



SOUTHERN HIGHLANDS REGIONAL SHOOTING  
COMPLEX (SHRSC)

QUARTER 1-2 MONITORING REPORT

(FOR SAMPLING 18 DEC 2023)

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# Part A: Background to Monitoring Event and SAQP

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## 1 Introduction

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### 1.1 Background to Document

This report forms part of the annual monitoring program for the Southern Highlands Regional Shooting Complex (SHRSC) and support the performance of the Operational Monitoring Program as detailed within Section 5 of the SHRSC Water Cycle Management Plan.

The monitoring undertaken may also be modified on site depending on site observations or in response to recommendations made as part of previous sampling exercises.

### 1.2 Structure of Document

This Report has been written in general accordance with the Guidelines for Consultants reporting on Contaminated Sites (OEH 2011) and National Environment Protection (Assessment of Site Contamination) Measure (NEPM) 1999 (Amended 2013) specifically Section 4, Section 7 and Schedule B5a Guideline on Ecological Risk Assessment.

This document is presented in two parts;

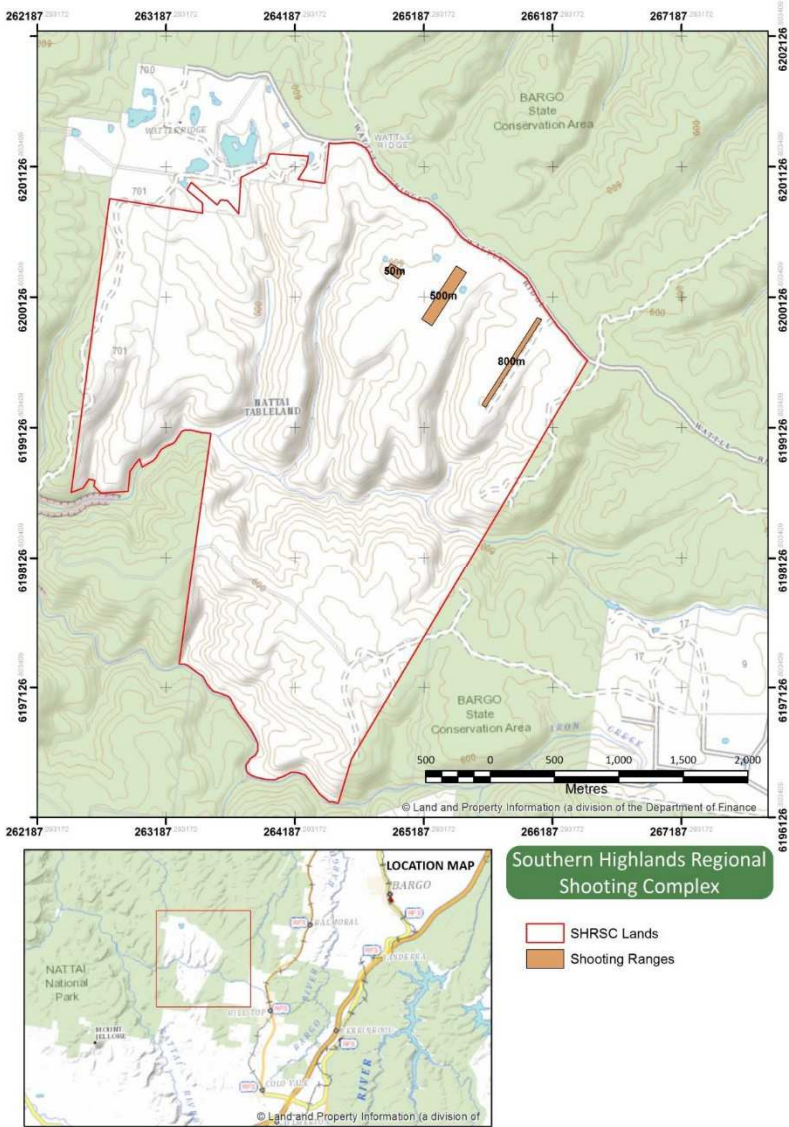
Part A – Background to Monitoring Event and SAQP

Part B – Monitoring Program Implementation and Report

# 2 Background information

## 2.1 Site Location

The Southern Highlands Regional Shooting Complex (SHRSC) is located in the Wingecarribee LGA on Wattle Ridge Road, approximately 5.5 km northwest of the centre of the village of Hill Top in the southern highlands of New South Wales. The catchment for the site is between the upper reaches of the Nepean River and other rivers such as the Wollondilly, Nattai, Bargo and Wingecarribee. These rivers flow into the Nepean River further to the north. See Figure 1 – Site Location.



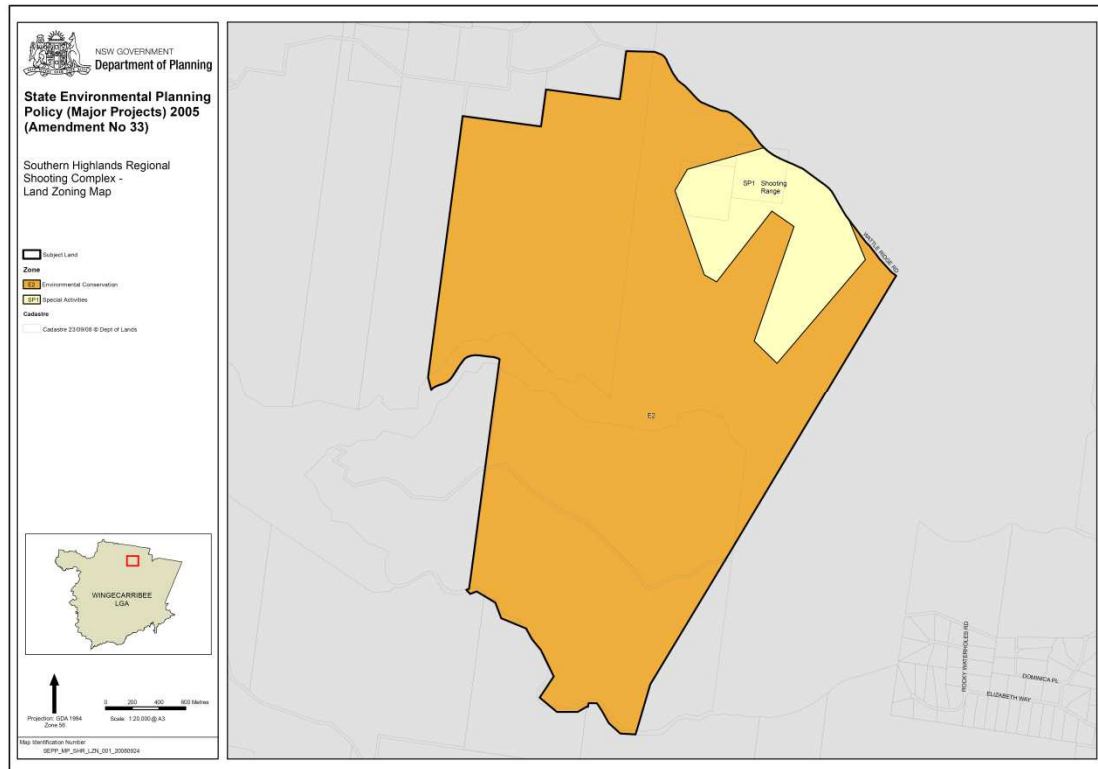
**FIGURE 1: Site Location**

1,036 hectares (ha) of land has been excised from the Bargo State Conservation Area by means of the National Parks and Wildlife (Adjustment of Areas) Act 2006. The SHRSC occupies an area of approximately 16 ha within this land. The remainder of the land on the site (approximately 1,000 ha) has been retained in its existing condition as a vegetation buffer zone. This area acts as a safety zone for the SHRSC.

## 2.2 Current Zoning

Figure 2 presents the current zoning of the SHRSC as SP1: Special Activities – Shooting Range referenced from the NSW Department of Planning SEPP 2005. For the purposes of this contamination assessment the area within the range will therefore be considered ‘recreational and open space’.

The SP1 areas are bounded by a large parcel of land zoned E2: environmental conservation. This E2 land includes the receiving catchments of the shooting ranges from the Wattle Ridge Range to the nearest water course of Rocky Waterholes Creek. For the purposes of this SAQP the area outside the range is considered ‘recreational and open space’.



**FIGURE 2: SHRSC Zoning Plan showing SP1 Special Activities and E2 Environmental Conservation**

Table 1 below summarises the information relevant to the site.

**TABLE 1 : SHRSC Information and Land Use**

Site information	
Owner	Office of Sport
Operator	Office of Sport
Address	Wattle Ridge Rd
Lot and DP	100 DP1088254
County /Parish	Camden County, Cumbertine Parish
Local Government Area	WINGECARRIBEE
Zoning	SP1 Special Activities
Land Use (current )	Shooting range or proposed shooting range
Land Use (proposed)	Shooting range
Applicable LEP	Wingecarribee Local Environmental Plan 1989

## 2.3 Surrounding Land Use and Sensitive Receptors

The site is bounded by:

- Wattle Ridge – a grazing property/residence which adjoins the site to the northwest (located approximately 2.5 km north of the existing range);
- Bargo State Conservation Area to the southwest;
- A 330 kV cleared electricity easement (Transgrid) to the southeast; and
- Wattle Ridge Road to the northeast.

Bargo State Conservation Area is located further southwest, southeast and northeast. Nattai National Park is located further to the northwest, on the opposite site of the Wattle Ridge property. Nattai National Park is accessible from the end of Wattle Ridge Road approximately 3 km away.

Sensitive receptors include Rocky Waterholes Creek, located approximately 1.5 km south of the site. The creek is a tributary of the Nattai River. The Nattai River is located approximately 7.5 km west of the site.

## 2.4 Site Setting

The information in the sections below with respect to the physical setting at the site and the surrounding environment has been referenced from:

***NSW Sport and Recreation Southern Highlands Regional Shooting Complex Environmental Assessment (Volume 1) GHD February 2008***

### 2.4.1 Geology

The underlying geology of the site comprises the Hawkesbury Sandstone of the Mittagong Formation (Herbert and Helby: 1980: pp256). The site lies within an outcrop of the Narrabeen group, which comprises sandstone, claystone and siltstone. The Hawkesbury sandstone overlies a Triassic shale unit – the Wianamatta Group. Geologically, the site is transitional between the Cumberland Plain of the Sydney Basin and the southern uplands.

### 2.4.2 Soils

The three main groups of soils that occur within the regional environment are:

- Sandstone tableland soils;
- Valley soils (sandstone derived); and
- Soils associated with nutrient rich shales and igneous rocks.

Land surfaces on the site do not appear to have been significantly reworked cut or in-filled. Some grading has been undertaken at the ranges to construct the fairways and the Stop-butts. Deeper excavations and possible import of materials has occurred as part of the construction of the retention basins.

These soil landscape types are unstable when disturbed. They are highly susceptible to mass movement, such as slides and rock falls, as well as wind and water erosion (Hazelton and Tille: 1990).

#### 2.4.3 Topography

The (SHRSC) is characterised by relatively flat topography and is situated on spur lines that trends to the north from the Wattle Ridge Range. The spur-line occupies a position between tributaries of the Rocky Waterholes Creek. All watercourses are upper tributaries of the Nattai River. Topographically the site is transitional between the Cumberland Plain of the Sydney Basin and the southern uplands.

#### 2.4.4 Hydrology

Review of climate data for the region indicates that there is some variability in the rainfall with the maximum mean monthly rainfall of 93.8 mm in March, while the minimum mean monthly rainfall recorded is about 43.7 mm in September. The average annual rainfall is approximately 848 mm.

Rocky Waterholes Creek, which is immediately south of the proposal location, drains directly to the Nattai River approximately 6 km to the west of the existing Hill Top Rifle Range. The Nattai River drains north to Lake Burragarang.

The Hawkesbury Nepean Catchment Management Authority has classified 98% of the Nattai River as being 'Near Intact'.

The catchment of Rocky Waterholes Creek is approximately 23.5 km<sup>2</sup>, whilst the catchment of the Nattai River upstream of the junction with Rocky Waterholes Creek is approximately 240 km<sup>2</sup>. The total catchment area of the Nattai River upstream of Lake Burragarang is approximately 480 km<sup>2</sup>.

Given the site location and the surrounding physical environment, the site is to be designed to regulate / retain run off of the surface water and sediment from the stop butt and the range areas using site drainage measures that discharge to designated retention basins. The site design aims to minimise the net sediment load migrating off site under heavy rainfall conditions throughout the year.

#### 2.4.5 Groundwater

The site is located within the Hawkesbury Sandstone – southeast groundwater flow system, which consists of layered aquifer system with yields ranging from less than one to 50 litres per second.

Basalt caps are expected to occur in some areas of the Mittagong Ranges, with groundwater from this horizon discharging into seeps, springs and rivers (Sydney Catchment Authority: 2006).

According to the Department of Natural Resources Groundwater Licence database, groundwater within the Hill Top area was found to be present at depths of approximately 20 metres in the sandstone aquifer.

The depth to groundwater within the aquifers is expected to be dependent on rainfall and therefore is likely to vary seasonally. However, groundwater is expected at depths greater

than 15 metres below ground level. Drilling undertaken on 12 and 13 July 2007 at the (SHRSC) location indicated no obvious groundwater table present within 50 metres below ground level. Based on the reported depth to groundwater on the site being greater than 50m below ground level, potential for surficial contaminants to impact ground water existing beneath the operational ranges is therefore considered to be of low likelihood. Groundwater assessment was therefore not considered to be necessary as part of this site assessment.

#### 2.4.6 Surrounding Groundwater Use

The Bureau of Meteorology Australian Ground Water Explorer (<http://www.bom.gov.au/water/groundwater/explorer/map.shtml>) and the DPI Office of Water ground water data base was used to search for bores within 800m of the site.

A number of monitoring bores were reported to be located within 2-5km of the site with no water quality data available. Two stock domestic bores were reported to be located within 5km.

- GW114443  
A 120m stock/domestic bore located in the Hilltop Village approximately 3.2km to the south east of the site.
- GW065725  
A 122m stock/domestic bore located around Wattleridge approximately 5k to the north of the site

**Based on the results of the bore search and the reported local water quality the NEPM 1999 (amended 2013) ground water investigations levels (GILs) suitable for the protection of fresh water species should therefore be adopted as the assessment criteria for this SAQP.**

## 3 SHRSC Description

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The SHRSC is a regional recreational shooting complex incorporating the existing 800 metre Hill Top Rifle Range (HTRR) and separate newly constructed facilities located approximately 700m to the North West. The HTRR has been used since the 1980s by a local club for long rifles and pistol use.

It includes:

- An 800m range consisting of a of a single target area and stop butt with multiple firing points on raised mounds located at 100m intervals. In 2018-19 the 800m range was subject to major civil works to improve and rehabilitate the stop butt and surrounds.
- Club house and out buildings
- Informal parking

The newly constructed facilities include:

- A (500 metres by 100 metres) shooting range consisting of a single firing point and multiple target points set in front of intermediate mounds. A final large stop butt is provided at the end of the range;
- A (50 metres by 115 metres) shooting range consisting of 6 separated galleries each single firing point and large stop butt;
- Supporting facilities and infrastructure, including:
  - Range control and Toilet facilities;
  - Access roads (designed for two-wheel drive vehicle access) connecting to Wattle Ridge Road and between the ranges;
  - Diesel generator, solar panels, water supply tanks and septic system;
  - Informal parking for 160 cars; and
  - Basins to contain water for water quality control purposes.
- Future facilities include:
  - A (200 metres by 85 metres) shooting range;
  - A shotgun range;
  - An indoor air range (21 metres by 17 metres by 6.5 metres); and
  - A Clubhouse

Environmental controls are included in the design for the ranges at the SHRSC. These specific environmental controls are discussed following.

### 3.1 Water Quality Structures

A single pond or informal retention structure is located to the east of the 800m range primarily taking water from the access road adjacent to the range.

