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Environmental Consultants Otago Ltd

**Waterfall Park Developments Ltd**

*Ayrburn Homestead 1953*

# Preliminary Site Investigation For Soil Contamination Ayrburn Farm and Waterfall Park Residential Development 341 -345 Arrowtown – Lakes Hayes Road, Wakatipu

**November 2016**

| Task | Responsibility | Signature |
|---|---|---|
| Project Manager: | Mona Wells | |
| Prepared By: | Ciaran Keogh | |
| Reviewed By: | Mona Wells | |
| Approved For Issue By: | | |

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|---|---|---|---|---|
| September 2016 | 0 | C Keogh | MCW | M Wells |
| November 2016 | 1 | C Keogh | CMK | M Wells |

Prepared By:
Environmental Consultants Otago Ltd

Job Ref.: 16-16 Waterfall
Date: November 2016

PO Box 5522
Dunedin 9058
Telephone: + 64 3 472 8875
Email: ciaran.keogh@xtra.co.nz

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# Executive Summary

Waterfall Park Developments Ltd is proposing to develop a rural landholding into residential estate, with a limited area for commercial activities, at a site of approximately 32ha at 341–345 Arrowtown – Lake Hayes Rd approximately 3.5 kilometers south-west of Arrowtown in the Wakatipu Basin. The proposed activity constitutes a change of use of the land.

Queenstown Lakes District Council has provided Land Information Memoranda (LIMs) for the property that state that there is no known HAIL (hazardous activities and industries list, i.e. potentially contaminating land use) activity associated with the land. The LIMs provide little information relating to the site use other than a summary of consents. The property is however known to have been used for activities listed on the HAIL. This is a Preliminary Site Investigation Report (PSIR) with detailed soil sampling investigations prepared to assess whether an activity or industry described in the Ministry for the Environment's (MfE's) HAIL is being, or has been, undertaken on a property or whether the property has been affected by known HAIL activity on a neighbouring site. If this is found to be so then the Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations 2011 (hereafter the NES Soil), apply when soil disturbance, subdivision or change of use take place at the property.

Subsequent to a desk-top analysis, described herein, which did confirm a number of past HAIL land uses, the site was subject to two rounds of soil sampling and analysis to determine the status of the site soils. The initial round comprising seventy-five samples representing the top 10cm of the soil profile distributed across the site. These were analysed for the primary contaminants of concern from the historical HAIL activities. The results of analysis for the initial sampling presented individual sample exceedances of the Residential acceptance criteria for arsenic and lead within an area of the site occupied by a barn and stockyards. The sampling and analysis over much of the rest of the site did not result in exceedances for individual samples, however based on the initial results, there were locations where further investigation was warranted. The second round of sampling expanded the area investigated to include parts of the site initially inaccessible during the first round of sampling and analysis, more sampling in the area around a former sheep dip, the homestead grounds, two areas possibly formerly used for landfilling, and parts of a local creek running by the former sheep dip area. There are five fuel tanks at site in the general area where exceedances were found that will require further sampling and investigation, however this will be more effectively investigated at the time that the installations are being removed.

This report concludes that there is a footprint of lead and arsenic contamination associated with the farmyard and homestead area. Beyond the farmyard precinct there is no evidence of contamination that presents an impediment to development as proposed; this conclusion

relies on a number of assumptions, and suggestions for how environmental exposure risk may be managed during development are provided herein. It is our conclusion (within the limitations stipulated), that the proposed residential development of the site represents suitable land use by current standards over the greater part of the site, however the farmyard and homestead precincts are not suited to this activity without further investigation and remediation.

# 1 Introduction

Environmental Consultants Otago Ltd (hereafter EC Otago) has been commissioned by Waterfall Park Developments Ltd to undertake a Preliminary Site Investigation (PSI) with soil sampling for soil contamination, at the site at 341-345 Arrowtown – Lakes Hayes Road, Wakatipu. Investigation is required to facilitate assessment of the potential effects of past activities to ascertain suitability of the site for the proposed development and also to provide certainty as to the site's contamination status prior to its conversion to a predominantly residential (with some commercial) development. This PSI was undertaken in accordance with a proposal submitted by EC Otago on the 11th of July, 2016, and a further proposal for the additional sampling dated the 27th of September, 2016.

## 1.1 Background and Objectives

If an activity or industry described in the New Zealand Ministry for the Environment's (MfE's) Hazardous Activities and Industries List (HAIL) is being, or has been, undertaken on a property, then the Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations 2011 (hereafter the NES Soil)[1], apply when soil disturbance, subdivision or change of use take place at the property. The HAIL is a compilation of activities and industries that are considered to have the potential to cause land contamination as a result of hazardous substance use, storage or disposal. However, it should be noted that the list merely indicates that such activities and industries have a greater probability of causing site contamination than other uses or activities, not that hazardous substances are present.

