Thallium**	**Tin**	**Titanium**	**Uranium**	**Vanadium**	**Zinc**
					mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	MG/KG	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
EQL					10	10	2	10	2	10	10	0.4	5	5	5	20	5	5	0.1	5	5	2	0.2	10	10	10	10	10	5
NEPM 2013 Table 1A(1) HILs Rec C Soil							300		90		20000	90	300	300	17000		600	19000	80		1200	700							30000
NEPM 2013 Table 1B(1-5) Generic EIL - Areas of Ecological Significance							40						60		20		470				5								15
Field ID	**Sample Depth**	**Sampled Date**	**Sample Comments**	**Lab Report Number**																									
TP01-1.0	1.00	08-Jul-20	Coarse sand	731111	2100	<10	230	25	<2	<10	<10	<0.4	7.7	<5	8	14,000	16	110	0.7	<5	6.7	<2	<0.2	<10	<10	28	<10	<10	26
TP02 (<100 um)		08-Jul-20	Bulk sample	731071	4200	<10	470	36	<2	<10	<10	<0.4	9.1	5.4	21	18,000	26	180	1.4	<5	12	<2	<0.2	<10	<10	40	<10	<10	49
TP02 (>250 um)		08-Jul-20	Bulk sample	731071	4200	<10	290	61	<2	<10	<10	<0.4	10	7	21	20,000	18	190	1	<5	11	<2	<0.2	<10	<10	40	<10	14	34
TP02 (100-250 um)		08-Jul-20	Bulk sample	731071	4500	<10	440	38	<2	<10	<10	<0.4	9	6.3	18	17,000	24	190	1.5	<5	11	<2	<0.2	<10	<10	36	<10	10	43
TP02-2.4	2.40	08-Jul-20	Fine silt	731111	5500	<10	890	53	<2	<10	<10	<0.4	14	9.4	21	30,000	100	230	2.8	<5	15	<2	<0.2	<10	<10	45	<10	18	65
TP02-3.0	3.00	09-Jul-20	Natural	737860	7100	<10	70	71	<2	<10	<10	<0.4	13	7.6	12	20,000	13	180	0.2	<5	9.1	<2	<0.2	<10	<10	54	<10	17	22
TP03-0.4	0.40	08-Jul-20	Clayey silt	731111	4900	<10	1100	51	<2	<10	<10	<0.4	12	9.8	28	23,000	44	240	4.1	<5	18	<2	<0.2	<10	<10	41	<10	13	79
TP04-0.5	0.50	08-Jul-20	Clayey silt	731111	3300	<10	180	32	<2	<10	<10	<0.4	10	6.1	10	17,000	23	130	0.6	<5	8.5	<2	<0.2	<10	<10	40	<10	12	39
TP04-1.2	1.20	08-Jul-20	Fine silt	731111	2700	<10	210	38	<2	<10	<10	<0.4	7	<5	7	11,000	14	82	1.2	<5	5.2	<2	<0.2	<10	<10	52	<10	11	21
TP04-2.1	2.10	09-Jul-20	Natural	737860	13,000	<10	32	30	<2	<10	<10	<0.4	20	<5	10	21,000	15	37	<0.1	<5	6.6	<2	<0.2	<10	<10	96	<10	30	16
TP05 (<100 um)		08-Jul-20	Bulk sample	731071	6300	<10	330	62	<2	<10	<10	<0.4	13	7.4	22	18,000	23	200	1.4	<5	12	<2	<0.2	<10	<10	63	<10	15	37
TP05 (>250 um)		08-Jul-20	Bulk sample	731071	8500	<10	120	120	<2	<10	<10	<0.4	18	17	23	25,000	30	1100	0.4	<5	14	<2	<0.2	<10	<10	87	<10	29	29
TP05 (100-250 um)		08-Jul-20	Bulk sample	731071	7200	<10	270	71	<2	<10	<10	<0.4	14	10	19	19,000	25	350	1.1	<5	13	<2	<0.2	<10	<10	55	<10	18	35
TP06-0.5	0.50	08-Jul-20	Coarse sand	731111	1800	<10	110	20	<2	<10	<10	<0.4	6	<5	7.2	12,000	12	130	0.3	<5	6.3	<2	<0.2	<10	<10	27	<10	<10	26
TP07 (<100 um)		08-Jul-20	Bulk sample	731071	4300	<10	730	43	<2	<10	<10	<0.4	8.6	5.8	29	19,000	25	230	1.5	<5	12	<2	<0.2	<10	<10	38	<10	<10	60
TP07 (>250 um)		08-Jul-20	Bulk sample	731071	1900	<10	290	17	<2	<10	<10	<0.4	5.7	<5	13	12,000	14	98	0.7	<5	7.8	<2	<0.2	<10	<10	21	<10	<10	35
TP07 (100-250 um)		08-Jul-20	Bulk sample	731071	2500	<10	350	21	<2	<10	<10	<0.4	5.7	<5	15	14,000	16	150	0.8	<5	8.5	<2	<0.2	<10	<10	24	<10	<10	39
TP08-0.7	0.70	08-Jul-20	Natural	731111	10,000	<10	47	32	<2	<10	<10	<0.4	20	<5	11	22,000	16	52	0.2	<5	7.7	<2	<0.2	<10	<10	93	<10	31	18