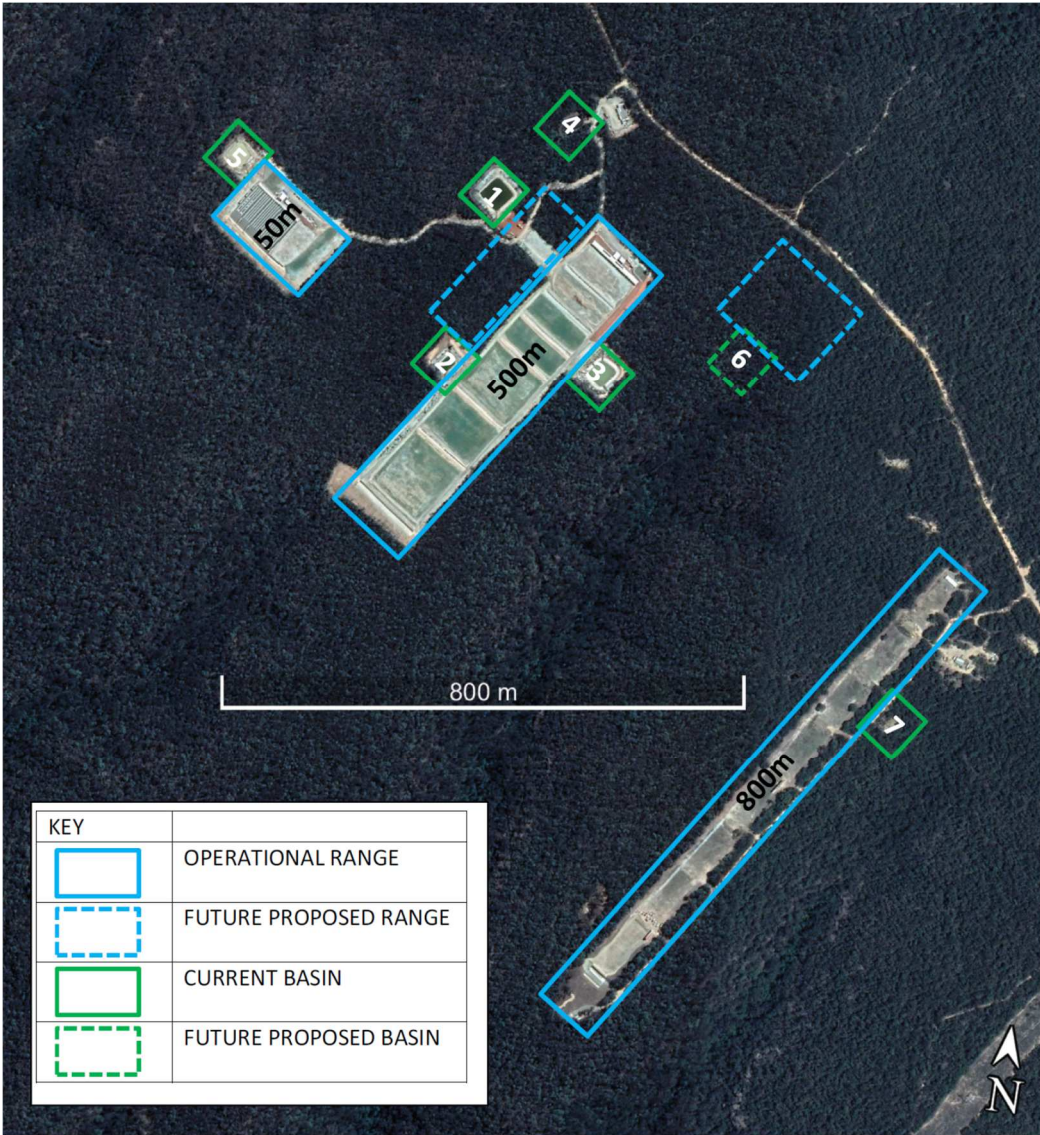
Four water quality structures/ retention basins have been constructed as part of the development of the of the 50m, 200m (yet to be built) and 500m ranges. A fifth Structure is proposed as part of a future shot gun range.

Additionally, works have been undertaken to modify an existing pond/structure located near the gate to the new ranges from Wattle Ridge Road. All structures above will be



referred to in this Plan as “basins” including the informal ponds.

**Figure 3** shows the layout at the SHRSC. Range and basin numbers are also indicated.



**FIGURE 3: Site Layout of the SHRSC**

### 3.2 Lime Treatment and Drainage

As part of the rehabilitation works to the 800m range and construction of the 500m and 50m ranges improved drainage measures were included. This drainage consists of a network of sub soil drainage trenches set down gradient of primary impact areas leading to lime treatment pits to raise pH and reduce the transport of heavy metals from the range areas. Stormwater lines from these treatment pits either lead to formal outlet measures or to new basins.

The 800m range has an additional pit to retain water/sediment for testing purposes as is the case for the basins at the 50 and 500 ranges. Lime pits and directional pits do not retain water.



Figure 4 provides schematic of the collection trenches, and the lime treatment pits

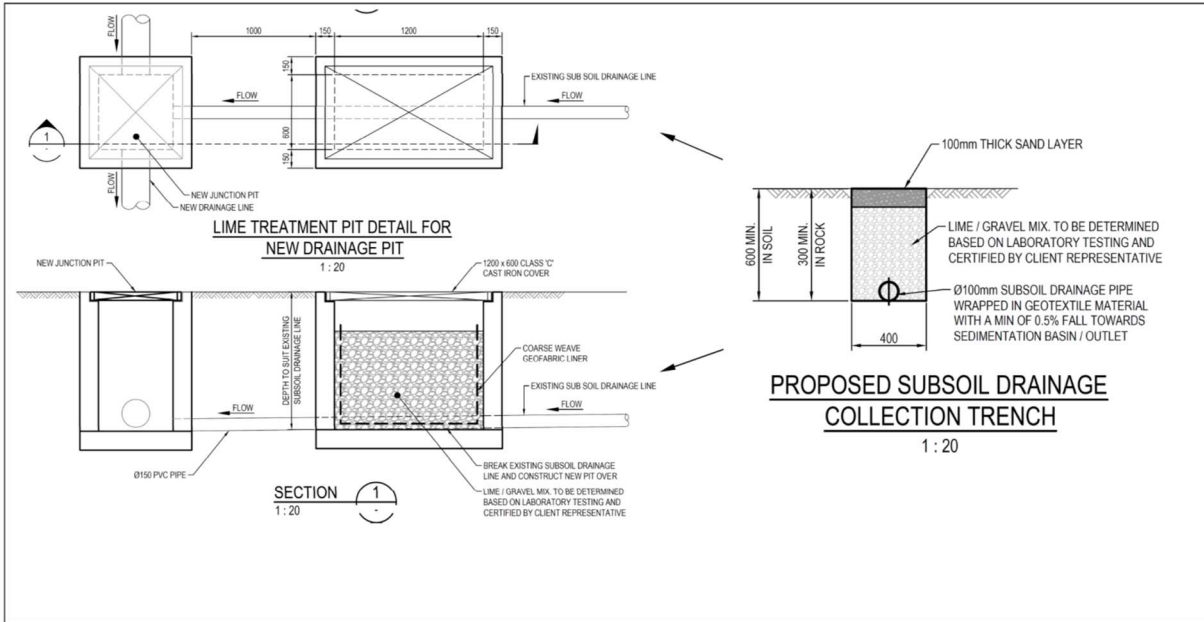
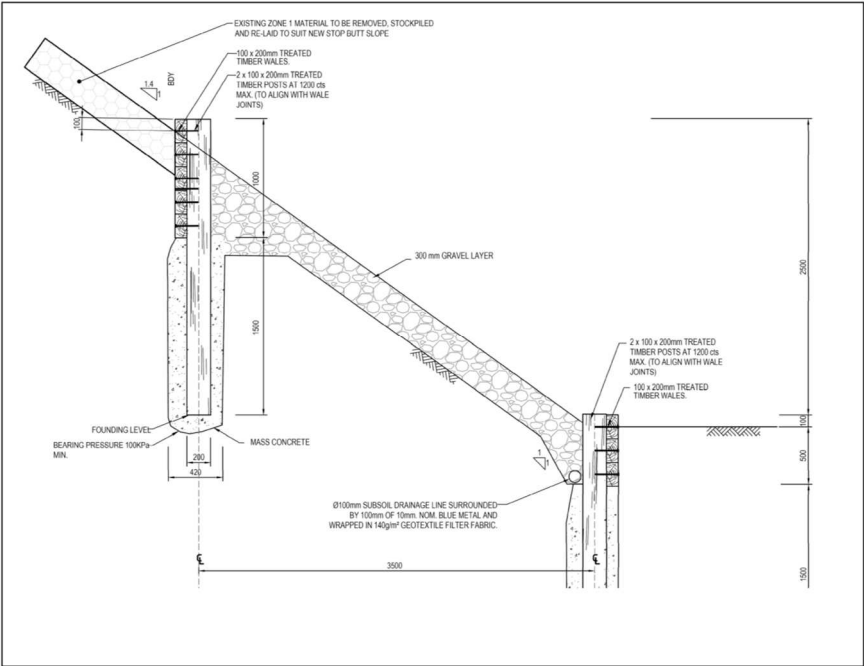


FIGURE 4: Lime treatment and Drainage Details.

### 3.3 Stopbutts and Bullet Catchers

As part of the rehabilitation works to the 800m range and construction of the 500m and 50m ranges specialised bullet catchers were included in the construction of the final stop butts for all the ranges. These bullet catchers consist of 300mm gravel layer enclosed in treated pine timber boxing and are designed to reduce potential for bullet skip or ricochet. The gravel also acts to allow free drainage to collection trenches and the lime treatment process reducing potential for leaching of contaminants to the sub surface.

Figure 5 provides an indicative bullet catcher and stop butt detail.



**FIGURE 5: Bullet Catcher and Stop Butt Detail.**

## 4 Quality Assurance and Data Control

### 4.1 Data Quality Objectives (DQO) Process

The DQO process is a seven (7) process applied to optimise the design of the sampling and analysis and to ensure that all objectives of the investigation are met.

DQOs have been developed to detail the type of data that is needed to meet the overall objectives of this project. The DQOs presented in this document have been developed consistent with the following published guidance;

- National Environment Protection Council (1999) National Environmental Protection Measure 1999 as amended 2013 – Assessment of Site Contamination. Schedule B (2) Guideline on Site Characterisation (NEPC 2013);
- NSW DECC (2007) Guidelines for the Assessment and Management of Groundwater Contamination;
- NSW DECC (2006) Guidelines for the NSW Site Auditor Scheme (2nd Edition);
- NSW EPA (1995) Sampling Design Guidelines;
- NSW EPA (2000) Guidelines for Consultants Reporting on Contaminated Sites;
- Australian/New Zealand Standard, AN/NZS 4360:2004, Risk Management – Principles and guidelines; and
- Australian/New Zealand Standard, AN/NZS 5667.11:1998, Water Quality – Sampling - Guidance on sampling of ground waters.

The seven (7) steps are outlined, as follows:

***Step 1: State the Problem – concisely describe the problem to be studied. Review prior studies and existing information to gain a sufficient understanding to define the problem;***

Previous assessments, range design and current usage indicate potential contamination issues associated with the stop butt and immediate surrounds, primary and secondary shot fall areas AND drainage pathways.

Further investigation is needed to confirm the location, nature and extent of contamination (if present) and to determine what further action may be required.

***Step 2: Identify the Decision – identify what questions the study will attempt to resolve, and what actions may result;***

***The primary question(s) that this investigation will attempt to resolve are ....***

What are the characteristics of any contamination if present in the range and surrounds?  
Is further action e.g. a risk assessment or Remediation Action Plan (RAP) required to address any contamination issues?  
Are additional works required to respond to ongoing contamination and mitigate any risk to the surrounding environment?

***Step 3: Identify the Inputs to the Decision – identify the information that needs to be obtained and the measurements that need to be taken to resolve the decision statement;***

The locations for sampling are presented in a Sampling Rationale Matrix for each range (see Sect 6).

The contaminants of potential concern in soil/sediment/water have been selected based on the

past and use as a shooting facility.

Contaminants of potential concern are presented in the list of Analytes within the SAQP Tables for each range (see Section 6.0)

Results will be assessed against the following guidelines

ANZECC 2000 Water Quality and Sediment Quality Guidelines and

NEPM 1999 (amended 2013) Health Investigation Levels (HILs) and Ecological Investigation Levels (EILs) for Soil.

(HILs) C. Parks, recreational open space and playing fields: includes secondary schools.

(HILs) D. Commercial/Industrial: includes premises such as shops and offices as well as factories and industrial sites.

NEPM (2013) HIL D criteria do not appear to be applicable on the site and have been referenced for information purposes only. The site is zoned SP1 Special Activities for the purposes of a shooting range under the State Environmental Planning Policy (State Significant Precincts) 2005. There are areas outside the ranges themselves within the SHRSC that are zoned E2 Environmental Conservation.

Specific investigation levels for the contaminants of potential concern are presented in Section 6 Site Assessment Criteria

***Step 4: Define the Study Boundaries – specify the time periods and spatial area to which decisions will apply. Determine when and where data should be collected;***

The investigation is confined to range areas including fairway, rear of stop butt and associated drainage as shown in Figure 3.

No investigation will be conducted outside of the site boundaries as the areas of concern are on top of a spur line/hill and contaminant migration has been limited vertically and horizontally by design layout and area usage.

Soil sampling will be conducted around the face of the stop butt plus from areas immediately down gradient from areas which receive bullet impacts.

Sampling will also be undertaken down gradient of the stop butt in overland/surface flow lines and within the area at the rear of the stop butt where surface water exits the site.

Samples will be collected surrounding bushland areas in close proximity to the ranges

Water and Sediments will be taken from basins within the SHRC in addition to adjacent creeks off the range but where these can be readily accessed below the outlet points of the basins.

***Step 5: Develop a Decision Rule – define the statistical parameter of interest, specify the action level, and integrate the previous DQO outputs into a single statement that describes the logical basis for choosing among alternative actions;***

The proposed sampling density/frequency across the subject assessment area has not been strictly prepared to comply with the NSW EPA sampling density guidelines based on the assessment area.

The sampling strategy is based on previous assessments of site condition, range design, knowledge of site use and shot fall and the condition of the surrounding environment. The strategy is therefore considered sufficient to characterize contaminant impacts at the area in general accordance with the NSW EPA Sampling Design Guidelines.

The sampling frequency as acceptable for the purposes of site audit as it is in general accordance with the NSW EPA Sampling Design Guidelines.

Additional targeted sampling may be undertaken based on site observations during the site inspection;

If the contaminants in the soil outside defined shot fall areas are identified above the adopted assessment criteria, then the soil should be considered as potentially contaminated and then either subjected to further risk assessment AND/OR remediated AND/OR managed accordingly.

If concentration of contaminants in sediments or water samples is identified above the adopted assessment criteria then the sampled areas should be considered as potentially contaminated and then managed accordingly. Augmentation of drainage from the stop butt area should be considered.

***Step 6: Specify Tolerable Limits on Decision Errors – define the decision maker's tolerable decision error based on a consideration of the consequences of making an incorrect decision.***

***Data generated during this project must be appropriate to allow decisions to be made with confidence.***

***The potential decision errors must be identified, the potential consequences evaluated, and the severity of decision error consequences assessed, the null hypothesis must be defined and what level of false positive or false negative decision error will be acceptable for the site assessment must be specified.***

Considering the current and ongoing use as a recreational shooting range it has been determined that the two decision errors for the contaminants of concern are:

Type I error – deciding that site soils are within the assessment criteria when they truly are not; and

Type II error – deciding that site soils exceed the assessment criteria when they truly do not.

The consequences of deciding that the soils exceed the assessment criteria when they truly do not, will be further human health and/or ecological risk assessment and/or active remediation/management of site soils.

The consequences of deciding that the soils do not exceed the remediation acceptance criteria when they truly do, will be that contaminated soils will be left unmanaged on the site and may potentially endanger human health or pose ongoing risks to the environment. Additionally, the owners of the site may be liable for future damages and environmental clean-up costs.

For site soils, sediments and water and for each respective contaminant of concern, the baseline condition or null hypothesis is “the soils/sediments/water levels exceed the assessment criteria”. The alternative hypothesis is “the soils/sediments/water levels are within the assessment criteria”.

It is noted that the past and ongoing use of the site is such that contamination is expected and that ongoing contamination of specific areas will be unavoidable. As such management of the site as a potentially contaminated area is the default approach.

Samples will be analysed at a National Association of Testing Authorities (NATA) Accredited Laboratory and as per the laboratory's Quality Assurance targets.

***Step 7: Optimise the Design – evaluate information from the previous steps and generate alternative data collection designs. Choose the most resource-effective design that meets all DQOs.***

The proposed data collection design has been described in Section 6: SAQP and is expected to satisfy the DQOs.

Targeted sampling will be conducted to accurately define the lateral and vertical extent of contaminants expected at the site.