The proposed development constitutes a change of use of the land as defined by 5(2)(5) and (6) of the NES Soil as it is more likely than not that an activity or industry described in the HAIL is being or has been undertaken on it. The NES Soil stipulates that a PSI be undertaken for a property such as the one that is the subject of this report. The main objectives of a PSI are to gather information about a designated land area to determine whether it may potentially be contaminated, to assess the suitability of the land for its current or intended future land use, and to determine whether a detailed site investigation is required. This PSI has been undertaken to confirm what current and historic activities have occurred at the property and what the potential is for these activities to have resulted in ground contamination.



[1] http://www.mfe.govt.nz/laws/standards/contaminants-in-soil/

## 1.2 Scope of Work

Consistent with the MfE Guidelines[2] for PSIs of potentially contaminated land, the following scope of work was undertaken:

- Source and review of all available relevant information, including any previous reports relating to the property at 341-345 Arrowtown – Lake Hayes Road. Sources were as follows:
  - Queenstown Lakes District Land Information Memorandum (LIM) Reports;
  - Results of a HAIL enquiry of the Otago Regional Council (ORC);
  - Historical and recent photographs;
  - Personal comments by the Farm Manager;
  - Archaeologist's report; and
  - Other sources of information as cited herein.
- Carry out a site walkover to verify site conditions and inspect for indicators of potential site contamination;
- Perform detailed sampling of the soils at the site in two phases of sampling and analyse soil samples, variously, for heavy metals (arsenic, cadmium, chromium, copper lead, mercury, nickel and zinc) and for organochlorine pesticides (OCPs).
- Prepare this report, which summarises our findings and is compliant with MfE reporting Guidelines[3], inclusive of all work having been undertaken, managed and reviewed by suitably qualified and experienced practitioners as defined in the NES Soil[4]. Specifically, this report assesses the following:
  - Whether previous and/or current on-site activities or adjoining land uses had or have the potential to cause on-site contamination;
  - The likely nature of any contamination;
  - The risks to future site users from any contamination;
  - The disposition of the property with respect to the NES Soil;
  - The requirement for further on-site investigations to define the degree or extent of any contamination; and
  - Any conclusions and/or recommendations specifically pertinent to the objectives of this investigations.

## 1.3 Limitations

Services for this project have been performed in accordance with current professional standards for environmental site assessments, and the persons undertaking, managing reviewing and certifying this PSI are suitably qualified and experienced practitioners as defined in the NES Soil. No guarantees are either expressed or implied. This report does not attempt to fulfil the requirements of legal due diligence.

There is no investigation that is thorough enough to preclude the presence of materials at the property that presently, or in the future, may be considered hazardous. As regulatory criteria are subject to change, a property status with respect to contamination that is presently considered to be acceptable may, in the future, become subject to different



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2 https://www.mfe.govt.nz/issues/managing-environmental-risks/contaminated-land/managing/guidelines.html
3 ibid
4 https://www.mfe.govt.nz/publications/rma/users-guide-nes-for-assessing-managing-contaminants-in-soil/

regulatory standards that cause the property to become unacceptable for existing or proposed land use activities. Any recommendations, opinions or findings stated in this report are based on circumstances, facts and assessment criteria as they existed at the time that we performed the work and on data obtained from the investigations and site observations as detailed in this report. Opinions and judgments expressed in this report, which are based on an understanding and interpretation of assessment standards, should not be construed as legal opinions. This report and the information it contains have been prepared solely for the use of Waterfall Park Developments Ltd. Any reliance on this report by other parties shall be at such party's own risk without prior agreement to the contrary.

# 2 Site Overview

## 2.1 Site Identification

The address of the subject property is 341 -345 Arrowtown – Lakes Hayes Road, Wakatipu, and the general locale of the site is as shown in Figure 1. The legal description of the property is – Part Lot 3 DP 5737 and the associated Certificate of Title (CT) number 666857 (with a land area of 45.0964ha); Lot 1 DP 18109 and the associated CT OT9A/1001 (with a land area of 0.6495ha); LOTS 1-2 DP 23038 and the associated CT OT15B/345 (with a land area of 8.0781ha); LOT 1 DP 27503 LOT 1 DP 27422 and associated CT OT19A/796 (with a land area of 2.6644ha); and SEC 69 BLK VII SHOTOVER SD and associated CT OT250/39 (with a land area of 3.9786ha). Copies of the current certificates of title are attached as Appendix A.

The subject property is shown outlined with a red dashed line on an aerial photograph in Figure 2. For the purposes of this report, the site is defined as the part of the site comprising 35 hectares in extent within the area outlined with a yellow dashed line in Figure 2. References to individual portions of the property are also labelled in Figure 2.