Summary Table 1 - Soil Assessment
Project Number: 58207
Project Name: Huntly Common

					Organic Sulfur Compounds	Major Cations				Major Anions	Ionic Balance	Particle Size							Metals	Other
					Sulphur as S	Calcium	Potassium	Magnesium	Sodium	Phosphorus	pH (aqueous extract)	<63 Micron	1000-2000 Micron	>2000 Micron	125-250 Micron	250-500 Micron	500-1000 Micron	63-125 Micron	Silicon	Moisture Content (dried @ 103°C)
					mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	pH Units	% (w/w)	% W/W	% (w/w)	% W/W	% W/W	% W/W	% W/W	mg/kg	%
EQL					5	5	5	5	5	5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	2	1
NEPM 2013 Table 1A(1) HILs Rec C Soil																				
NEPM 2013 Table 1B(1-5) Generic EIL - Areas of Ecological Significance																				
Field ID	**Sample Depth**	**Sampled Date**	**Sample Comments**	**Lab Report Number**																
TP01-1.0	1.00	08-Jul-20	Coarse sand	731111	33	650	240	800	28	150	7.5	-	-	-	-	-	-	-	340	3.5
TP02 (<100 um)		08-Jul-20	Bulk sample	731071	140	2700	410	2900	65	280	8	39	2.3	4.5	25	8.8	5.5	15	340	7.5
TP02 (>250 um)		08-Jul-20	Bulk sample	731071	1200	3300	580	1700	78	130	7.5	-	-	-	-	-	-	-	420	-
TP02 (100-250 um)		08-Jul-20	Bulk sample	731071	100	2900	460	2100	55	200	7.6	-	-	-	-	-	-	-	250	-
TP02-2.4	2.40	08-Jul-20	Fine silt	731111	240	2400	580	2400	100	290	8.2	-	-	-	-	-	-	-	250	5.9
TP02-3.0	3.00	09-Jul-20	Natural	737860	500	810	760	1700	460	120	-	-	-	-	-	-	-	-	-	10
TP03-0.4	0.40	08-Jul-20	Clayey silt	731111	160	2600	650	3500	38	350	7.9	-	-	-	-	-	-	-	280	23
TP04-0.5	0.50	08-Jul-20	Clayey silt	731111	44	490	460	1300	22	180	6.3	-	-	-	-	-	-	-	320	11
TP04-1.2	1.20	08-Jul-20	Fine silt	731111	70	1700	410	1000	82	110	8.4	-	-	-	-	-	-	-	280	4.3
TP04-2.1	2.10	09-Jul-20	Natural	737860	170	670	1200	1800	580	82	-	-	-	-	-	-	-	-	-	9.8
TP05 (<100 um)		08-Jul-20	Bulk sample	731071	88	2200	730	1500	64	150	7.7	64	0.2	0.5	17	3.9	2.4	13	320	8.7
TP05 (>250 um)		08-Jul-20	Bulk sample	731071	120	3700	1300	1700	96	130	7.7	-	-	-	-	-	-	-	480	-
TP05 (100-250 um)		08-Jul-20	Bulk sample	731071	97	3000	920	1700	64	150	7.8	-	-	-	-	-	-	-	200	-
TP06-0.5	0.50	08-Jul-20	Coarse sand	731111	51	780	230	1400	31	210	5.7	-	-	-	-	-	-	-	320	4.1
TP07 (<100 um)		08-Jul-20	Bulk sample	731071	120	2500	390	3400	32	310	7.4	18	0.5	1.6	46	11	5.2	17	270	11
TP07 (>250 um)		08-Jul-20	Bulk sample	731071	79	1300	200	1000	20	180	7.8	-	-	-	-	-	-	-	260	-
TP07 (100-250 um)		08-Jul-20	Bulk sample	731071	91	1700	260	2200	21	230	7.4	-	-	-	-	-	-	-	260	-
TP08-0.7	0.70	08-Jul-20	Natural	731111	53	730	1400	1600	190	87	7.9	-	-	-	-	-	-	-	260	13