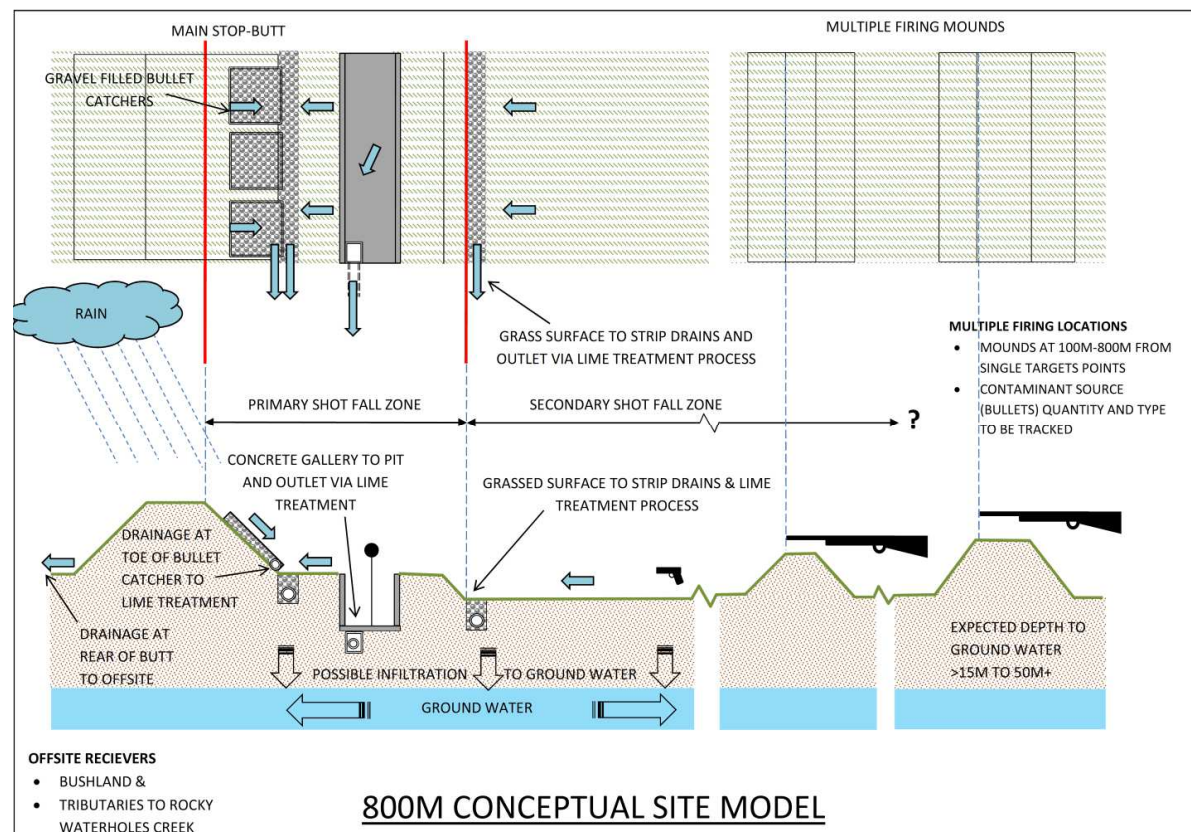
## 5 Conceptual Site Models (CSM)

### 5.1 800m Range: Conceptual Site Model (CSM)

The figure below provides a schematic CSM for the 800m range target area and surrounds. The CSM below aims to identify the following aspects relevant to the 800m range, they are:

- Areas of potential concern;
- Contaminants of potential concern;
- Potential contaminant exposure or migration pathways; and the
- Human and/or ecological receptors.

Additional elements of the CSM are discussed in the sections following.



**FIGURE 6: 800m Range: Conceptual Site Model (CSM)**

#### 5.1.1 Existing infrastructure and layout

##### **Stop butt and target area**

The primary potential area of concern identified at the 800m range is the target area, stop butt, bullet catcher, and surrounds.

The 800m range target area consists of target frames which are manually controlled from within a safe ~3m deep trench (or gallery). This gallery provides access to the stop butt for maintenance and is set below the line of fire.

In-front of the gallery there is a smaller mound or mantlet running the full length of the gallery and the target area. The purpose of this mantlet is to capture low projectiles and low ricochets, to protect the gallery from repeated strikes and protect the back side of the gallery by defining the firing line for targets so that it is backed by the stop butt.

At the rear of the gallery, a large earthen mound forms the stop butt. Directly behind the targets gravel filled boxes or bullet catchers are set on the face of the stop butt. These boxes act to capture bullet strikes after they have passed through the targets.

In addition, there are multiple firing mounds along the range spaced at 100m intervals set at 100-800m from the target area. A defined firing area used by pistol shooters is located on flat ground at approximately 25m from the targets.

A gallery area has been provided in-front of the stop butt face.

#### **Formal and informal drainage system**

A secondary area of potential concern identified at the 800m range is the new drainage system from the stop butt leading off site to the South East.

The rear area of the stop butt drains via a single channel to the south. This channel discharges over a flat area located 100-110m to the rear of the targets. Water then makes its way to natural drainage channels and upper tributaries of Rocky Waterholes Creek.

### 5.1.2 Sources of contamination and potential contaminants of concern

The OEMP for the SHRSC requires record keeping of the number of rounds /volume of bullets fired and the type of bullets fired so that annual estimates of shot fall can be calculated for each range for management purposes.

The 800m range is designed so that all bullets strike the mantlet face or the stop butt behind the target into the bullet catchers. These are the primary impact areas.

The material at the primary impact areas of the 800m range are able to be removed and sifted to remove bullet fragments or relocated for further treatment and/or removed from site as part of maintenance activities.

It is possible that some bullets may be fired over the stop butt entirely or similarly into the intermediate firing mounds along the range length prior to the target area (the secondary impact areas) however given this is a supervised range, this loss should be in very low volumes.

A broad suite of sample analytes was proposed within this SAQP given the potential variety of ammunition used at the range. However, the primary contaminant of concern at the 800m range is considered to be Lead (Pb). Lead is the predominant constituent of ammunition shot used in most higher calibre rifles which have been used at the range.

The nominated suite of analytes for this site assessment is presented in Section 6.1 Tables 3A, B & C.

### 5.1.3 Identified contaminant migration pathways

The primary process for migration of contaminants from the stop butt and surrounds is identified to be via surface runoff and infiltration into the subsurface. Maintenance of stable ground cover over the surface acts to minimise potential for generation of dust from the area and also reduce potential for erosion and mobilisation of sediments. Maintenance may also include application of ameliorants to maintain a stable soil pH.

The CSM indicates the current pathways for surface water movement:

- The stop-butt benches and gallery drains as to the south east via new formal drainage infrastructure including subsoil drains, pits and open drains.
- Surface water runoff from the mantlet and the area immediately in front flows with other surface water from the range area to various points at the range perimeter.
- The area at the rear of the stop butt drains to the south via an open channel.
- Surface water at the side of the target area flows to the perimeter of the range.

The potential exists for leaching and vertical migration of contaminants into the subsurface from the primary and secondary shot fall areas. This potential is mitigated by the design of the gravel bullet catcher at the primary shot fall area which moves water more quickly to the formal drainage.

Depth to ground water is not known at the 800m range however based on the environmental assessment undertaken prior to construction of the SHRSC, groundwater is considered unlikely to be impacted by the contaminants of potential concern on the site. Therefore impacts on sources of potential water supply are not a consideration and as such Groundwater Investigations (GILs) for Fresh Waters will be used as the assessment level for management response.

### 5.1.4 Identified exposure routes

Three possible human exposure routes have been identified for the lead shot present at the range, they are:

- Direct contact by range users with lead impacted soils and shot
- Migration/infiltration of lead impacted surface water into retention ponds/basins and recreational water resources;
- Inhalation/ingestion of airborne lead impacted dust.

#### **Direct contact**

Two shot fall areas have been identified where direct contact (includes ingestion or absorption through the skin) with lead present in soil or shot by range users is possible where areas are not managed.

The primary impact areas where direct shot is received are the stop-butt face and the face of the mantlet. The secondary areas impact areas are the gallery and the areas in front of the mantlet. These areas in are shown on the CSM diagram.

#### **Surface Water migration**

Runoff and infiltration of rainwater that becomes impacted with lead could potentially have a low level impact on nearby downgradient surface water receptors however specific site drainage and water quality measures have been included in the design of the SHRSC to address and mitigate this potential.

**Airborne dust ingestion/inhalation**

Soil particles contaminated with lead around shot fall areas can become dry and be mobilized by wind events to either migrate off site or be ingested/inhaled by range users where areas are not managed.

**5.1.5 Identified Receptors**

The number of potential receptors identified are consistent between all the ranges at the SHRC:

- The SHRSC is situated within the Bargo State Conservation Area and is next to Nattai National Park which are known recreational areas and are home to local flora and fauna.
- The SHRSC is situated on a ridge line and drains to multiple drainage lines in the upper catchment. These are tributaries to Rocky Waterholes Creek which is a potential recreational water resource.
- SHRSC users and the general public visit the facility under supervised management protocols.

Receptor exposure will be managed under the OEMP which will take into account the specific shot fall patterns, ground cover requirements and direction of surface water movement at each range.

Site access restrictions and maintenance of suitable ground cover at the areas of potential concern will reduce the likelihood of direct human exposure to contaminants at the source.



## 5.2 50m: Conceptual Site Model (CSM)

The figure below provides a schematic CSM for the 50m range target area and surrounds. The CSM below aims to identify the following aspects relevant to the 50m range, they are:

- Areas of potential concern;
- Contaminants of potential concern;
- Potential contaminant exposure or migration pathways; and the
- Human and/or ecological receptors.

Additional elements of the CSM are discussed in the sections following.

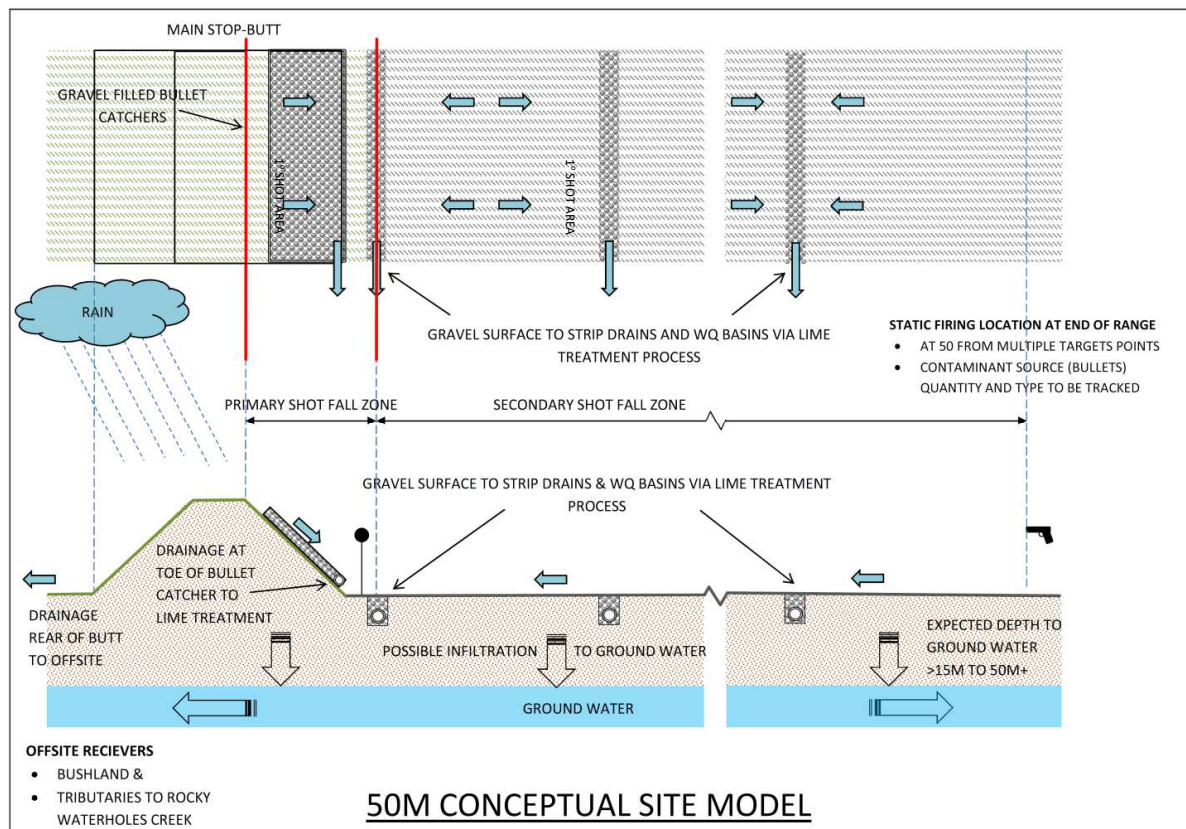


FIGURE 7 - 50m: Conceptual Site Model (CSM)

### 5.2.1 Existing infrastructure and layout

#### **Stop butt and target area**

The primary potential areas of concern identified at the 50m range are the target area, stop butt, bullet catcher, and surrounds.

The 50m Range consists of a five individual ranges separated by concrete dividing walls each with a single line of firing positions and a single stop butt behind the targets. The individual ranges are designed for varying uses; four are fully enclosed with gravel on the floor. The fifth range is more open with a grassed surface.

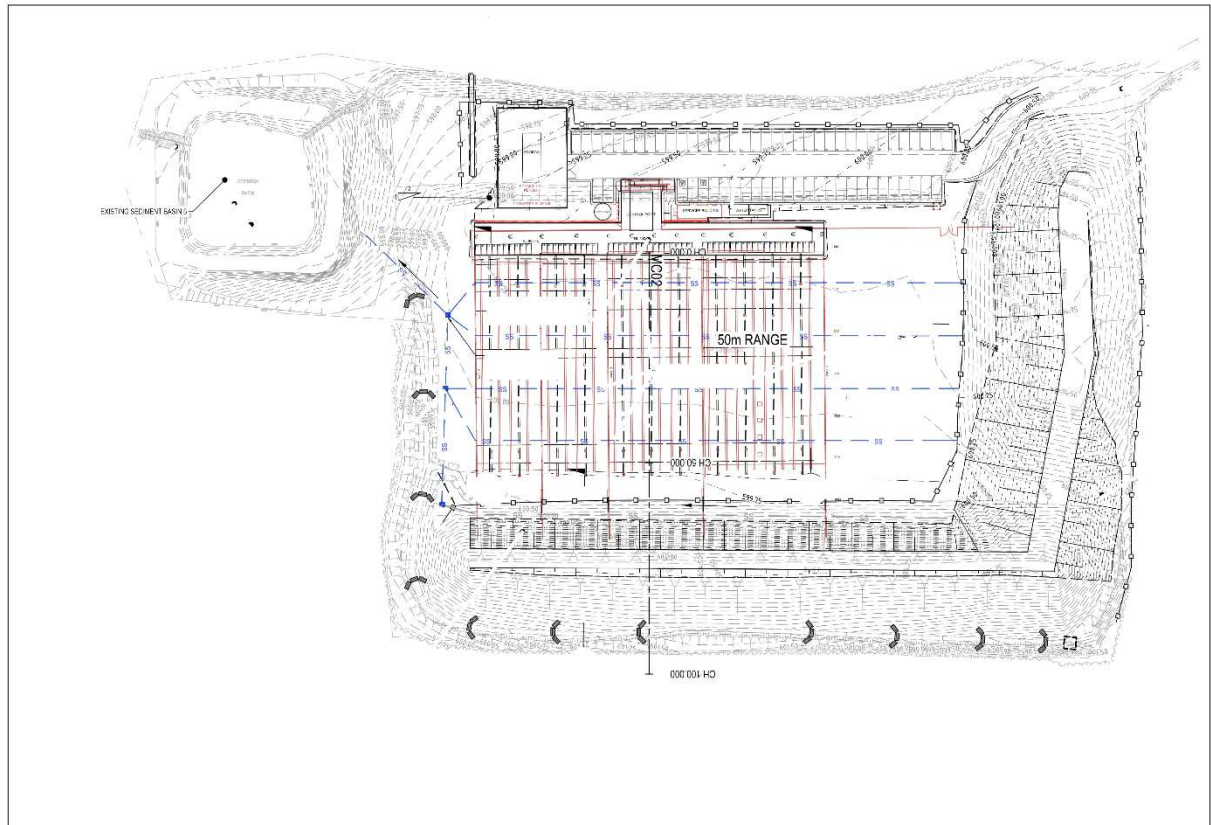
Behind the targets, a gravel filled bullet catcher is proved at the face of the stop butt.

### **Formal and informal drainage system**

A secondary area of potential concern identified at the 50m range is the new drainage system from in front of the stop butt leading to Basin 5.

It is possible that some shot fall will occur within the floor area of the ranges.

Refer to Figure 8 for the current 50m Range layout.