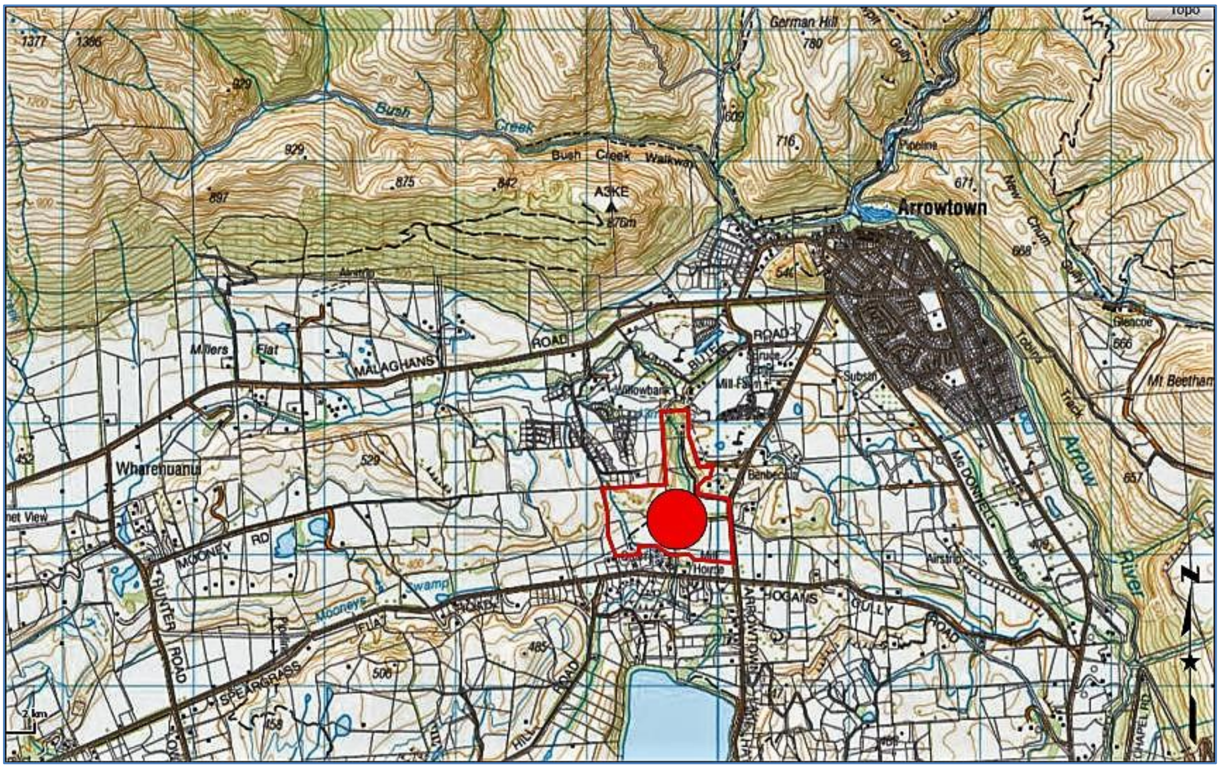


*Figure 1: General locale of subject property (red dot) and outlined in red.*

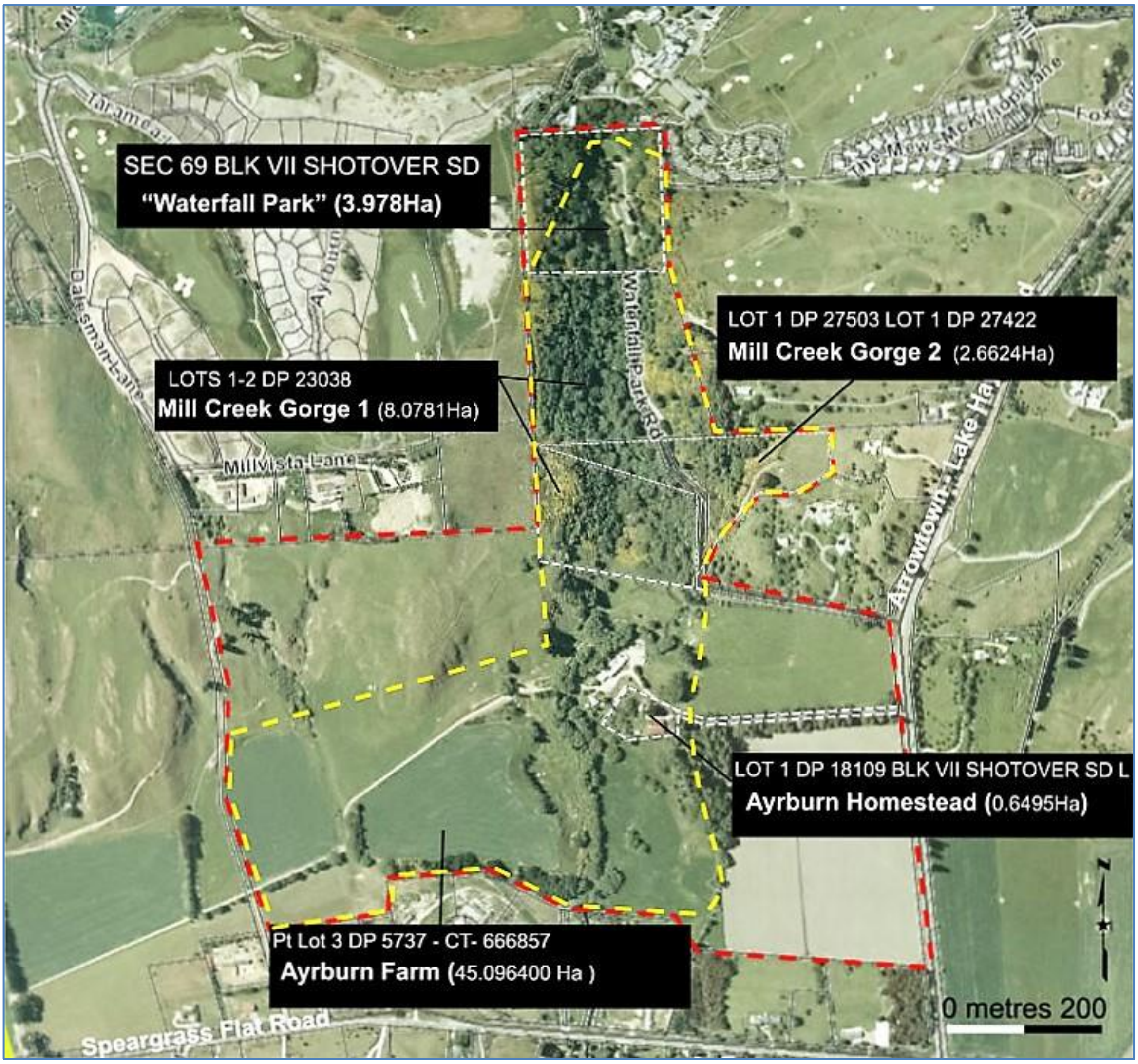


*Figure 2: Specific location of the site at 341 -345 Arrowtown – Lakes Hayes Road, which, for the purposes of this report, is defined as the area outlined by the yellow dashed line. The property boundary is outlined with a red dashed line (aerial photo from Queenstown Lake District Council, GIS 2013). The individual certificates of title are outlined with white dashed lines and the references used in this report for the separate lots are as labelled.*

## 2.2 Site Ownership and Use History

The use history for the site spans the period 1862 to 2016, and a photographic record exists for the period 1904 to 2016. The site is a proposed incorporation of two properties that have quite distinct landforms and that historically have been a part of the on property but have been separate for the past four decades. The larger, southern part of the site has been a farm and farm homestead setting that has been subject to very little change in land use since its original development in the 1860's. Its history is well documented in an Archaeological Report prepared in 2006[5], a copy of which is attached as Appendix B.

Copies of the historical certificates of title were obtained but, being hand-written, the earliest one is difficult to decipher. Legible titles exist from 1931, and the ownership history of the two key blocks, Ayrburn Farm and Waterfall Park, are set out in Table 1 and Table 2 , The early ownership history of the farm is summarised in a book entitled *Queenstown's*



[5] Southern Archaeology Ltd, PG Petchey, Ayrburn Farm Wakatipu Basin, Archaeological Assessment, 2006.

*Farms & Sheep Stations: Families that Farmed the Land* [6], and this is quoted from as appropriate herein.