Summary Table 2 - Surface Water Assessment
Project Number: 58207
Project Name: Huntly Common

					Metals and Metalloids										
					Aluminium (Filtered)	Antimony (Filtered)	Arsenic (Filtered)	Barium (Filtered)	Beryllium (Filtered)	Bismuth (Filtered)	Boron (Filtered)	Cadmium (Filtered)	Chromium (III+VI) (Filtered)	Cobalt (Filtered)	Copper (Filtered)
					mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
EQL					0.05	0.005	0.001	0.02	0.001	0.005	0.05	0.0002	0.001	0.001	0.001
ANZG (2018) Freshwater 95% toxicant DGVs					0.055[#1]						0.37[#2]	0.0002[#3]			0.0014[#3]
ZZ - 2(a). Recreation / Aesthetics - NHMRC (2011 updated 2018) ADWG: Health x10						0.03	0.1	20	0.6		40	0.02			20
ZZ - 2(a). Recreation / Aesthetics - NHMRC (2011 updated 2018) ADWG: Aesthetics															1
ZZ - 2(a). Recreation / Aesthetics - NHMRC (2019): Recreational water															
ZZ - 3(a). Aquatic Ecosystems - ANZECC (2000) Freshwater, 95% species protection					0.055		0.013[#11]				0.37	0.0002	0.001[#12]		0.0014
ZZ - 4(a). Primary Industries - ANZECC (2000) Aquaculture															1
ZZ - 4(a). Primary Industries - ANZECC (2000) Irrigation, long term					5		0.1		0.1		0.5	0.01	0.1	0.05	0.2
ZZ - 4(a). Primary Industries - ANZECC (2000) Livestock					5[#15]		0.5[#15]				5[#15]	0.01[#15]	1[#15]	1[#15]	0.4[#16]
Field ID	**Sampled Date**	**Lab Report Number**	**Matrix Type**	**Sample Comments**											
DS-01	09-Jul-20	731084	water	Creek	0.06	<0.005	0.011	<0.02	<0.001	<0.005	0.05	<0.0002	<0.001	<0.001	0.002
MS-01	09-Jul-20	731084	water	Creek	0.06	<0.005	0.013	<0.02	<0.001	<0.005	0.06	<0.0002	<0.001	<0.001	0.002
US-01	09-Jul-20	731084	water	Channel	0.12	<0.005	0.007	0.05	<0.001	<0.005	<0.05	<0.0002	<0.001	<0.001	0.001