**FIGURE 8 - 50m Range Layout**

#### **5.2.2 Sources of contamination and potential contaminants of concern**

The 50 and 500m ranges are used by recreational and competitive shooters. The OEMP for the SHRSC requires record keeping of the number of rounds /volume of bullets fired and the type of bullets fired so that annual estimates of shot fall can be calculated for each range for management purposes.

The 50m range is designed so that all bullets strike the stop butt behind the target into the bullet catchers. These are the primary impact areas. Other areas within the range (e.g. the range floor) may receive bullet fall, ricochet or skip from the primary impact area. These are indicated as secondary impact areas on Figure 7.

The butt and bullet catcher at the 50m is designed to prevent the skipping of bullets or fragments to the rear of the butt. Ongoing sampling includes the rear of the stop-butt to confirm the effectiveness of design. It is possible that some bullets may be fired over the stop-butt entirely however, given this is a supervised range this loss should be in very low volumes.

The material at the primary impact areas of the 50m range are able to be removed and sifted to remove bullet fragments or relocated for further treatment and/or removed from site as part of maintenance or construction activities.

The type of bullets will be used to confirm the range of analytes for ongoing sampling. A broad suite of sample analytes is proposed within this SAQP given the potential variety of ammunition used at the range. However, the primary contaminant of concern at the range is considered to be Lead (Pb).

The suite of analytes is presented in Section 6.2 Tables 5A, B & C

### 5.2.3 Identified contaminant migration pathways

The primary process for migration of contaminants from the primary and secondary impact areas and surrounds would be via surface runoff and potentially leaching to ground water. Maintenance of stable ground cover over the surface acts to minimise potential for generation of dust from the area and also reduce potential for erosion and mobilisation of sediments. Maintenance may also include application of ameliorants to maintain a stable soil pH.

The CSM diagram indicates the pathways for surface water movement:

- A collection trench runs in-front of the stop butt of the 50m Range which directs surface water via a pipe to the lime treatment pit and then to the water quality basin
- No surface water from possible shot-fall areas (primary and secondary) is able to bypass the drainage to the Water Quality Basins.
- The new water quality basin has stable gabion spillways. The basins discharge to the natural catchment and then ultimately to the tributaries of Rocky Water Holes Creek.

The potential exists for leaching and vertical migration of contaminants into the subsurface from the primary and secondary shot fall areas. This potential is mitigated by the design of the gravel bullet catcher at the primary shot fall area which moves water more quickly to the formal drainage.

Environmental Assessment undertaken prior to the construction of the SHRSC presented that groundwater is expected at depths greater than 15m and likely greater than 50m (Refer to 2.4.5 Groundwater). Therefore impacts on sources of potential water supply are not a consideration and as such Groundwater Investigations (GILs) for Fresh Waters will be used as the assessment level for management response.

### 5.2.4 Identified exposure routes

Three possible human exposure routes have been identified for the lead shot present at the range, they are:

- Direct contact by range users with lead impacted soils and shot
- Migration/infiltration of lead impacted surface water into retention ponds/basins and recreational water resources;
- Inhalation/ingestion of airborne lead impacted dust

**Direct contact**

Two impact areas have been identified where direct contact (includes ingestion or absorption through the skin) with lead present in soil or shot by range users is possible where areas are not managed.

The primary impact areas where direct shot is received are the stop-butts face and the face of the mantlet.

The secondary impact areas are the floor of the range especially in front of the target area and potentially at the rear of the stop butt. These areas are shown on the CSM diagram.

**Surface Water migration**

Runoff and infiltration of rainwater that becomes impacted with lead could potentially have a low-level impact on nearby downgradient surface water receptors however specific site drainage and water quality measures have been included in the design of the SHRSC to address and mitigate this potential.

**Airborne dust ingestion/inhalation**

Soil particles contaminated with lead around shot fall areas can become dry and be mobilized by wind events to either migrate off site or be ingested/inhaled by range users where areas are not managed.

### 5.2.5 Identified Receptors

The number of potential receptors identified are consistent between all the ranges at the SHRSC:

- The SHRSC is situated within the Bargo State Conservation Area and is next to Nattai National Park which are known recreational areas and are home to local flora and fauna.
- The SHRSC is situated on a ridge line and drains to multiple drainage lines in the upper catchment. These are tributaries to Rocky Waterholes Creek which is a potential recreational water resource.
- SHRSC users and the general public visit the facility under supervised management protocols.

Receptor exposure will be managed under the OEMP which will take into account the specific shot fall patterns, ground cover requirements and direction of surface water movement at each range.

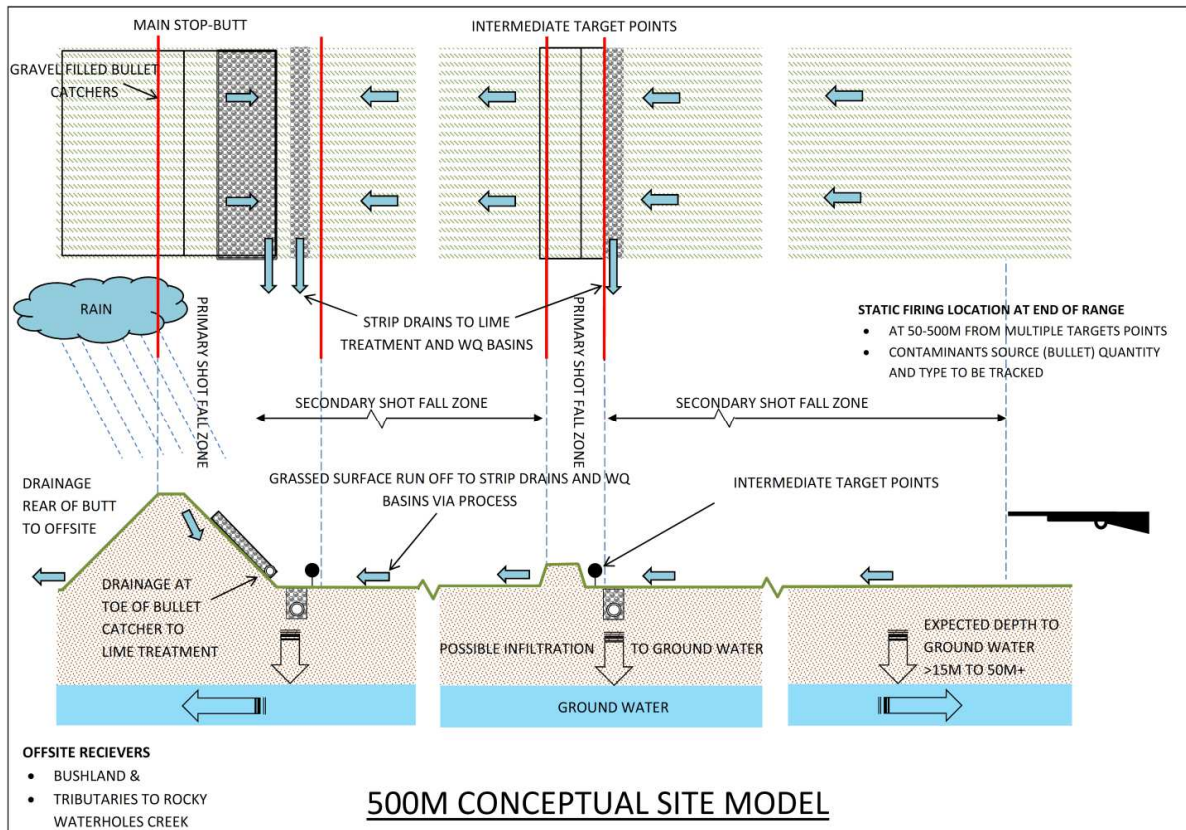
Site access restrictions and maintenance of suitable ground cover at the areas of potential concern will reduce the likelihood of direct human exposure to contaminants at the source.

### 5.3 500m Range: Conceptual Site Model (CSM)

The figure below provides a schematic CSM for the 500m range target area and surrounds. The CSM below aims to identify the following aspects relevant to the 50m range, they are:

- Areas of potential concern;
- Contaminants of potential concern;
- Potential contaminant exposure or migration pathways; and the
- Human and/or ecological receptors.

Additional elements of the CSM are discussed in the sections following.



**FIGURE 9 - 500m: Conceptual Site Model (CSM)**

#### 5.3.1 Existing infrastructure and layout

##### **Stop butt and target area**

The primary potential areas of concern identified at the 500m range are the target areas, stop butt & intermediate mound, bullet catcher and surrounds.

The 500m is a single range consists of a single firing point and multiple (x6) mounds and target points set along the range length with a 7<sup>th</sup> Primary stop butt at the end of the range.

A gravel filled bullet catcher is proved at the face of the stop butt.

It is expected that significant shot fall will occur within the floor area of the range and into the intermediate target mounds.

##### **Formal and informal drainage system**

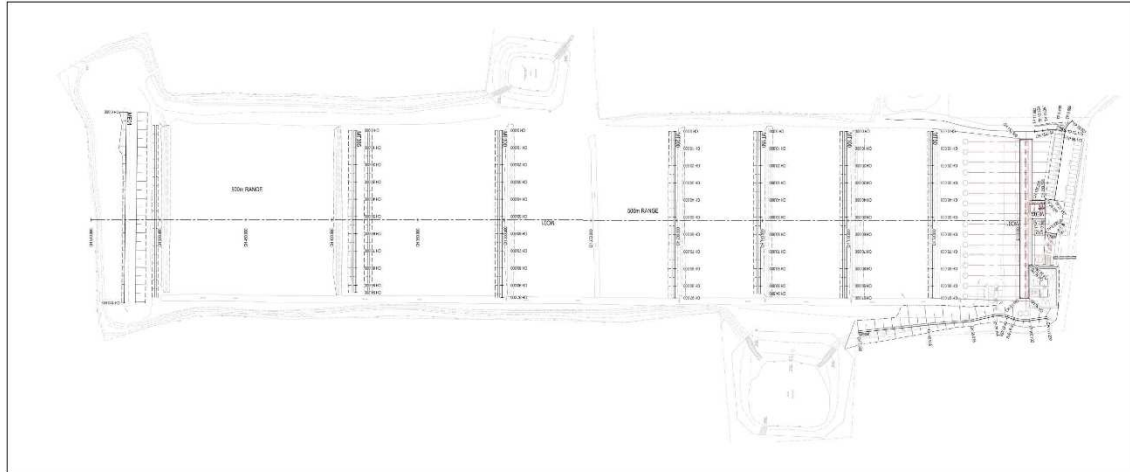
A secondary area of potential concern identified at the 500m range is the new drainage



system from the stop butt and intermediate mound.

Surface water from the 500m range fairway flows to strip drains set at the rear of the intermediate target mounds and at the toe of the stopbutt face. These drains then are connected via pipes to either of the two water quality basins.

Refer to Figure 10 for the for the current 500m Range layout.



**FIGURE 10 - 500m Range Layout**

### 5.3.2 Sources of contamination and potential contaminants of concern

The 500m range is used by recreational and competitive shooters. The OEMP for the SHRSC requires record keeping of the number of rounds /volume of bullets fired and the type of bullets fired so that annual estimates of shot fall can be calculated for each range for management purposes.

The 500m range and its use are designed so that bullets strike the intermediate target mounds and the final stop butt at the end of the range. Significant shot fall is expected between the intermediate mounds and into the fairway. These are the primary impact areas.

It is possible that some bullets may be fired over the stop butt entirely or into adjacent off range areas. These are the secondary impact areas.

The butt at the 500m is designed to prevent the skipping of bullets or fragments to the rear of the butt. Ongoing sampling includes the rear of the stop-butt to confirm the effectiveness of design. It is possible that some bullets may be fired over the stop-butt entirely however, given this is a supervised range this loss should be in very low volumes.

The material at the bullet catcher at face of the stopbutt is able to be removed and sifted to remove bullet fragments or relocated for further treatment and/or removed from site as part of maintenance activities.

The type of bullets will be used to confirm the range of analytes for ongoing sampling. A broad suite of sample analytes is proposed within this SAQP given the potential variety of ammunition used at the range. However, the primary contaminant of concern at the range is considered to be Lead (Pb). The suite of analytes is presented in Section 6.2 Tables 5A, B & C

### 5.3.3 Identified contaminant migration pathways

The primary process for migration of contaminants from the primary and secondary impact areas and surrounds would be via surface runoff and potentially leaching to ground water. Maintenance of stable ground cover over the surface acts to minimise potential for generation of dust from the area and also reduce potential for erosion and mobilisation of sediments. Maintenance may also include application of ameliorants to maintain a stable soil pH.

The CSM diagram indicates the pathways for surface water movement:

- Strip drains in-front of the stop butt of the 500m Range which directs surface water via a pipe to the lime treatment pit and then to the water quality basin
- No surface water from possible shot-fall areas (primary and secondary) is able to bypass the drainage to the Water Quality Basins.
- The new water quality basins have stable gabion spillways. The basins discharge to the natural catchment and then ultimately to the tributaries of Rocky Water Holes Creek.

The potential exists for leaching and vertical migration of contaminants into the subsurface from the primary and secondary shot fall areas. This potential is mitigated by the design of the gravel bullet catcher at the stopbutt and at the drainage within the primary shot fall areas which moves water more quickly to the formal drainage.

Environmental Assessment undertaken prior to the construction of the SHRSC presented that groundwater is expected at depths greater than 15m and likely greater than 50m (Refer to 2.2.5 Groundwater). Therefore impacts on sources of potential water supply are not a consideration and as such Groundwater Investigations (GILs) for Fresh Waters will be used as the assessment level for management response.

### 5.3.4 Identified Receptors

The number of potential receptors identified are consistent between all the ranges at the SHRC:

- The SHRSC is situated within the Bargo State Conservation Area and is next to Nattai National Park which are known recreational areas and are home to local flora and fauna.
- The SHRSC is situated on a ridge line and drains to multiple drainage lines in the upper catchment. These are tributaries to Rocky Waterholes Creek which is a potential recreational water resource.
- SHRSC users and the general public visit the facility under supervised management protocols.

Receptor exposure will be managed under the OEMP which will take into account the specific shot fall patterns, ground cover requirements and direction of surface water movement at each range.

Site access restrictions and maintenance of suitable ground cover at the areas of potential concern will reduce the likelihood of direct human exposure to contaminants at the source.

## 6 Sampling Analysis and Quality Plans

The following sampling plans detail sampling exercises in accordance the Monitoring Program detailed within Section 5 of the SHRSC WCMP.

- Section 5.4 of the WCMP provides frequency of scheduled sampling activities;
- Section 5.4 of the WCMP provides the concentrations of analytes used in the assessment;
- Section 5.3 of the WCMP provides information on constraints and limitations for sampling surface waters off range; and
- Section 5.5 WCMP provides adopted assessment criteria and derivation method for EILs.

During the sampling activity any variations from the SAQP should be recorded for reference in the future annual review.

### 6.1 SAQP for the 800m Range

Table 2 provides the Sampling Rationale Matrix for the 800m range.

<b>TABLE 2 – Sampling Rationale Matrix (800m Range)</b>			
<b>Sample Location</b>	<b>Sample type</b>	<b>Context (in landscape) of Sample location</b>	<b>Rationale for selection</b>
Bullet Catcher	Gravel (per Soil)	Primary Impact Zone	Confirm levels in area of expected contamination
Stop butt above bullet catcher	Soil	Face of stop- butt behind targets – impact area and adjacent to impact area	Confirm levels in area of expected contamination
Rear of stop butt	Soil	Possible shot fall area	Confirm no contamination
Bench in front of stop butt	Soil	Down gradient of stop butt impact area	Confirm levels in expected area of contamination. Identify contamination
Gallery	N/A	Shot fall area	Concrete area – record of cleaning to be made. Record visual inspection
Target Mound/Mantlet and associated drainage	Soil	Mound in front of galley – potential impact area	Confirm levels in expected area of contamination. Identify migration of contamination
Area in front of Mantlet	Soil	Outside drainage to impact areas	Identify migration of contamination
Over storeroom – west of gallery	Soil	Outside drainage to impact areas	Identify migration of contamination
New culvert East of Stopbutt	Soil	Down gradient of stop butt impact area	Confirm levels in expected area of contamination. Confirm/characterise migration of contamination
Mulched area behind stop butt	Soil	Down gradient of impact area– water quality area for stop butt	Confirm levels in expected area of contamination. Confirm migration of contamination



Outlet from mulched area	Soil, water, sediment	Discharge point for surface water	Assess for contamination from local catchment
Basin: East of 800m range	Surface, water sediment	Surface water from road and part range areas	Assess for contamination from local catchment
Pits – Lime treatment process	Water, Sediment if present	Possible water and sediment from primary impact area stop butt and surrounds	Monitor function of lime treatment process. Assess for failure of control and movement of sediment

Tables 3A -C provide the suite of analytes, planned location and numbers of samples at the 800m range as prepared for the SAQP.