According to the Archaeological Report, the property was established as a farm by William Paterson in the early 1860's and given the name "Ayrburn Farm". This is verified by McDonald (2010), according to this excerpt:

> *"William (W.R.) Paterson arrived in Port Chalmers in 1862 and walked to Arrowtown with Peter Butel (Millbrook) and Tom McIntyre (McIntyre's Hill). WR. Paterson leased Ayrburn finally free holding it in 1872. It was one of the larger farms in the district and he built a large house on it; In 1876, WR. took over Glencoe, Motatapu and Soho which had been split from Wanaka Station."* [7]

The Archaeological Report contains several maps pertaining to the farm. The earliest of these is dated 1865, and this shows several buildings in the meander in Mill Creek, also sometimes referred to as Hayes Creek, being the stream crossing the site. A second map, dated 1867, contains more detail and this shows five buildings on the farm homestead site. It is the archaeologist's view that these buildings were indicated representatively as a later addition to the map and were not surveyed, as they are not recorded in the surveyor's field book.

A photograph taken in 1904 is shown in Figure 3 and shows the homestead and farm buildings on the site during the occasion of the 1904 Lake Hayes A&P Show. The homestead in the centre of the photo is referred to in the Archaeological Report as "the newer homestead" as the original homestead was a small stone cottage located to the rear of this newer homestead (henceforth, reference to the homestead indicates this "newer homestead"). The site is not in the greater part visible in this image, however the photo does present the early development and the state of the homestead and surrounds at this stage in the property's history.