	Metals and Metalloids														Organic Sulfur Compounds
	Iron (Filtered)	Lead (Filtered)	Manganese (Filtered)	Mercury (Filtered)	Molybdenum (Filtered)	Nickel (Filtered)	Selenium (Filtered)	Silver (Filtered)	Thallium (Filtered)	Tin (Filtered)	Titanium (Filtered)	Uranium (Filtered)	Vanadium (Filtered)	Zinc (Filtered)	Sulphur as S (Filtered)
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
EQL	0.05	0.001	0.005	0.0001	0.005	0.001	0.001	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.5
ANZG (2018) Freshwater 95% toxicant DGVs		0.0034[#1]	1.9[#4]	0.0006[#5]		0.011[#5]	0.011[#5]	0.00005[#5]						0.008[#6]	
ZZ - 2(a). Recreation / Aesthetics - NHMRC (2011 updated 2018) ADWG: Health x10		0.1	5	0.01	0.5	0.2	0.1	1				0.17			
ZZ - 2(a). Recreation / Aesthetics - NHMRC (2011 updated 2018) ADWG: Aesthetics	0.3		0.1											3	
ZZ - 2(a). Recreation / Aesthetics - NHMRC (2019): Recreational water															
ZZ - 3(a). Aquatic Ecosystems - ANZECC (2000) Freshwater, 95% species protection		0.0034	1.9	0.0006		0.011	0.011	0.00005						0.008	
ZZ - 4(a). Primary Industries - ANZECC (2000) Aquaculture														5	
ZZ - 4(a). Primary Industries - ANZECC (2000) Irrigation, long term	0.2	2	0.2	0.002	0.01	0.2	0.02					0.01	0.1	2	
ZZ - 4(a). Primary Industries - ANZECC (2000) Livestock		0.1[#15]		0.002[#15]	0.15[#15]	1[#15]	0.02[#15]					0.2[#15]		20[#15]	
Field ID															
DS-01	0.11	<0.001	0.005	<0.0001	<0.005	0.002	<0.001	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.014	32
MS-01	0.05	<0.001	<0.005	<0.0001	<0.005	0.002	<0.001	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.016	33
US-01	0.52	<0.001	0.084	<0.0001	<0.005	0.002	<0.001	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.014	18

	Non-Metallic Inorganics		Major Cations								Major Anions					Ionic Balance		Metals	Other	
	Ammonia as N	Nitrate (as N)	Calcium	Calcium (Filtered)	Potassium	Potassium (Filtered)	Magnesium	Magnesium (Filtered)	Sodium	Sodium (Filtered)	Phosphorus (Filtered)	Alkalinity (Carbonate as CaCO3)	Alkalinity (Bicarbonate as CaCO3)	Chloride	Sulphate	Electrical Conductivity (Lab)	pH (Lab)	Silicon (Filtered)	TDS	TSS
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µS/cm	pH Unit	mg/L	mg/L	mg/L
EQL	0.01	0.02	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	10	20	1	5	10	0.1	0.5	10	1
ANZG (2018) Freshwater 95% toxicant DGVs	0.9[#7]																			
ZZ - 2(a). Recreation / Aesthetics - NHMRC (2011 updated 2018) ADWG: Health x10		112.9[#8]													5000[#9]					
ZZ - 2(a). Recreation / Aesthetics - NHMRC (2011 updated 2018) ADWG: Aesthetics	0.5[#10]								180	180				250	250		6.5-8.5		600	
ZZ - 2(a). Recreation / Aesthetics - NHMRC (2019): Recreational water																				
ZZ - 3(a). Aquatic Ecosystems - ANZECC (2000) Freshwater, 95% species protection	0.9[#13]	2.4[#14]																		
ZZ - 4(a). Primary Industries - ANZECC (2000) Aquaculture																				
ZZ - 4(a). Primary Industries - ANZECC (2000) Irrigation, long term		2.4[#14]									0.05									
ZZ - 4(a). Primary Industries - ANZECC (2000) Livestock																				
Field ID																				
DS-01	0.02	3.1	34	34	20	20	35	35	210	210	<1	<10	200	260	80	1300	8.2	3.1	850	4
MS-01	<0.01	3.3	36	36	22	22	39	39	240	240	<1	<10	250	290	88	1600	8.3	3.3	950	2.7
US-01	0.02	0.44	27	27	7.3	7.3	30	30	150	150	<1	<10	140	190	43	970	8	4.7	600	6.2