Metals of concern included in the analysis suite are those to be common in the composition of bullets.

Depth of samples is generally 100mm as this reflects the expectation of shot fall lying on or near to the surface and also the possible migration of contaminants primary via surface run off.

Additional samples may be taken in other locations due to site conditions and observations made at the time of sampling.

Analytes/Suite	Locations	Number (SAQP)
PAH	Stop butt/bullet catcher (impact area behind targets)	2
Cadmium	Stop butt non-shot area – between bullet catchers	2
Arsenic	Stop butt directly under bullet catcher	2
Chromium	Gallery area- concrete	NIL-Visual only
Mercury	Bench at front of butt/foot of stop butt	only
Nickel	Target mound/mantlet	3
Tin	In front of target mound/mantlet and associated drainage	3
pH	Stop butt –rear	3
Lead	West of Gallery (grassed area over store room)	1
Copper	Below outlet of culvert from stop butt drainage	1
Zinc	Exit channel from sump to offsite- to flow line over escarpment	2
Antimony		2
Iron		
CeC		
Clay Content	<b>Duplicate samples</b>	
TCLP	<b>Triplicate samples</b>	<b>2</b>
<b>(for samples with elevated results only)</b>		<b>2</b>
	Total	25

Analytes/Suite	Locations	Number
Nickel	Basin adjacent to 800m range	1
Arsenic	Reservoir in lime treatment unit	1
Chromium	Channel at rear of 800m range (If available)	1

Total Phosphorus (TP)	Pit within Lime treatment process (if accessible and water present)	1
Total Nitrogen (TN)		
Ammonia (NH3)		
Dissolved Oxygen (DO)		
pH 1		
Lead		
Copper		
Zinc		
Antimony		
Phosphate		

<b>TABLE 3C: SEDIMENT (800m Range)</b>				
Analytes/Suite	Locations	Number		
PAH	Basin adjacent to 800m range	1		
Cadmium	Pit within Lime treatment process (if accessible and sediment present)	1		
Arsenic				
Chromium				
Mercury				
Nickel				
Tin				
Clay Content				
pH				
Lead				
Copper				
Zinc				
Antimony				
Iron				
CeC				
TCLP (for samples with elevated results only)				
			Total	2

## 6.2 SAQP for the 50m and 500m Range

Table 4 below gives the Sampling Rationale Matrix for the 50 and 500m Ranges.

<b>TABLE 4: SAMPLING RATIONALE MATRIX: 50M &amp; 500M RANGES</b>			
<b>Sample Location</b>	<b>Sample Type</b>	<b>Context (in landscape) of Sample location</b>	<b>Rationale for selection</b>
On range (500m)	Soil	Main body of range / fairway/shot zone	Identify contamination – confirm no migration of contamination
On range (50m)	Soil or Gravel	Main body of range	Identify contamination – confirm no migration of contamination
Face of stop butt / bullet catcher	Gravel	Impact area of range	Confirm concentrations of expected contamination
Face of stop but above bullet catcher	Soil	Potential impact area of range	Confirm concentrations of expected contamination
Area immediately in front of toe of stop butt associated drainage	Soil	Outside drainage to impact area	Confirm no migration of contamination
Basins/basins	Water, sediment	Basins receive water from range areas	Confirm no migration of contamination Confirm water quality parameters
Rear of stop butt	Soil	Possible shot fall area	Confirm no contamination
Creek water off range (where available from Ephemeral creeks following rainfall or from natural pools)	Water, sediment	Separate from range run off	Confirm no migration of contamination. Confirm water quality parameters
Pits within the Lime treatment process (Note Lime and directional pits do not retain water)	Water, Sediment if present	Possible water and sediment from primary impact area stop butt and surrounds	Monitor function of lime treatment process. Assess for failure of control and movement of sediment

Tables 5A -C provide the suite of analytes, planned location and numbers of samples at the 50m and 500m ranges as prepared for the SAQP.

Metals of concern included in the analysis suite are those to be common in the composition of bullets.

Depth of samples is generally 100mm as this reflects the expectation of shot fall lying on or near to the surface and also the possible migration of contaminants primary via surface run off.

Additional samples may be taken in other locations due to site conditions and observations made at the time of sampling.

<b>TABLE 5A: SOILS</b>				
Analytes/Suite	Range	Locations	Number	
PAH	500	On range – 1 from each target bay	7	
Cadmium		- plus random over all bays (max 2 per bay)	3	
Arsenic			5	
Chromium		Off range / bush land	3	
Mercury		Face of stop main stop butt	6	
Nickel		-plus 1 from each intermediate mound	3	
Tin				
pH		Within 10m in-front of toe of main	6	
Lead		Stop-butt and associated drainage		
Copper		-plus 1 from in front of each		
Zinc		intermediate mound		
Antimony		50	On range – gravel or soil range floor	3
Iron			Off range / bushland	3
CEC	Face of stop butt – bullet catcher		3	
Clay Content	Face of stop butt – from above bullet		2	
TCLP	catcher		1	
<b>(for samples with elevated results only)</b>	Soil material below invert of bullet		3	
	catcher			
	Within 10m in-front of toe of Stop-			
	butt and associated drainage			
	50m/500m range	<b>Duplicate sample</b>	1	
		<b>Triplicate sample</b>	1	
	<b>Total</b>		<b>50</b>	

<b>TABLE 5B: WATER</b>		
Analytes/Suite	Locations	Number
Nickel	Basin at car park (Basin 4)	1
Arsenic	50m (Basin 5)	1
Chromium	500m East (Basin 3)	1
Total	500m West (Basin 2)	1
Phosphorus (TP)	200m (Basin 1)	1
Total Nitrogen (TN)	Creek waters off range (where available from Ephemeral creeks following rainfall or from natural pools)	2
Ammonia (NH3)	Pits in Lime treatment process (if accessible/ present)	8
Dissolved Oxygen (DO)	Duplicate sample	1
pH 1	Triplicate sample	1
Lead		
Copper		
Zinc		
Antimony		
Phosphate		
Turbidity		
	<b>Total</b>	<b>18</b>

<b>TABLE 5C: SEDIMENT</b>		
Analytes/Suite	Locations	Number
PAH	Basin at car park (Basin 4)	1
Cadmium	50m (Basin 5)	1
Arsenic	500m East (Basin 3)	1
Chromium	500m West (Basin 2)	1
Mercury		
Nickel	200m (Basin 1)	1
Tin	Creek waters off range (where available from Ephemeral creeks following rainfall or from natural pools)	2
Clay Content		
pH		
Lead	Pits within Lime treatment process (if present)	8
Copper		
Zinc		
Antimony		
Iron		
CEC		
<b>TCLP (for samples with elevated)</b>		
	Total	15

## 6.3 Visual Inspections

Section 5.4 of the SHRSC WCMP presents the items and frequency for visual inspections. These inspections are summarised following.

### 6.3.1 Water quality structures and surrounds

Inspect water quality basins for;

- evidence of scour from flows at inlet or outlet
- evidence of scour or failure at inside batters of structures
- evidence of scour, instability or failure of external batters of structure

### 6.3.2 Engineering controls – earthworks

Inspect Berms, drains channels, stock butts, access tracks and culverts for;

- evidence of scour from flows at inlet or outlet of culverts and channels or at invert of channels and drains.
- evidence of instability or erosion of track surfaces and associated drainage.
- evidence of scour, instability or failure of batters or formation of stopbutts.

### 6.3.3 Engineering controls – lime treatment process

Inspect accessible subsurface elements of lime treatment process / Engineering controls for;

- Evidence of fragments of bullets and other extraneous materials within pits or chambers of the treatment control.
- Evidence of sediment washed into pits or chambers of the treatment control.

### 6.3.4 Safety and signage

Inspect site safety and signage including fencing around sediment basins and drainage measures for;

- Visibility of signage
- Location per that in SHRSC OEMP
- Condition

### 6.3.5 Shot loss

Inspect Range perimeter, especially 800m and 500m ranges for;

- Evidence of loss and/or damage from stray projectiles

### 6.3.6 Vegetation health

Inspect vegetation health of range floor and revegetated areas for;

- Percentage of ground cover -equivalent to C factor of 0.1 or lower (see WCMP)
- and vigour

## 6.4 Methodology

### 6.4.1 Soil sampling methodology

1. Soil Samples are to be collected in ~250ml glass sample jars provided by the Analytical Laboratory. Jars are to be labelled with;
  - Project title
  - Sample ID Number
  - Depth of Sample
  - Date of Sample
  - Identifier of Officer taking Sample
2. Samples will then be packed in a cooler with ice packs prior to being transported to the laboratory and tracked under chain of custody documentation.
3. Soil samples to be collected using a shallow auger or similar within the top 100mm of the soil surface where bullet or fragments was expected to be present (unless indicated otherwise).
4. Where soil material is too hard or soft for the auger, material was collected using a hand mattock/tool.
5. Where soils are observed to be excessively friable or where rocks/vegetation were present repeated samples are to be collected adjacent to each other to obtain an adequate sample volume.
6. Soil samples below 100mm if required are to be collected using a hand auger with extensions.
7. Vegetation/grass and rocks/gravel are to be screened from the samples collected.
8. Where shot fragments or projectiles are found in the sample these are to be removed and their presence recorded so that pure lead shot is not included in the sample submitted for analysis.
9. Between each sample collection the auger or hand tool is to be decontaminated by removing excess material from the face of the tool and washed down with distilled water.
10. Nitrile gloves are to be worn during sample collections and changed between locations to avoid cross contamination from the samplers hands.

### 6.4.2 Sediment sampling methodology

1. Sediment Samples are to be collected in ~250ml glass sample jars provided by the Analytical Laboratory. Jars are to be labelled with;
  - Project title
  - Sample ID Number
  - Depth of Sample

- Date of Sample
  - Identifier of Officer taking Sample
2. Samples are then then packed in a cooler with ice packs prior to being transported to the laboratory and tracked under chain of custody documentation.
  3. Sediment samples are to be collected within identified contaminant flow paths from ground level alluvium in surface water channels or from settled sediments at the sides of the water quality basins using a hand mattock or similar suitable collection tool.
  4. The collection tool is to be decontaminated using distilled water prior to collection.
  5. Nitrile gloves are to be worn during sample collections and changed between locations to avoid cross contamination from the samplers hands.

### 6.4.3 Water sampling methodology

1. Water samples are to be collected in a laboratory prepared and provided collection bottle. Bottles are to be labelled with;
  - Project title
  - Sample ID Number
  - Depth of Sample
  - Date of Sample
2. Samples will be collected from water quality basins using a sample bailer/pre-washed bottle attached to a sampling pole so samples could be collected from greater than 1.5m from the edge of the basin.
3. Samples collected from natural streams or pools within streams are to be collected from the middle of streams / pools.
4. Prior to collecting a sample the sample bailer bottle is rinsed with distilled water. And the rinsate is discarded well away from sample location.
5. Water samples were transferred to the collection bottles provided by the laboratory. Samples were then packed in a cooler with ice packs prior to being transported to the laboratory and tracked under chain of custody documentation and within the confirmed holding times for the various analytes.

#### Field Sampling

Field sampling of Soil pH or Water (pH or Turbidity) are to be undertaken in accordance with the instrument guidelines.

Field instruments are to be confirmed as calibrated per instrument guidelines and before every sampling exercise undertaken as part of the Monitoring Program within the SHRSC WCMP.



## 6.5 Laboratory QA QC

**The following information has been provided by the laboratory selected for the analysis (Envirolab Services Chatswood NSW.)**

### **NATA Accreditation**

*Envirolab is accredited by NATA to ISO 17025 under corporate accreditation number is 2901.*

### **Quality Assurance**

*Envirolab is NATA accredited to AS ISO/IEC 17025. This includes all aspects of the analytical process including sample preservation, sample registration, methodology, instrument calibration and maintenance, data records, calculations and reporting of results.*

*The laboratory operates under a definitive plan which specifies the measures used to produce data of a known precision and bias. The quality assurance plan includes implementation of Quality Control and Quality Assessment Procedures.*

*Quality Control is a set of measures within a sample analysis methodology to assure that the process is in control.*

*Quality Control measures included:*

- *Certification of operator competence*
- *Recovery of known additions*
- *Analysis of externally supplied standards*
- *Analysis of reagent blanks*
- *Calibration with standards*
- *Analysis of duplicates*
- *Control charts*

*Quality Assessment is the procedure for determining the quality of laboratory measurements by use of data from internal and external quality control measures.*

*Quality Assessment measures included:*

- *Laboratory inter-comparison trials*
- *Performance evaluation samples*
- *Performance audits*

*Envirolab met or exceeded NEPM (2013) guidelines for QC for this assessment.*

*The Quality Control guidelines for this assessment were:*

- *Duplicate: every 10 samples or per batch if <10*
- *Matrix Spike: every 20 samples or per batch if <20*
- *LCS: every 20 samples or per batch if <20*
- *Blank: every 20 samples or per batch if <20*

## 6.6 Laboratory Methods

Tables 6A and 6B below summarise the laboratory methods and NATA accreditation for each of the analytes for Soil/Sediment and Waters. Details within this table have been taken from the laboratory's capability statement.

<b>Table 6A :Soil /Sediment</b>				
Analysis suite	Technique	Reference method	PQL mg/L	NATA
Cadmium	020 ICP-AES	NIOSH 7301	0.4	Y
Arsenic			4	
Chromium			1	
Mercury			0.1	
Nickel			1	
Tin			1	
Lead			1	
Copper			1	
Zinc			1	
Antimony			7	
Iron			1	
PAH			Org-012 subset	
CEC	ICP	Aust. Lab Handbook 15B3	1meq/100g	
Clay Content	Hydrometer		1%	
pH	soil/water electrode	USEPA 9045	0.1 unit	Y

<b>Table 6B: Water</b>				
Analysis suite	Technique	Reference method	PQL	NATA
pH	Electrode	APHA4500H+	0.1 unit	Y
Arsenic	Metals-022 ICP-MS	USEPA 200.8 USEPA 3005A (prep) USEPA 6020A	1 µg/L	Y
Chromium			1 µg/L	
Nickel			1 µg/L	
Lead			1 µg/L	
Copper			1 µg/L	
Zinc			1 µg/L	
Antimony			1 µg/L	
Phosphate			Colourmetric	
Ammonia	Paste	EPA 350.1	0.005mg/L	Y
Total Nitrogen	Colourmetric	APHA4500-Norg	0.1 mg/L	Y
Total Phosphorous	ICP-AES or Colourmetric	USEPA 200.7 or APHA 4500-P	0.05mg/L	Y
Dissolved Oxygen		Inorg-112	0.1	

## 7 Site Assessment Criteria

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### 7.1 Rationale for Selection of Assessment Criteria

The following published assessment criteria have been referenced in the summary of results tables to characterise the contamination status of the site.

Comments are offered detailing why each criterion has been selected.

Section 6.1.1 presents the method for determination of EILs used for this assessment.

The data previously collected from non-operational areas of the SHRSC and surrounds has been used to determine Ambient Background Concentrations (ABC) as part of derivation of the EILs to be applied on the operational ranges.

#### Soil

##### NEPM

National Environment Protection (Assessment of Site contamination) Measure (2013)  
Health investigation level (HILs)

- C – Developed Open Space such as parks, playgrounds, playing fields
- D - Commercial/industrial includes premises such as shops, offices, factories and industrial sites.

The site is currently zoned as SP1: Special Activities – Shooting Range. The HIL C has been adopted as Tier 1 soil trigger values for management response. The HIL D have been presented for comparison and further discussion given that the shooting ranges are proposed to be managed and operated as a commercial facility.

##### NEPM

National Environment Protection (Assessment of Site contamination) Measure (2013)  
Ecological Investigation Levels (EILs)

#### Sediment

##### ANZECC

Water Quality Guidelines Chapter 3- Section 3.5.4 Table 3.5.1 Interim Sediment Quality Guidelines (LOW and HIGH triggers) (Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Australian and New Zealand Environment and Conservation Council, 2000)

#### Water

##### ANZECC PFWS

Protection of fresh water species - 95% level of protection trigger values (Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Australian and New Zealand Environment and Conservation Council, 2000) (Note that the NEPM GILs for Freshwater have been adopted from the ANZECC 2000 guidelines.)

The ANZECC PFWS was selected due to the proximity to fresh water courses and fresh groundwater

**ANZECC RWCG**

Recreational Water Quality Guidelines (Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Australian and New Zealand Environment and Conservation Council, 2000)

**NEPM**

National Environment Protection (Assessment of Site contamination) Measure (2013) Ground Water Investigation Levels (GILs) for Freshwater.