McDonald[8] records a change in hands in ca. 1914, with the property's still having remained in the Paterson family:

> *"W.R. transferred Ayrburn to his son Robert Murray (R.M.) Paterson about 1914. RM.Paterson acquired the West Dome Station at Mossburn and in 1917 leased Mt Aurum*."

There is no other record of activity for the site between the 1904 photograph until a surveyor's map of the homestead area was produced in 1942 (Figure 4) that shows the main farm buildings and the avenue to the homestead from the Arrowtown-Lake Hayes Road.



[6] McDonald, B. *Queenstown's Farms & Sheep Stations: Families that Farmed the Land*, Queenstown & District Historical Society: Queenstown, 2010.
[7] Ibid.
[8] Ibid.

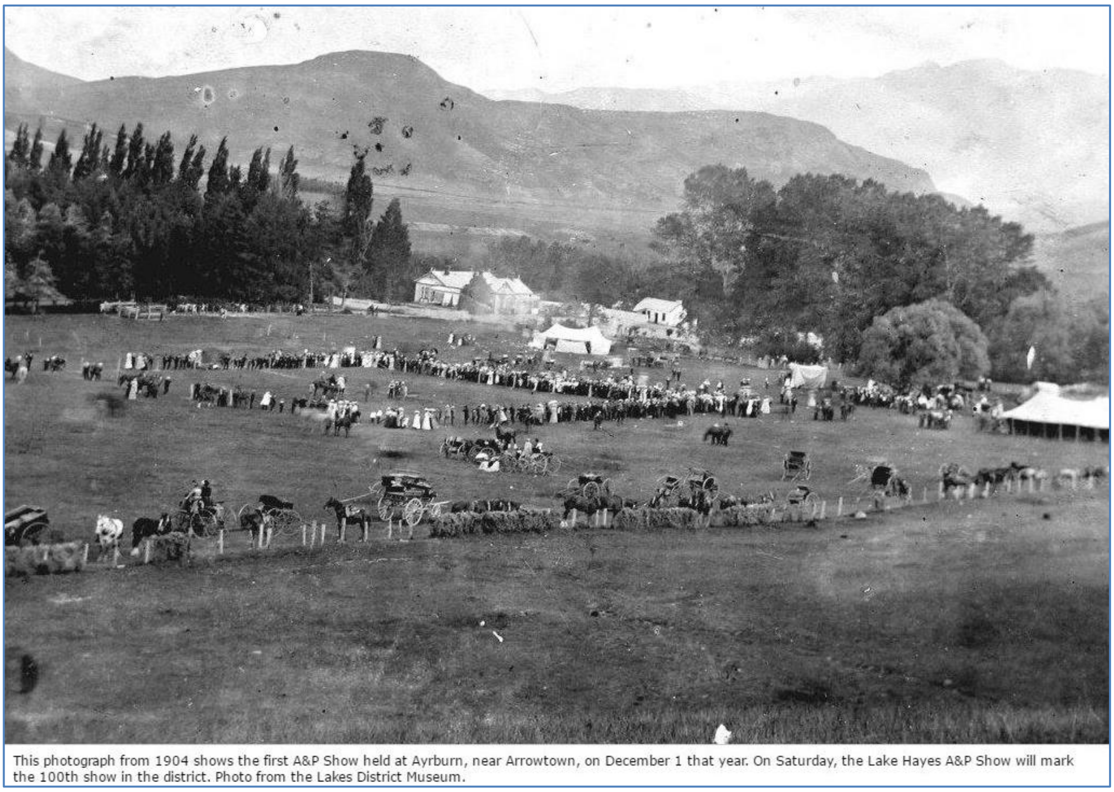


*Figure 3: Ayrburn Farmyard in 1904. The site includes the homestead and the land behind. This photo, taken from the east looking west, in comparison to the modern day shows how little the site has changed in the subsequent 112 years.*