Env Stds Comments
#1:Moderate reliability
#2:High reliability. DGV may not protect key test species from chronic toxicity (this refers to experimental chronic values or geometric mean for species). Check toxicant DGV technical brief for spread of data and its significance.
#3:Very high reliability
#4:Moderate reliability. DGV may not protect key test species from chronic toxicity (this refers to experimental chronic values or geometric mean for species). Check toxicant DGV technical brief for spread of data and its significance.
#5:Low reliability
#6:High reliability
#7:High reliability. Ammonia as total ammonia, measured as [NH3-N] at pH 8. DGV may not protect key test species from chronic toxicity (this refers to experimental chronic values or geometric mean for species).
#8:Calculated using ratio of molecular weight of N and O to NHMRC Guideline Value of 50mg/L for Nitrate and Nitrate
#9:Guideline value is taste threshold. >500 mg/L can have purgative effects.
#10:TV based on NH3 as NH3 (needs to be calculated based on in situ pH and temperature).
#11:Refer to ANZECC 2000 Table 8.3 - 107 and 108. Trigger value derived from Arsenic V
#12:Conservative trigger value taken from CrVI. Speciation maybe required.
#13:Total Ammonia-N freshwater trigger value (adjust for pH 6 - 9 Table 8.3.7)
#14:Based on NIWA 2013 Nitrate toxicity effects on freshwater species
#15: Higher concentrations may be tolerated in some situations (details provided in Volume 3, Section 9.3.5)
#16:Sheep 0.4, Cattle 1, Pigs 5, Poultry 5. Up to 5mg/L, may be tolerated if not provided as a food additive and natural levels in the diet are low

Summary Table 3 - Sediment Assessment
Project Number: 58207
Project Name: Huntly Common

					Metals and Metalloids																		
					Aluminium	Antimony	Arsenic	Barium	Beryllium	Bismuth	Boron	Cadmium	Chromium (III+VI)	Cobalt	Copper	Iron	Lead	Manganese	Mercury	Molybdenum	Nickel	Selenium	Silver
					mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	MG/KG	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
EQL					10	10	2	10	2	10	10	0.4	5	5	5	20	5	5	0.1	5	5	2	0.2
ANZG (2018) - Sediment Quality DGV						2	20					1.5	80		65		50		0.15		21		1
ANZG (2018) - Sediment Quality GV-high						25	70					10	370		270		220		1		52		4
Field ID	**Sample Depth**	**Lab Report Number**	**Sampled Date**	**Sample Comments**																			
DS-01	0.10	731111	09-Jul-20	Sediment	4500	<10	43	25	<2	<10	<10	<0.4	19	<5	5.7	23,000	12	56	<0.1	<5	6.5	<2	<0.2
MS-01	0.10	731111	09-Jul-20	Sediment	1900	<10	39	26	<2	<10	<10	<0.4	13	<5	5.2	21,000	11	35	<0.1	<5	<5	<2	<0.2
US-01	0.10	731111	09-Jul-20	Sediment	7600	<10	59	65	<2	<10	<10	<0.4	16	7.1	11	19,000	19	160	0.2	<5	9.4	<2	<0.2

					Metals and Metalloids						Organic Sulfur Compounds	Major Cations				Major Anions	Ionic Balance	Metals	Other
					Thallium	Tin	Titanium	Uranium	Vanadium	Zinc	Sulphur as S	Calcium	Potassium	Magnesium	Sodium	Phosphorus	pH (aqueous extract)	Silicon	Moisture Content (dried @ 103°C)
					mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	pH Units	mg/kg	%
EQL					10	10	10	10	10	5	5	5	5	5	5	5	0.1	2	1
ANZG (2018) - Sediment Quality DGV										200									
ANZG (2018) - Sediment Quality GV-high										410									
Field ID	**Sample Depth**	**Lab Report Number**	**Sampled Date**	**Sample Comments**															
DS-01	0.10	731111	09-Jul-20	Sediment	<10	<10	49	<10	31	19	21	340	560	470	110	110	7.1	400	16
MS-01	0.10	731111	09-Jul-20	Sediment	<10	<10	37	<10	22	26	52	470	220	420	110	210	7.2	430	19
US-01	0.10	731111	09-Jul-20	Sediment	<10	<10	83	<10	22	40	230	1000	1200	1200	170	150	8	330	21

Env Stds Comments

Appendix A Sampling Plan

Appendix B Groundwater Resource Report

Appendix C Photograph Log

Appendix D Test pit Logs

Appendix E Soil Laboratory Results

Appendix F Surface Water and Sediment Photograph Log

Appendix G Surface Water Laboratory Results

Appendix H QA/QC Table

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