GILs for Antimony (Sb), within the 2000 Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Volume 2. Aquatic Ecosystems — Rationale and Background Information (Chapter 8) are not available due to insufficient data. As such a Low Reliability Trigger Value has been adopted.

### 7.1.1 Derivation of Ecological Investigation Levels (EILs)

This section presents the NEPM 1999 (amended 2013) method adopted by ErSed to derive the Ecological Investigation Levels (EILs) for this assessment.

Ecological Investigation Levels EILs (EILs) have been derived by summing the Ambient Background Concentration (ABC) and the Added Concentration Limit for the contaminants of concern i.e.

$$\text{EIL} = \text{ABC} + \text{ACL}$$

#### **Derivation of ABC**

Samples were collected from non-operational areas of the SHRSC and the heavy metal analytical results were used as a background sample data set. Data from samples collected from surface soils taken from drainage areas (sediments) was also used within the set.

Where sample results were below the limit of laboratory detection (i.e. <LOR) these were adjusted to the detection limit. The geometric mean of the data was used as the ABC to derive the EIL.

#### **Derivation of ACL**

Ambient Concentration Limits (ACLs) for metal analytes have been referenced from Tables 1(B) Schedule B1 (NEPM 2013).

Where required the geometric mean of pH and CEC have been used to calculate the ACL. The geometric mean for the clay content from samples taken from the 800m range has been used as a conservative value.

For the calculations of the EILs for lead (Pb) and copper the consultant has assumed that the criteria for public open space is the most relevant to the current site use.

### 7.1.2 Referenced NEPM 1999 (2013) Tier 1 Health Investigation Levels (HILs)

Published human health investigation criteria (HILs) have been sourced from table 1A Schedule B1 NEPM 1999 (Amended 2013).

As the site is currently zoned as SP1: Special Activities – Shooting Range, the HILs C – Recreational criteria will be applied.

## Part B: Monitoring Program Implementation and Report

### 8 Monitoring Program – Implementation

Table 7 below summaries the required frequency operational monitoring detailed in Section 5.4 of the WCMP

**Table 7: Annual Operational Monitoring Program**

What to be monitored	Frequency
Soils - Complete (Laboratory)	Annually
- pH (Laboratory)	Six monthly
- pH (Field with laboratory confirmation at 10% of samples)	Quarterly
Sediments - Complete (Laboratory)	Annually
- pH (Laboratory)	Quarterly
- pH (Field with laboratory confirmation at 10% of samples)	Six monthly
Surface Waters - Complete (Laboratory)	Six monthly
Visual - Basins - Engineering controls - Gallery (800m Range) - Lime treatment process - Safety and signage	Annually
- Range perimeter - Vegetation health	Six monthly

Table 8 below presents the annual monitoring program prepared to meet requirements detailed within section 5.4 the WCMP.

**Table 8: Monitoring Program Schedule**

Quarter	Activities	See Report Section
1	Field Sampling – pH in Primary and Secondary Impact Areas <ul style="list-style-type: none"> <li>• Soils</li> <li>• Sediments</li> </ul> Six Monthly Visual Inspections <ul style="list-style-type: none"> <li>• WQ Basins</li> <li>• Engineering Controls</li> <li>• Lime Treatment Process</li> <li>• Safety and Signage</li> <li>• Vegetation Health</li> </ul>	Part B this Report
2	Six Monthly Monitoring pH in Primary and Secondary Impact Areas <ul style="list-style-type: none"> <li>• Soils</li> <li>• Sediments</li> </ul> Six Monthly Monitoring <ul style="list-style-type: none"> <li>• Surface Waters</li> </ul>	Not included in this report
3	Field Sampling – pH in Primary and Secondary Impact Areas <ul style="list-style-type: none"> <li>• Soils</li> </ul>	Not included in this report

	<ul style="list-style-type: none"> <li>• Sediments</li> </ul> <p>Six Monthly Visual Inspections</p> <ul style="list-style-type: none"> <li>• WQ Basins</li> <li>• Engineering Controls</li> <li>• Lime Treatment Process</li> <li>• Safety and Signage</li> <li>• Vegetation Health</li> </ul> <p>Annual Visual Inspection of Range perimeter for shot loss.</p>	
4	<p>Annual Monitoring</p> <ul style="list-style-type: none"> <li>• Soil</li> <li>• Surface Waters</li> <li>• Sediments</li> </ul>	Not included in this report

Summaries of each sampling event are provided in the following sections. Laboratory results for monitoring events are provided within Appendixes;

- **Appendix 1: Quarter 1 Laboratory Results**

## 9 Monitoring Program – Quarter 2

A samplings exercise was undertaken **18 DEC 23** in accordance with Section 8.

A summary of the sampling event is given below.

### Variation this sampling event:

Quarter 1 sampling excise was missed due to illness.

A modified Quarter 2 was included incorporating any missed items from the Quarter 1

Summary of sampling event

**Table 9: Quarter 2 Sampling Event**

Aspect	See Report Section
Six Monthly Monitoring pH in Primary and Secondary Impact Areas (Laboratory) <ul style="list-style-type: none"> <li>• Soil</li> <li>• Sediments</li> </ul>	9.1
Six Monthly Monitoring <ul style="list-style-type: none"> <li>• Surface Waters</li> </ul>	
<b>Variation</b> Additional from Quarter 1 - Six Monthly Visual Inspections <ul style="list-style-type: none"> <li>• WQ Basins</li> <li>• Engineering Controls</li> <li>• Lime Treatment Process</li> <li>• Safety and Signage</li> <li>• Vegetation Health</li> </ul>	
<b>Additional</b> following recommendations from previous sampling <ul style="list-style-type: none"> <li>• Ammonia as N - If water is present within the drainage line at rear of 800m stop butt</li> </ul>	

### 9.1 Sampling (pH) Soil, Sediments and Surface Waters

The results from the QTR2 sampling exercise are provided for each range following. Results outside the target criteria are indicated in **RED**.

Results are discussed at Section **9.3.1** following.

## 9.1.1 Results – pH Soils, Sediments and Surface Waters 50m range

**Table 10: Soils Sediment and Surface Waters 50m range**

TABLE 10: SOIL & SEDIMENT RESULTS 50m		DATE: 18 DEC 23
Sample ID	Sample Location	pH Units
<b>RANGE OF VALUES</b>		6.5-8.5
101	Range Floor - BAY 1	7.2
101	Duplicate	7.2
102	Range Floor - BAY 3	6.8
103	Range Floor - BAY 2	7.3
104	Range Floor - BAY 4	6.8
105	Bushland - South	5.3
106	Bushland - West	5.1
107	Bushland - North	5.5
108	Bullet catcher - B 3	9.2
109	Bullet catcher - B 5	9.5
110	BC or Mantlet - B 2	7.2
111	Above Bullet Catcher - BAY 5	8.7
110	Duplicate	8.7
112	Above BC - BAY 1	8.5
113	10m front BC - B 3	7.4
114	10m front BC - B 2	6.8
115	10m front BC - B 5	6.7
117	Sediment - Basin 5	6.6
119	Mound Range 1 East	7.3

## 9.1.2 Results – Soils, Sediments and Surface Water 500m range

**Table 11: Soils Sediment and Surface Waters 500m range**

TABLE 11 SOIL & SEDIMENT RESULTS 500m		DATE: 18 DEC 23
Sample ID	Sample Location	pH
<b>RANGE OF VALUES</b>		6.5-8.5
201	Bushland 1 - South	5.0
202	Bushland 1-West 1	5.2
203	Bushland 1- West 2	5.3
204	Bushland 1 -East	5.4
205	Bushland 1- North	5.4
211	Range floor 0-50m	5.2
212	Range floor 50-100m	6.8
213	Range floor 100-150m	7.1



TABLE 11 SOIL & SEDIMENT RESULTS 500m		DATE: 18 DEC 23
Sample ID	Sample Location	pH
<b>RANGE OF VALUES</b>		6.5-8.5
214	Range floor 150-200m	7.2
215	Range floor 200-285m	6.3
216	Range floor 285-350m	6.4
216	Duplicate	6.9
217	Range floor 350-500m	6.0
218	Additional 285-350m	6.1
219	Additional 100-150m	7.2
210	Additional 350-500m	6.7
221	Int Mound - 50m	6.3
222	Int Mound - 100m	7.8
222	Int Mound - 150m	7.7
223	Int Mound - 200m	8.3
224	Int Mound - 250m	8.6
225	Int Mound - 300m	7.5
226	Int Mound - 385m	6.7
227	Main Butt -West	7.1
228	Main Butt - Central	6.9
229	Main Butt - East	7.1
231	50m mound less 10m	7.3
232	100m mound less 10m	6.7
233	150m mound less 10m	6.7
234	200m mound less 10m	7.2
234	250m mound less 10m	7.0
235	300m mound less 10m	7.4
236	385m mound less 10m	6.7
237	Main butt - 10m (west)	7.3
238	Main butt - 10m (central)	6.7
239	Main butt - 10m (East)	6.0
240	Gravel – western container area	7.0
241	Sediment - Basin 2 (W)	6.9
241	Duplicate	6.7
243	Sediment - Basin 3 (E)	6.0
245	Sediment below Basin 3	7.7
261	Sediment - basin 1 – 200m	8.2
263	Sediment below Basin 1	6.1
265	Sediment - Basin 4 (CP)	7.8
	Duplicate	7.8

## 9.1.3 Results – Soils, Sediments and Surface Waters 800m range

**Table 12: Soils Sediment and Surface Waters 800m range**





TABLE 12 2022 SOIL & SEDIMENT RESULTS 800m		DATE: 18 DEC 23
Sample ID	Sample Location	pH
<b>RANGE OF VALUES</b>		6.5-8.5
Practical Quantitation Limit or Limit of Reporting (PQL)		
301	Bullet Catcher 2	9.6
301	Duplicate	9.9
302	Bullet Catcher 7	7.4
303	Above B Catcher 6	7.0
304	Butt BTW BC 3-4	7.3
305	Butt under BC 1	8.9
306	Butt under BC 5	8.0
307	Mantlet West	6.4
308	Mantlet Central	6.3
309	Mantlet East	6.9
310	Infront of Mantlet West	8.4
311	Infront of Mantlet Central	8.2
	Duplicate	7.8
312	Infront of Mantlet East	7.4
313	Bench in front of Butt West	8.3
314	Bench in front of Butt Central	8.1
315	Bench in front of Butt East	7.2
316	Rear of Butt	5.4
317	Area over Storeroom	7.0
318	Stormwater culvert upper	6.9
319	Stormwater culvert lower	5.9
320	Rear channel upper	6.9
321	Rear channel lower	6.8
322	Sediment – Basin 7	5.6
323	Sediment – gallery	6.9






## 9.2 Six Monthly Visual Inspections

The observations from the **QTR1 Visual Inspection** are provided for each range following.





Results are discussed at Sections 8.2.1- 8.2.4 following.

### 9.2.1 50m range



TABLE 13: VISUAL INSPECTION, 50M RANGE AND SURROUNDS		DATE: 18 DEC 23
<b>Basins</b>		
<b>Basin 5 (at 50m range)</b>		
	<ul style="list-style-type: none"> <li>Basin full and clear.</li> </ul>	
		
	<ul style="list-style-type: none"> <li>Previously observed scour near entrance does not appear to have progressed.</li> </ul>	
	<ul style="list-style-type: none"> <li>Spillway and outlet area stable</li> </ul>	




Vegetation Health/Surface cover	
	<ul style="list-style-type: none"> <li>• The Gravel &amp; DGB surfaces Range 1 is stable</li> <li>• The Eastern mound to Range 1 is stable with cover greater than 70%</li> <li>• Stability of butt to range 1 is stable</li> <li>• Some woody plants beginning to establish to the top of the butt.</li> </ul>
	<p>Gravel surfaces Range 2</p> <ul style="list-style-type: none"> <li>• erosion evident at the area from the top of the butt</li> <li>• Some weed growth is evident</li> </ul> <p>Woody plants beginning to establish to the top of the butt.</p>
	<p>Gravel surfaces Range 3</p> <ul style="list-style-type: none"> <li>• erosion evident at the area from the top of the butt</li> <li>• Some weed growth is evident</li> </ul> <p>Woody plants beginning to establish to the top of the butt.</p>
	<p>Gravel surfaces Range 4</p> <ul style="list-style-type: none"> <li>• erosion evident at the area from the top of the butt</li> <li>• Some weed growth is evident</li> </ul> <p>Woody plants beginning to establish to the top of the butt.</p>
	<p>Gravel surfaces Range 5</p> <ul style="list-style-type: none"> <li>• erosion evident at the area from the top of the butt</li> <li>• Some weed growth is evident</li> </ul> <p>Woody plants beginning to establish to the top of the butt.</p>





	<ul style="list-style-type: none"> <li>• Pit at South East corner of 50m stop butt</li> <li>• Pit is full of sediment and being bypassed</li> </ul> <p><b>Modification of this outlet area may be required.</b></p>
 	<ul style="list-style-type: none"> <li>• The Drain to stormwater pit is bare</li> <li>• Minor sediment loss is evident</li> <li>• This is consistent with previous observations</li> </ul> <p><b>Further stabilization of the back of the mound will be required to reduce the sediment load to the drainage outlets.</b></p> <p>This is consistent with previous observations</p>
	<p>Bushland external to 50m range</p> <ul style="list-style-type: none"> <li>• Natural bushland is dense with little weed growth evident</li> </ul>
<p><b>Engineering controls: Lime treatment Process</b></p> <ul style="list-style-type: none"> <li>• The lime treatment process is a closed sealed unit.</li> <li>• Inspection of the unit is not possible</li> </ul> <p>This item has been removed from sampling program. Servicing or inspection by a qualified technician may be recommended by monitoring outcomes.</p>	
<p><b>Engineering controls: Road Infrastructure and Drainage</b></p> <ul style="list-style-type: none"> <li>• Road Infrastructure and Drainage for the 50m range is addressed within Section 8.2.2</li> </ul>	
<p><b>Safety and Signage</b></p> <ul style="list-style-type: none"> <li>• Safety and signage for the 50m range is addressed within Section 8.2.2</li> </ul>	

9.2.2 500m range:




TABLE 14: VISUAL INSPECTION, 500M RANGE AND SURROUNDS		DATE: 18 DEC 23
<b>Basins</b>		
<b>Basin 2 (500m west)</b>		
	<ul style="list-style-type: none"><li>• Basin is full to trickle/low flow level</li><li>• Inlet and out let areas to basin are stable</li><li>• The water is clear</li></ul>	
<b>Basin 3 (500m east)</b>		
	<ul style="list-style-type: none"><li>• Basin is full to trickle/low flow level</li></ul>	



	<p>Water is passing out the side of the primary inlet control and is leading to scour adjacent to the inlet and sediment material being moved to the surrounds of the basin inlet.</p> <p><b>It is likely that re work of the inlet structure will be required. Geotextile will be required within any re work of the invert to the control.</b></p>
	<p>The secondary inlet is stable</p>
	<p>The outlet control is stable.</p> <p>Some woody plants are establishing within the gabions which may require work to repair.</p> <p>The area below the outlet is stable.</p>









<p><b>Vegetation Health Surface Cover</b></p> <p><b>General comments to vegetation on 500m range</b></p> <ul style="list-style-type: none"> <li>• No significant erosion evident</li> <li>• Significant percentage of surface cover provided by grasses, moss and lichens and weeds.</li> <li>• In several bays drainage is an issue – this will limit plant growth in the heavy or compacted soils</li> <li>• Absence of real topsoil is a limitation in long term. Also very low organic matter</li> </ul>	
	<p><b>Shooting Point 0m to Intermediate mound 50m</b></p> <ul style="list-style-type: none"> <li>• Ground cover good – greater than 70%</li> <li>• Very dry surface</li> <li>• Nil erosion evident</li> </ul>
	<p><b>Intermediate mound 50m to intermediate mound 100m</b></p> <ul style="list-style-type: none"> <li>• Ground cover good – greater than 70%</li> <li>• Grasses and lichens</li> <li>• Some bare patches</li> <li>• Nil erosion evident</li> </ul>



	<p><b>Intermediate mound 100m to intermediate mound 150m</b></p> <ul style="list-style-type: none"><li>• Ground cover good – greater than 70%</li><li>• Grasses and lichens</li><li>• Nil erosion evident</li></ul>
	<p><b>Intermediate mound 150m to intermediate mound 200m</b></p> <ul style="list-style-type: none"><li>• Ground cover good – greater than 70%</li><li>• Grasses and lichens</li><li>• Nil erosion evident</li></ul>
	<p><b>Intermediate mound 200m to intermediate mound 300m</b></p> <ul style="list-style-type: none"><li>• Ground cover good – greater than 70%</li><li>• Grasses and lichens</li><li>• Some bare patches</li><li>• Nil erosion evident</li></ul>

	<p><b>Intermediate mound 300m to intermediate mound 385m</b></p> <ul style="list-style-type: none"> <li>• Ground cover good – greater than 70%</li> <li>• Grasses and lichens</li> <li>• Nil erosion evident</li> </ul>
	<p><b>Intermediate mound 385m to 500m Butt</b></p> <ul style="list-style-type: none"> <li>• Ground cover good – greater than 70%</li> <li>• Grasses and lichens</li> <li>• Nil erosion evident</li> </ul>
<p>No Photos</p>	<p><b>Gravel lay down area located to north of basin 2</b></p> <p>Gravel surface stable</p>





	<p>Swale drain leading to south west corner of 500m stop butt</p> <ul style="list-style-type: none"> <li>• Invert of drainage swales bare, with some scour/sediment loss evident</li> <li>• Rock check dams installed</li> </ul> <p><b>Recommend intermix smaller rock (75mm-150mm) into gaps of existing structures plus some smaller rock (diameter 25mm)</b></p>
	
	
	<p><b>Stormwater pit located at rear western corner of stop butt</b></p> <ul style="list-style-type: none"> <li>• surrounds of pit protected with rockwork</li> <li>• pit and surrounds accumulating sediment.</li> </ul>
	<p><b>Swale drains at 500m east</b></p> <ul style="list-style-type: none"> <li>• Installed rock checks with diameter 75-100mm</li> <li>• Invert between check dams beginning to stabilise with grass.</li> </ul>
	<p><b>Top of Stop butt at 500m</b></p> <ul style="list-style-type: none"> <li>• Some riling at front of batter</li> <li>• Occurs where water is pooling on top of butt formation and overflows over face</li> </ul>

**Engineering controls: Road Infrastructure and Drainage**








- All road areas are stable
- Coir logs are set to reduce scour and accumulate sediment
- Culvert crossings are maintained.