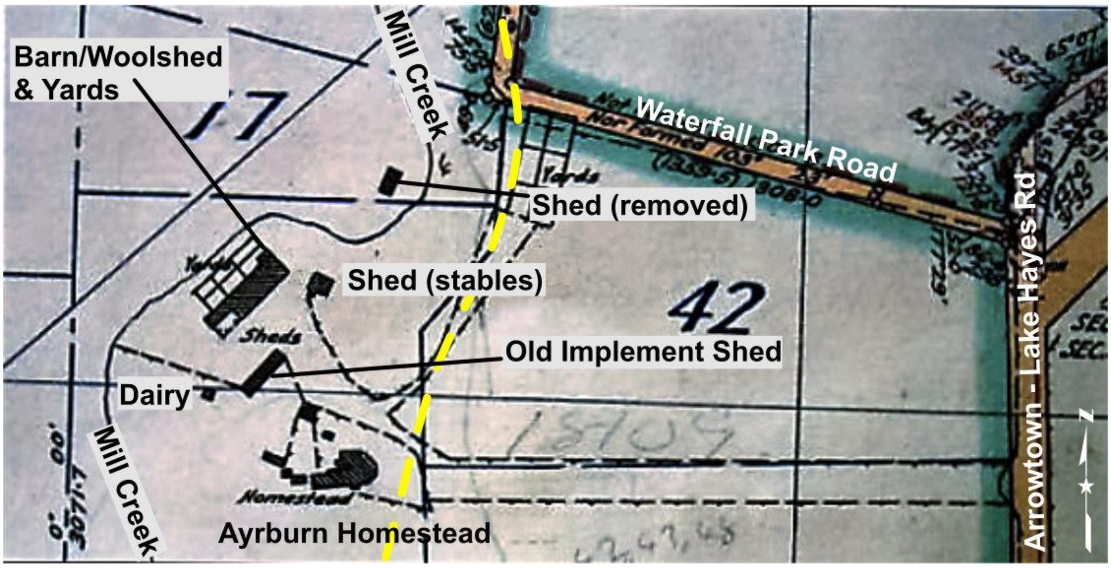


*Figure 4: Detail of DP 5737 (Ayrburn Farm, 1942) showing the main farm buildings and their location relative to the road and Mill Creek. Part of site is seen to the left of the dashed yellow line (Source, LINZ, from the Archaeological Report [9]).*

Several aerial photos of the farm taken in 1954 are available. The aerial photo in Figure 5 shows the bulk of the site with the Ayrburn Homestead in the centre of the image. This photo shows that greater part of the site was in pasture. The patterns of roading and fencing within



[9] Southern Archaeology Ltd, PG Petchey, Ayrburn Farm Wakatipu Basin, Archaeological Assessment, 2006.

the farm at this time remain intact to the present. According to McDonald[10], the ownership of land near the site and the site itself changed hands during this period:

> *"RM. Paterson added some small blocks round the Mill Creek area to Ayrburn. In the 1950s, Ayrburn was sold to Bob Collingwood and then* [i.e., at later dates] *Wilf Cotton, followed by Geoffrey and Christine Dennison."*


*Figure 5: Ayrburn Farm in 1954. The farm homestead is located at the centre of this photo and the site is indicatively shown by the dashed yellow line. Mill Creek flows across the centre of the photo in the line of willows. The Arrowtown–Lake Hayes Road crosses the foreground (Source Whites Aviation Collection, National Archive).*

A 2007 article in the Queenstown Mountain Scene[11] reports that in 1971 a Mr Kevin Ritchie purchased a 4ha block from Mr Wilf Cotton, who then owned Ayrburn Farm. This block (the Waterfall Park Block, Figure 2) comprised a little less than 4ha of land containing the upper part of the Mill Creek Gully (an incised gorge at this point) and the waterfall at its head; Mr Ritchie is quoted in the Mountain Scene article as stating that the site was overgrown with willows when he bought it (note: early aerial photography indicates this land was already willow-infested in 1945). The article states that Mr Ritchie purchased this block to establish a function centre and tourist attraction based at the waterfall in Mill Creek at the upstream (northern-most) part of the block. The article further states that Mr Ritchie constructed the road into the waterfall (Waterfall Park Road) in the late 1970's and built a large "A frame" building for use as a function centre and museum until he sold the property in 1984. This timeline of events is confirmed by the Queenstown Lakes District Council (QLCD) LIM Report, which notes that a building permit was issued in 1973 for the erection of a toilet block and "to erect sign", and that a further permit was issued in 1975 to "build A frame cabin". The A-frame cabin remains to the present the principal structure on the Waterfall Park Block. Further consents were issued in 1976 to build a carport and in 1977 to erect a teashop.

The aerial photo in Figure 6 taken on in 1976 shows the site earthworks for the Waterfall Park development have been completed but construction of the Waterfall Park complex has



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[10] McDonald, B. Queenstown's Farms & Sheep Stations: Families that Farmed the Land,: Queenstown, 2010.

[11] *A $5m Wakatipu gem comes complete with waterfall,* Queenstown Mountain Scene, 7 July 2007.

not yet commenced. In 1984, Kevin Ritchie sold Waterfall Park to Allagonda Estate Ltd, which owned it into the 1990s, during which time it is not clear what the land use was.

*Figure 6: The site of the Waterfall Park development in 1976 showing recently completed site earthworks, but no buildings are present (Source New Zealand Aerial Mapping archive).*

In 1985 the QLDC LIM notes that subdivision consent was granted to separate the homestead site from the remainder of the farm. Jason Glendining, the Farm Manager at Ayrburn for the past twelve years was interviewed on the 16th of August, 2016. Mr Glendining noted that the owner of the farm in 1982, Mr Cotton, sold Ayrburn Farm to Geoff Dennison (including Mill Creek Gorge 1 and 2 blocks in Figure 2) after this subdivision, i.e. minus the Ayrburn Homestead and its immediate garden surrounds (comprising an area of 0.6495ha). Mr Cotton retained ownership of the Ayrburn Homestead and continued to live in it. According to Mr Glendining, the farm manager's house, the only recent structure built on the farm, was built by Geoff Dennison in its present location approximately 100m to the north-west of the homestead soon after he moved to the property, i.e. in the late 1980s. Mr Glendining indicated that, according to his memory, the farm manager's house would be around 30 years old. A LIM Report records that several building permits were issued for the erection of an extension to a shearers quarters in 1988 and 1989, along with drainage works and a new septic tank located to the immediate south of the building. No other building permits are recorded on the LIM, and a drainage plan reflects the floor footprint of the present farm manager's residence, so it is reasonable to assume that the shearers quarters noted in the building permit is now the present farm manager's house, as no other structures of this recent vintage are present on the farm property.

It appears from CTs that the Mill Creek Gorge blocks changed hands in the early 1990s, i.e. during this period the Mill Creek Gorge blocks were no longer part of Ayrburn Farm, albeit with these changes of ownership in the early 1990s there was no notable development of these areas during the time. In 1992 application was made for a plan change to rezone Waterfall Park from Rural A and Rural B to Tourist Development 2, and in January 1994 consent was granted for subdivision and boundary adjustment. Plan Change 91 was adopted by QLDC to rezone the Waterfall Park site as Resort. Between 1990 and 1993 a number of minor permits issued for establishing a performance area and alterations to buildings and installing fireplaces. A set of plans relating to a proposed shop and office extension to the A-frame building, dated 29 November, 1991, were obtained from the QLDC. These show the layout of the extension and side and end elevations of the entire structure, but do not indicate the presence of any installation that could be considered a potential source of contamination. The plans do reference a "plant room". By 1993, Pan Tai Holdings Ltd owned the Waterfall Park and Mill Creek Gorge blocks, a total of 14.7ha[12].

In 1989, CTs indicate that Ayrburn Farm changed hands from the Dennisons to Ayrburn Farm Ltd, and the Ayrburn Homestead was also acquired by Ayrburn Farm Ltd in that year. Ayrburn Farm Ltd was then transferred to Ayrburn Farm Estates Ltd in 2002. In 2002 and 2003 several certificates of compliance were applied for covering maintenance of farm tracks and amenity planting and also various applications to operate a truffle farm, cherry orchard, a vineyard and commercial livestock production were granted, but the latter developments appear not to have been given effect to.

In 2002 consent was granted to erect a dwelling on LOT 1 DP 27503 LOT 1 DP 27422, the Mill Creek Gorge II block, on eastern slope at the entrance to Mill Creek Gully. A track was cut to the proposed building platform, but no building occurred. In 2004 application was made to establish a Maori Cultural Experience (concert and hangi) using the existing buildings at Waterfall Park. This activity did establish, but was apparently short-lived, and from that point the structures forming the Waterfall Park complex appear to have fallen into disuse. This activity is confirmed in the 2007 article in the Queenstown Mountain Scene article mentioned above, which also notes that "several years ago" the facilities at Waterfall Park were used for a while as a commercial Maori cultural centre. This activity appears to have been operated on a leasehold basis as the ownership record does not reflect this occupancy.

In 2006 a certificate of compliance was granted to remove some of the trees from around the Ayrburn Homestead and a subdivision consent was granted for a boundary adjustment. Also in 2006, Bonsich Surveyors produced a map of the site (Figure 7) that shows the buildings as they existed at that date. In comparing Figure 4 to Figure 7, one addition has occurred, this being the farm manager's house, and two small sheds or structures have been removed, one



[12] Ibid, confirmed by CTs.

on the west side of Mill Creek and one very small structure that was originally located directly in between the main homestead and the original cottage.

According to Mr Glendining, on Ayrburn Farm, sometime around 2005 an old concrete plunge-style sheep dip and race located to the north-east of the large Barn/Woolshed & Yards (label from Figure 4, labelled Woolshed (stable) in the Bonisch map in Figure 7) and on the true left of Mill Creek immediately upstream of this, was demolished and the former sheep dip locale was levelled and metalled. Mr Glendining was unsure of the exact fate of the sheep dip, but is of the view that the greater part of it likely remains in-situ after having been pushed in and covered over. Mr Glendining recalls the site's having pipework and the area's "being a mess". The location of the former sheep dip, as described by Mr Glendining, was at the northern end of the Barn/woolshed & Yards in the grassed area to the west of the present vehicle turning area nearby.