	<ul style="list-style-type: none"> <li>• The main access area road is stable and well maintained.</li> <li>• Signage is in place</li> </ul>
	<ul style="list-style-type: none"> <li>• The car park area is clear of waste</li> <li>• The surface is stable.</li> </ul>
<p><b>Safety and signage</b></p>	
<p>No Photos</p>	<p>Safety direction signage in place per previous recommendaions</p>

9.2.3 Other Basins

<p><b>TABLE 15: VISUAL INSPECTION, OTHER BASINS</b></p>	<p><b>DATE: 18 DEC 23</b></p>
<p><b>Basin 1 (at future 200m range)</b></p>	
	<ul style="list-style-type: none"> <li>• Surrounds to basin are stable</li> <li>• Basin is full to low flow outlet pipe</li> </ul>
	

	<ul style="list-style-type: none"> <li>• Rock work at the invert has been moved by flows</li> <li>• Geotextile has been exposed</li> <li>• Some woody plants are establishing in the inlet channel.</li> </ul> <p><b>Additional works may be required in this area to control the woody plants before they disturb the channel protections.</b></p>
	<ul style="list-style-type: none"> <li>• Outlet control/spillway is stable</li> <li>• Previously observed “erosion” or movement of material below basin outlet has not progressed. No further action recommended at this time.</li> </ul>
<p><b>Basin 4 (at car park)</b></p>	
	<ul style="list-style-type: none"> <li>• Basin inlet and outlet stable</li> <li>• Basin full of reeds</li> <li>• Water level is low</li> <li>• Very high tannins in water.</li> </ul>

9.2.4 800m range

TABLE 16: VISUAL INSPECTION, 800M RANGE AND SURROUNDS		DATE: 18 DEC 23
<b>Basin 7 (800m Range)</b>		
	<p><b>Basin 7 - Bushland Pond</b></p> <ul style="list-style-type: none"> <li>• Water levels are low</li> </ul>	
<b>Vegetation Health</b>		
	<p><b>Vegetative health 0-100m from target</b></p> <ul style="list-style-type: none"> <li>• First 6-10m veg cover more patchy (see below)</li> <li>• Rest of range grass cover good to greater than 70%</li> </ul>	
	<p><b>Vegetative health first 6-10m from Mantlet</b></p> <ul style="list-style-type: none"> <li>• 50-70% cover with patchy bare areas</li> </ul>	
	<p><b>Vegetative health rear of stop butt</b></p> <ul style="list-style-type: none"> <li>• Vegetation establishing within channel</li> <li>• New limestone check structures have been constructed. Well-shaped per previous recommendations.</li> <li>• The upper check structure is solid and will hold back water</li> <li>• The lower checks are more free draining</li> <li>• Rear area is clear of waste</li> </ul>	



	
<p><b>Concrete Galley</b></p>	
	<p>The gallery is clear, no waste or bullet fragments evident.</p> <p>Sediment is accumulating within the swale drain at side of the concrete.</p>
<p><b>Engineering controls: Road Infrastructure and Drainage</b></p>	
<p>No Photos</p>	<p><b>Roads and Access tracks</b></p> <ul style="list-style-type: none"> <li>• Access track in good condition and well drained</li> <li>• Minor cross erosion evident</li> <li>• No action recommended.</li> </ul>
<p>No Photo</p>	<p><b>Safety and signage</b></p> <ul style="list-style-type: none"> <li>• <b>Signage is in place at the main gate</b></li> </ul>
<p><b>Engineering controls: Lime treatment Process</b></p> <ul style="list-style-type: none"> <li>• The lime treatment process is a closed sealed unit.</li> <li>• Inspection of the unit is not possible</li> <li>• A tool is requested to be able to access the sealed units</li> <li>• Lime treatment process sealed and intact</li> </ul>	



### 9.3 Discussion of results

Full results from the 6 monthly monitoring for soils, sediments and surface waters is provided within Appendix 1.

#### 9.3.1 Sampling (pH) Soil, Sediments and Surface Water

The following samples returned pH values outside the target range of pH 6.5-8.5; Discussions of results is included following each observation. Recommended actions are provided in bold.

**Table 17: pH Discussion of Results**

TABLE 17: SOILS pH DISCUSSION OF RESULTS		DATE: 18 DEC 23
Sample ID	Location	Laboratory pH
50m Range		
105	Bushland South /rear 50m Range	5.3
106	Bushland West of 50m Range	5.1
107	Bushland East of 50m Range	5.3
	Samples 105-106 returned pH values of pH of 5.1- 5.3. <ul style="list-style-type: none"> <li>• These samples are from bushland areas where a lower pH is to be expected</li> <li>• <b>No action is recommended</b></li> </ul>	
108	Bullet Catcher – Gravels Bay 3	9.2
108	Bullet Catcher – Gravels Bay 5	9.5
111	Above Bullet Catcher –Bay 5	8.7
500m Range		
201	Bushland 1 – South of Range	5.3
202	Bushland 2-West 1	5.2
203	Bushland 3- West 2	5.3
204	Bushland 4 -East	5.4
205	Bushland 5- North	5.4
	Samples 201-205 returned pH values of pH of 5.2- 5.4  These sample are from bushland areas where a lower pH is to be expected.  <b>No action is recommended.</b>	
211	Range floor 0-50m	5.2
216	Range floor 285-350m	6.4
217	Range floor 350-500m	6.0

218	Range floor 285-350m	6.1
221	Intermediate Mound - 50m	6.3
239	Main butt - 10m (East)	6.0
	<p>Samples 211, 216, 217, 218, 221 &amp; 239 have returned a pH outside the target pH range of 6.5-8.5.</p> <ul style="list-style-type: none"> <li>• Sampling of the range floor and intermediate mounds have returned values for pH outside the target range in the past.</li> <li>• Treatment with lime in this area has been recommended in previous annual reports.</li> </ul> <p><b>This ongoing regular treatment will be confirmed with Range Management.</b></p>	
243	Sediment - Basin 3 (500m East)	6.0
	<p>Sample 243 returned a pH outside the target pH range of 6.5-8.5.</p> <ul style="list-style-type: none"> <li>• Water within this basin returned a pH of 8.6 which is high and outside the range of the outside the target pH range of 6.5-8.5.</li> <li>• This sediment / soil is partially from eroded natural material adjacent to the inlet</li> <li>• As such the low pH may not be associated with flows from range areas</li> </ul> <p><b>Sampling from the next exercise will be reviewed for consistency.</b></p> <p><b>No recommendations at this time however this area will be compared in subsequent sampling exercises.</b></p>	
244	Water - Basin 5 (500m West)	8.6
	<p>Sample 244 returned a pH outside the target pH range of 6.5-8.5.</p> <ul style="list-style-type: none"> <li>• Soils within the catchments to the basin are either within or below the target range of 6.5-8.5.</li> </ul> <p><b>No recommendations at this time however this area will be compared in subsequent sampling exercises.</b></p>	
263	Sediment below Basin 1	6.1
	<p>Sample 263 returned a pH value of pH of 5.2- 5.4</p> <p>This sample is from a bushland area where a lower pH is to be expected.</p> <p><b>No action is recommended.</b></p>	
800m Range		
301	Bullet Catcher 2	9.6
	Duplicate	9.9
305	Butt under BC 1	8.9
	<p>Samples 301 &amp; 305 have returned pH values outside the target pH range of 6.5-8.5.</p> <ul style="list-style-type: none"> <li>• The bullet catchers are comprised of blue metal gravels which at times return elevated pH values.</li> <li>• The pH values of the benched area in front of the bullet catchers were from 7.2-8.3.</li> </ul> <p><b>No recommendations at this time however this area will be compared in subsequent</b></p>	

	<b>sampling exercises.</b>	
307	Mantlet West	6.4
308	Mantlet Central	6.3
	<p>Samples 307 &amp; 308 have returned pH values outside the target pH range of 6.5-8.5.</p> <ul style="list-style-type: none"> <li>• The mantlet is constricted of compacted upgrade materials</li> <li>• The pH of the range floor immediately in-front of the mantlet is within the target range.</li> <li>• The mantlet to the 800m range should not be a primary impact area.</li> </ul> <p><b>No recommendations at this time however this area will be compared in subsequent sampling exercises.</b></p> <p>Treatment with lime may be recommended at the 800m range per that applied to the range floor at the 500m range</p>	
316	Rear of Butt	5.4
	<p>Sample 316 returned pH values of pH of 5.4.</p> <p>These sample is from mulched natural material covering the back of the stop butt. Mulched organic material can be expected to generate acidic/lower pH runoff, however this is lower than recent sampling of this material.</p> <p>Recent works have been implemented to adjust acid runoff from this area.</p> <p><b>No recommendations at this time however this area will be compared in subsequent sampling exercises.</b></p>	
319	Stormwater culvert lower	5.9
322	Sediment – basin 7	5.6
	<p>Samples 319 &amp; 322 returned pH values of pH of 5.9 &amp; 5.6</p> <p>These sample are from bushland areas where a lower pH is to be expected.</p> <p><b>No action is recommended.</b></p>	

### 9.3.2 Surface Waters

Sample 244 return a pH value outside the target criteria. This is discussed at 9.3.1 above.

All other results for water samples are within criteria.

**Copper was not included within the heavy metal suite.  
This will be included in the sampling exercise for Q3.**

### 9.3.3 Visual Inspections: Water Quality Basins

The following table summarises observations and recommended actions from Section 9.2. Recommended actions are provided in bold.

**Table 18: Discussion of Observations Water Quality Basins**

TABLE 18: DISCUSSIONS OF OBSERVATIONS BASINS		DATE: 18 DEC 23
Item	Location	Observation and Comment
1.	Basin 1 (below future 200m Range)	<p>Rock work at the inlet to the basin has been moved by in-flows. Geotextile has been exposed</p> <p><b>Woody plants are establishing in the inlet and the outlet of the basin – these will need to be controlled as part of scheduled maintenance.</b></p>
2.	Basin 2 (500m west)	<p>Inlets and outlet areas are stable. No issues evident or required action.</p>
3.	Basin 3 (500m east)	<p>Significant erosion has occurred at the main (Southern) inlet of the basin with placement of rock.</p> <p>Water is passing out the side of the inlet control and is leading to scour adjacent to the inlet.</p> <p><b>It is likely that re work of the inlet structure will be required. It is recommended that any re work include shaping of the inlet channel to create a defined inflow and is lined with geotextile.</b></p> <p><b>The rock used should consist of well graded angular material. Geotextile will be required under the rock to create a stable inlet.</b></p> <p><b>Woody plants are establishing in the outlet of the basin – these will need to be controlled as part of scheduled maintenance.</b></p>
4.	Basin 4 (car park)	<p>Inlets and outlet areas are stable. No issues or required action is evident.</p>
5.	Basin 5 (50m)	<p>Scour is evident over batter at entrance to basin enclosure. This has not progressed since previous inspections.</p> <p><b>Woody plants are establishing in the outlet of the basin – these will need to be controlled as part of scheduled maintenance.</b></p>
6.	Basin 6	<p>This basin has not been constructed.</p>
7.	Basin 7 (800m range)	<p>The water on the eastern side of the 800m range is not a water quality basin but is a bushland pond or previous borrow pit.</p> <p>Inlets and outlet areas are stable. No issues or required action is evident. The levels of water within the basin have consistently been low. This may be due to changes in track drainage at the adjacent access track.</p> <p>This should be assessed – it may be desirable to reinstate drainage so that water is directed to the pond.</p>

### 9.3.4 Visual Inspections: Lime treatment Process

Visual inspection of the lime treatment process was not possible as this infrastructure is sealed and not readily accessible. It is recommended that this item be removed from the sampling program for future monitoring events. Servicing or inspection by a qualified technician may be identified as required by future monitoring results.

### 9.3.5 Visual Inspections: Road Infrastructure and Drainage

The following table summarises observations and recommended actions from Section 9.2. Recommended actions are provided in bold.

TABLE 19: DISCUSSIONS OF OBSERVATIONS ROAD INFRASTRUCRE			DATE: 18 DEC 23
Item	Location	Observation and Comment	
1.	50/500m	No issues or required action is evident.	
2.	800m	No issues or required action is evident.	

### 9.3.6 Visual Inspections: Signage

Directional and safety signage was in place across all areas.

Signage was provided at basin enclosures indicating that the water is not suitable for firefighting purposes.

### 9.3.7 Visual Inspections: Vegetation health - Range areas

All range areas are grazed or otherwise low cropped. Some bare areas exist however this is localised.

No significant sediment loss was observed from Range areas or surrounds.

The existing surface soil material is generally poor however seems to be resistant to erosion.

The following table summarises observations and recommended actions from Section 9.2. Recommended actions are provided in bold.

TABLE 20: DISCUSSIONS OF VEGETATION HEALTH			DATE: 18 DEC 23
Item	Location	Observation and Comment	
1.	Range 1 – 50m range	Localised pooling is occurring in the middle of the range. The surface is fine gravels or DGB.  Erosion is not evident over the surface.	
2.	Other ranges – 50m ranges	Woody plants are establishing within the top of butt at the 50m range.  Control of these with herbicide will be necessary to prevent them damaging the stop butt.	
3.	Various – 500m range	Surface cover is uniformly good with cover over 70% across most areas.  Erosion is not evident over the surface of the range.	
4.	800m range	Surface cover is uniformly good with cover over 70% across most areas.  Erosion is not evident over the surface of the range.	

### 9.3.8 Visual Inspections: Other Engineering Controls and Structures

The following table summarises observations and recommended actions from Section 9.2. Recommended actions are provided in bold.

TABLE 21: DISCUSSIONS OF OBSERVATIONS – ENGINEERING CONTROLS		DATE: 18 DEC 23
Item	Location	Observation and Comment
1.	Stop butt – 500m range	Some riling at front of batter occurring where water is pooling on top of butt formation and overflows over face  <b>This does not seem to have progressed since previous inspections</b>
2.	Pit at South East corner of 50m stop butt	Pit is full of sediment and being bypassed  <b>Modification of this outlet area may be required depending on existing stormwater arrangement</b>  <b>E.g. additional control to prevent pit becoming blocked or otherwise replace with a stable surface level outlet and spreader may be considered to avoid the need for continued clearing of a sediment pit.</b>
3.	Drain at rear of 50m stop butt	The Drainage swale leading to the SE stormwater pit is bare, with sediment loss evident  <b>Further stabilization of the back of the mound will be required to reduce the sediment load to the drainage outlets.</b>  This will require spreading of improved soil material as a growing medium.  Alternatively, more dense planting may be considered.
4.	Swale drain leading to south west corner of 500m stop butt	The invert of drainage swales bare, with some scour/sediment loss evident.  New rock check dams have been installed. It is noted that the rock size too large with no fabric installed causing water to be focused through with scour underneath.  <b>It is recommended intermix smaller rock (75mm-150mm) into gaps of existing structures plus some smaller rock (diameter 25mm).</b>  <b>The existing soil material comprising the swale invert is poor and unlikely to revegetate naturally.</b>
5.	Western corner at rear of 500m butt	Sediment from drainage swale is accumulating in rock work at the inlet to the stormwater pit.  <b>Improved erosion controls discussed above will reduce the generation of sediment leading to the lower controls.</b>
6.	Face of stop butt at 500m	Some riling at front of batter occurring where water is pooling on top of butt formation and overflows over face.  <b>This does not seem to have progressed severely since previous inspections. This will need to be reworked / reshaped at some future time.</b>

## 9.4 Recommendations

The following recommendations are made subsequent to this monitoring event;

### 9.4.1 Management Actions

The following management actions are presented summarised from section 9.3;

1. Investigate works to improve/ reinstate inlet controls at Basin 3.
2. Investigate works to improve stabilisation/vegetation rear of the stop butt mounds at the 50 and 500m ranges and associated drainage
3. Investigate works to improve check measures (as required) at the swale drains at the Eastern side of the 500m range and South Eastern corner of the 500m range.
4. Investigate works to maintain / improve drainage outlet at the southern corner at rear of 50m range.
5. Maintain scheduled regular treatment of the 500m range floor with Agricultural Lime.

### 9.4.2 Follow up Monitoring

No specific follow up monitoring beyond the scheduled program is recommended.

### 9.4.3 Changes to Sampling Program

No changes to scheduled monitoring/s program is recommended.

Additional sampling for Cu within water samples will be applied in the next sampling exercise – see comment 9.3.2, **Copper was not included within the heavy metal suite. This will be included in the sampling exercise for Q3.**

## 10 References

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Southern Highlands Regional Shooting Complex, Water Cycle Management Plan (ErSed Sept 2018)

National Environment Protection (Assessment of Site Contamination) Measure (NEPM), National Environment Protection Council (2013).

National Environment Protection (Assessment of Site Contamination) Measure (NEPM), Schedule B1 Guideline on Investigation Levels for Soil and Groundwater, National Environment Protection Council (2011).

Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Australian and New Zealand Environment and Conservation Council (October 2000).

Guidelines for Consultants Reporting on Contaminated Sites, NSW Office of Environment and Heritage (2011).

Contaminated Sites: Guidelines for the NSW Site Auditor Scheme (2nd edition), NSW Department of Environment and Conservation (2006).

Best Management Practices for Lead at Outdoor Shooting Ranges, United States Environmental Protection Agency (2005).

Southern Highlands Regional Shooting Complex Civil Works Plans Drawings C-SC-202-253 (Arcadis Australia Pacific Pty Limited, 2015)

## 11 Appendices

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### Appendix 1 – Results

TABLE 22	SOIL AND SEDIMENT RESULTS - 50M
TABLE 23	SOIL AND SEDIMENT RESULTS - 500M
TABLE 24	SOIL AND SEDIMENT RESULTS - 800M
TABLE 25	SURFACE WATERS (50M, 500M & 800M)



TABLE 22 SOIL & SEDIMENT RESULTS 50m															DATE: 18 DEC 23			
Sample ID	Sample Location	PAH-Total	PAH-B(a) PTEQ	PAH-B(a)P	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc	Tin	Antimony	Iron	CEC	pH	Clay in Soil <2µm
	Units	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	meq/100g	pH Units	% W/W
<b>EIL from WCMP</b>				<b>(ESL) 0.7</b>	<b>100</b>	<b>-</b>	<b>414</b>	<b>132</b>	<b>1113</b>	<b>-</b>	<b>34</b>	<b>190</b>	<b>OBS ONLY</b>	<b>-</b>	<b>OBS ONLY</b>			<b>OBS ONLY</b>
<b>HIL (C)</b>		<b>300</b>	<b>3</b>	<b>-</b>	<b>300</b>	<b>90</b>	<b>300</b>	<b>17000</b>	<b>600</b>	<b>13</b>	<b>1200</b>	<b>30000</b>		<b>252</b>				
<b>HIL (D)</b>			<b>-</b>	<b>-</b>	<b>3000</b>	<b>900</b>	<b>3600</b>	<b>240000</b>	<b>1500</b>	<b>180</b>	<b>6000</b>	<b>400000</b>						
<b>RANGE OF VALUES</b>																	6.5-8.5	
Practical Quantitation Limit or Limit of Reporting (PQL)		0.05			4	0.4	1	1	1	0.1	1	1	1	7	10	1		
101	Range Floor - BAY 1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	7.2	[NT]
101	Duplicate	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	7.2	[NT]
102	Range Floor - BAY 3	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	6.8	[NT]
103	Range Floor - BAY 2	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	7.3	[NT]
104	Range Floor - BAY 4	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	6.8	[NT]
105	Bushland - South	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	5.3	[NT]
106	Bushland - West	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	5.1	[NT]
107	Bushland - North	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	5.5	[NT]
108	Bullet catcher - B 3	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	9.2	[NT]
109	Bullet catcher - B 5	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	9.5	[NT]
110	BC or Mantlet - B 2	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	7.2	[NT]
111	Above BC - BAY 5	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	8.7	[NT]
	Duplicate	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	8.7	[NT]
112	Above BC - BAY 1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	8.5	[NT]

TABLE 22 SOIL & SEDIMENT RESULTS 50m															DATE: 18 DEC 23			
113	10m front BC - B 3	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	7.4	[NT]
114	10m front BC - B 2	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	6.8	[NT]
115	10m front BC - B 5	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	6.7	[NT]
117	Sediment - Basin 5	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	6.6	[NT]
119	Mound Range 1 East	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	7.3	[NT]

TABLE 23 SOIL & SEDIMENT RESULTS 500m															DATE: 18 DEC 23			
Sample ID	Sample Location	PAH-Total	PAH-B(a)PTEQ	PAH-B(a)P	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc	Tin	Antimony	Iron	CEC	pH	Clay in Soil <2µm
	Units	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	meq/100g	pH Units	% W/W
<b>EIL from WCMP</b>				(ESL) 0.7	100	-	414	132	1113	-	34	190	OBS ONLY	-	OBS ONLY			OBS ONLY
<b>HIL (C)</b>		300	3	-	300	90	300	17000	600	13	1200	30000		252				
<b>HIL (D)</b>			-	-	3000	900	3600	240000	1500	180	6000	400000						
<b>RANGE OF VALUES</b>																	6.5 - 8.5	
Practical Quantitation Limit or Limit of Reporting (PQL)		0.05			4	0.4	1	1	1	0.1	1	1	1	7	10	1		
201	Bushland 1 - South	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	5.0	[NT]
202	Bushland 1-West 1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	5.2	[NT]
203	Bushland 1- West 2	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	5.3	[NT]
204	Bushland 1 -East	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	5.4	[NT]
205	Bushland 1- North	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	5.4	[NT]
211	Range floor 0-50m	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	5.2	[NT]
212	Range floor 50-100m	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	6.8	[NT]
213	Range floor 100-150m	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	7.1	[NT]
214	Range floor 150-200m	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	7.2	[NT]
215	Range floor 200-285m	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	6.3	[NT]
216	Range floor 285-350m	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	6.4	[NT]
	Duplicate	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	6.9	[NT]

TABLE 23 SOIL & SEDIMENT RESULTS 500m															DATE: 18 DEC 23			
Sample ID	Sample Location	PAH-Total	PAH-B(a)PTEQ	PAH-B(a)P	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc	Tin	Antimony	Iron	CEC	pH	Clay in Soil <2µm
	Units	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	meq/100g	pH Units	% W/W
<b>EIL from WCMP</b>				(ESL) 0.7	100	-	414	132	1113	-	34	190	OBS ONLY	-	OBS ONLY			OBS ONLY
<b>HIL (C)</b>		300	3	-	300	90	300	17000	600	13	1200	30000		252				
<b>HIL (D)</b>			-	-	3000	900	3600	240000	1500	180	6000	400000						
<b>RANGE OF VALUES</b>																	6.5 - 8.5	
Practical Quantitation Limit or Limit of Reporting (PQL)		0.05			4	0.4	1	1	1	0.1	1	1	1	7	10	1		
217	Range floor 350-500m	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	6.0	[NT]
218	Additional 285-350m	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	6.1	[NT]
219	Additional 100-150m	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	7.2	[NT]
210	Additional 350-500m	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	6.7	[NT]
221	Int Mound - 50m	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	6.3	[NT]
222	Int Mound - 100m	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	7.8	[NT]
222	Int Mound - 150m	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	7.7	[NT]
223	Int Mound - 200m	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	8.3	[NT]
224	Int Mound - 250m	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	8.6	[NT]
225	Int Mound - 300m	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	7.5	[NT]
226	Int Mound - 385m	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	6.7	[NT]
227	Main Butt -West	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	7.1	[NT]
228	Main Butt - Central	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	6.9	[NT]

TABLE 23 SOIL & SEDIMENT RESULTS 500m															DATE: 18 DEC 23			
Sample ID	Sample Location	PAH-Total	PAH-B(a)PTEQ	PAH-B(a)P	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc	Tin	Antimony	Iron	CEC	pH	Clay in Soil <2µm
	Units	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	meq/100g	pH Units	% W/W
<b>EIL from WCMP</b>				(ESL) 0.7	100	-	414	132	1113	-	34	190	OBS ONLY	-	OBS ONLY			OBS ONLY
<b>HIL (C)</b>		300	3	-	300	90	300	17000	600	13	1200	30000		252				
<b>HIL (D)</b>			-	-	3000	900	3600	240000	1500	180	6000	400000						
<b>RANGE OF VALUES</b>																	6.5 - 8.5	
Practical Quantitation Limit or Limit of Reporting (PQL)		0.05			4	0.4	1	1	1	0.1	1	1	1	7	10	1		
229	Main Butt - East	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	7.1	[NT]
231	50m mound less 10m	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	7.3	[NT]
232	100m mound less 10m	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	6.7	[NT]
233	150m mound less 10m	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	6.7	[NT]
234	200m mound less 10m	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	7.2	[NT]
234	250m mound less 10m	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	7.0	[NT]
235	300m mound less 10m	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	7.4	[NT]
236	385m mound less 10m	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	6.7	[NT]
237	Main butt - 10m (west)	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	7.3	[NT]
238	Main butt - 10m (central)	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	6.7	[NT]

TABLE 23 SOIL & SEDIMENT RESULTS 500m															DATE: 18 DEC 23			
Sample ID	Sample Location	PAH-Total	PAH-B(a)PTEQ	PAH-B(a)P	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc	Tin	Antimony	Iron	CEC	pH	Clay in Soil <2µm
	Units	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	meq/100g	pH Units	% W/W
<b>EIL from WCMP</b>				(ESL) 0.7	100	-	414	132	1113	-	34	190	OBS ONLY	-	OBS ONLY			OBS ONLY
<b>HIL (C)</b>		300	3	-	300	90	300	17000	600	13	1200	30000		252				
<b>HIL (D)</b>			-	-	3000	900	3600	240000	1500	180	6000	400000						
<b>RANGE OF VALUES</b>																	6.5 - 8.5	
Practical Quantitation Limit or Limit of Reporting (PQL)		0.05			4	0.4	1	1	1	0.1	1	1	1	7	10	1		
239	Main butt - 10m (East)	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	6.0	[NT]
240	Gravel - western container area	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	7.0	[NT]
241	Sediment - Basin 2 (W)	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	6.9	[NT]
	Duplicate	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	6.7	[NT]
243	Sediment - Basin 3 (E)	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	6.0	[NT]
245	Sediment below Basin 3	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	7.7	[NT]
261	Sediment - basin 1 - 200m	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	8.2	[NT]
263	Sediment below Basin 1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	6.1	[NT]
265	Sediment - Basin 4 (CP)	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	7.8	[NT]
	Duplicate	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	7.8	[NT]

TABLE 24 SOIL & SEDIMENT RESULTS 800m															DATE: 18 DEC 23			
Sample ID	Sample Location	PAH-Total	PAH-B(a)PTEQ	PAH-B(a)P	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc	Tin	Antimony	Iron	CEC	pH	Clay in Soil <2µm
	Units	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	meq/100g	pH Units	% W/W
<b>EIL from WCMP</b>				(ESL) 0.7	100	-	414	132	1113	-	34	190	OBS ONLY	-	OBS ONLY			OBS ONLY
<b>HIL (C)</b>		300	3	-	300	90	300	17000	600	13	1200	30000		252				
<b>HIL (D)</b>			-	-	3000	900	3600	240000	1500	180	6000	400000						
<b>RANGE OF VALUES</b>																	6.5 - 8.5	
Practical Quantitation Limit or Limit of Reporting (PQL)		0.05			4	0.4	1	1	1	0.1	1	1	1	7	10	1		
301	Bullet Catcher 2	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	9.6	[NT]
	Duplicate	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	9.9	[NT]
302	Bullet Catcher 7	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	7.4	[NT]
303	Above B Catcher 6	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	7.0	[NT]
304	Butt BTW BC 3-4	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	7.3	[NT]
305	Butt under BC 1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	8.9	[NT]
306	Butt under BC 5	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	8.0	[NT]
307	Mantlet West	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	6.4	[NT]
308	Mantlet Central	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	6.3	[NT]
309	Mantlet East	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	6.9	[NT]
310	Infront of Mantlet West	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	8.4	[NT]
311	Infront of Mantlet Central	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	8.2	[NT]

TABLE 24 SOIL & SEDIMENT RESULTS 800m															DATE: 18 DEC 23				
	Duplicate	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	7.8	[NT]
312	Infront of Mantlet East	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	7.4	[NT]
313	Bench in front of Butt West	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	8.3	[NT]
314	Bench in front of Butt Central	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	8.1	[NT]
315	Bench in front of Butt East	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	7.2	[NT]
316	Rear of Butt	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	5.4	[NT]
317	Area over Storeroom	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	7.0	[NT]
318	Stormwater culvert upper	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	6.9	[NT]
319	Stormwater culvert lower	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	5.9	[NT]
320	Rear channel upper	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	6.9	[NT]
321	Rear channel lower	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	6.8	[NT]
322	Sediment – basin 7	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	5.6	[NT]
323	Sediment – gallery	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	6.9	[NT]



TABLE 25 WATER RESULTS – SHRSC (800M, 50M& 500M) & SURROUNDS														DATE: 18 DEC 23		
Sample ID	LOCATION	pH	TSS	Turbidity	Total N	Ammonia as N	DO	Phosphate as P	Phosphorus	Arsenic	Chromium	Nickel	Lead	Antimony	Copper	Zinc
					OBS ONLY		OBS ONLY		OBS ONLY							
	ANZECC 2000 PFWS/NEPM 2013 GIL				0.25	0.9		0.015	0.2	13	3.3	11	3.4	9	1.4	8
	<b>ANZECC 2000 RWQG</b>				0.25	<b>10</b>				<b>50</b>	<b>50</b>	<b>100</b>	<b>50</b>	-	<b>1000</b>	<b>5000</b>
Units		pH Units	TSS	NTU	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Practical Quantitation Limit or Limit of Reporting Test (PQL)					0.1	0.005	0.1	0.005	0.05	1	1		1		1	1
116	Basin 5 – 50m	7.5	<20	1	0.2	<0.005	8.9	<0.005	<0.05	3	<1	<1	<1	4	[NT]	5
	Duplicate								<0.05	3	<1	<1	<1	4	[NT]	4
118	Basin 5 – inlet pipe 50m	7.2	<20	2.6	0.2	<0.005	9	<0.005	<0.05	<1	<1	<1	<1	3	[NT]	<1
	Duplicate	[NT]	[NT]	[NT]	0.2	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
242	Basin 5 – 500m West	8.2	<20	0.2	0.4	<0.005	8.8	<0.005	<0.05	2	<1	<1	<1	4	[NT]	<1
244	Basin 5 – 500m East	8.6	<20	0.8	0.3	<0.005	8.7	<0.005	<0.05	<1	<1	<1	<1	2	[NT]	<1
246	Creek below 500m East	Not available														
262	Basin 1- 200m	7.6	<20	1	0.4	<0.005	8.6	<0.005	<0.05	<1	<1	<1	<1	<1	[NT]	2
264	Creek waters below 200m	Not available														
266	Basin 4 – Car Park 50/500	7	29	4.6	0.4	<0.005	8.7	<0.005	<0.05	1	<1	<1	<1	<1	[NT]	2
330	Water – rear channel	Not available														
332	Water: Pond side of 800	6.5	28	13	0.5	<0.005	8.6	<0.005	<0.05	<1	<1	<1	2	<1	[NT]	3