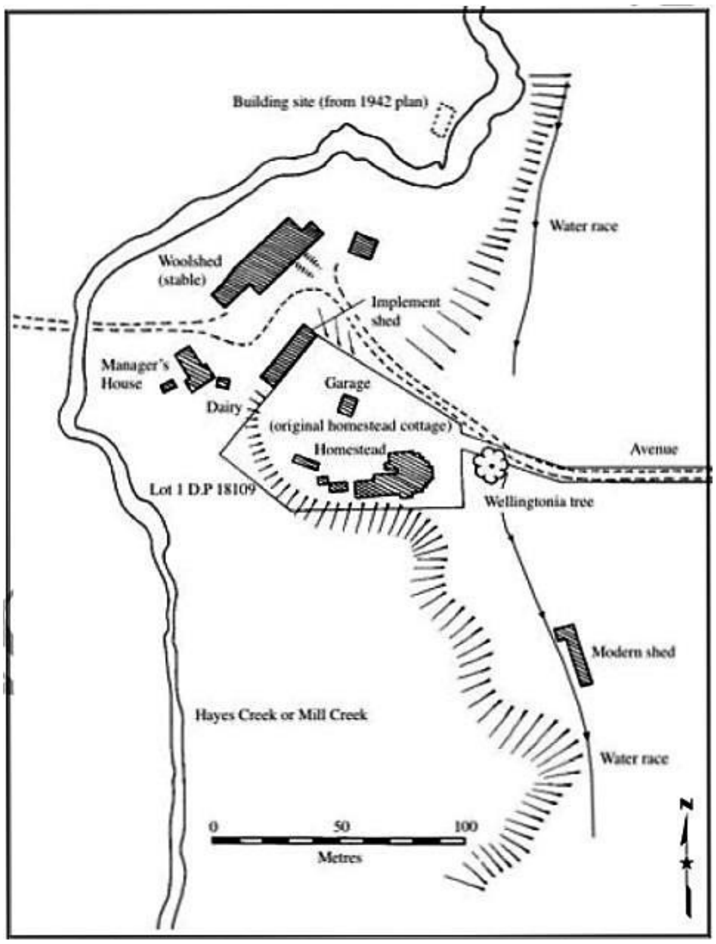


*Figure 7: The main buildings at Ayrburn Farm in 2005 as given in a 2006 plan by Noel Bonisch Ltd (Source Archaeological Report).*

When interviewed, Mr Glendining advised that there were other activities of a potentially contaminating nature at site, the timing of which is in some cases not well known. He noted that there is an underground storage tank (UST) by the eastern wall of the Barn/Woolshed in Figure 4, however the UST has been unused for the 12 years that he has been the farm manager. His understanding is that when the UST was in use, it was used for petrol. There are also two diesel above-ground storage tanks (ASTs) that are currently in use, and building consent records indicate that an oil burner installation (i.e. implicating fuel storage) is/has been associated with the homestead.

Mr Glendining was queried about whether or not he had knowledge of farm dumps or landfills at the site, and he commented that a small amount of material such as fencing wire was buried at the south end of one paddock. Mr Glendining also commented that metallic scraps surfaced when he has graded the main farm track where it passes through the cutting west of the bridge. The locale of these features, to the extent known or surmised, is further discussed with reference to site inspection, below.

Regarding the farm generally, since much of the land has been in cultivation for one hundred fifty odd years, it might be expected to have been subject to treatment with organochlorine pesticides at some time.

The LIMs for each title note that there is no record of HAIL activity on the site. A report from the ORC also states that they have no record of HAIL activity on the site. A copy of this notice and extracts of the relevant parts of the QLDC LIM reports are attached as Appendix C.

## 2.3 Historic Use of Land Adjacent to Site

The site surrounds were rural pastoral farmland with some historical grain cropping and two flour mills and a cheese factory on adjacent land, as described in the following quote from the Archaeological Report:

> *"Running through the Ayrburn property is a water race that once supplied a dairy factory on Speargrass Flat Road. The race runs along the eastern bank of Mill Creek on the north side of the homestead, crosses the driveway, and then runs south along a fenceline. While the race is no longer in use, it is still easily discernible for much of its length. There were two industrial operations on Speargrass Flat Road to the south of Ayrburn Farm. The Wakatipu Flour Mill operated from about 1870 until 1940, and was one of three flour mills in the Wakatipu Basin. It was powered by a 26 ft. diameter overshot water wheel, fed from Mill Creek (Petchey 1996: 163-4). The Lake County dairy factory operated between 1914 and 1958, producing 'Wakatipu' brand cheese (Petchey 1991: 60). According to Mr. Cotton (who bought Ayrburn in 1956) the water supply to the flour mill water wheel was piped, while the water race supplied the cheese factory (Mr. Cotton, pers. comm. 2006). Another water race can also be seen on the hillside that defines the northern boundary of the present Ayrburn property. This is probably an old irrigation race."* [13]

These features are marked on the 1950 aerial photo of the site and surrounds in Figure 8.

[13] *Ayrburn Farm Wakatipu Basin, Archaeological Assessment, PG Petchey).*

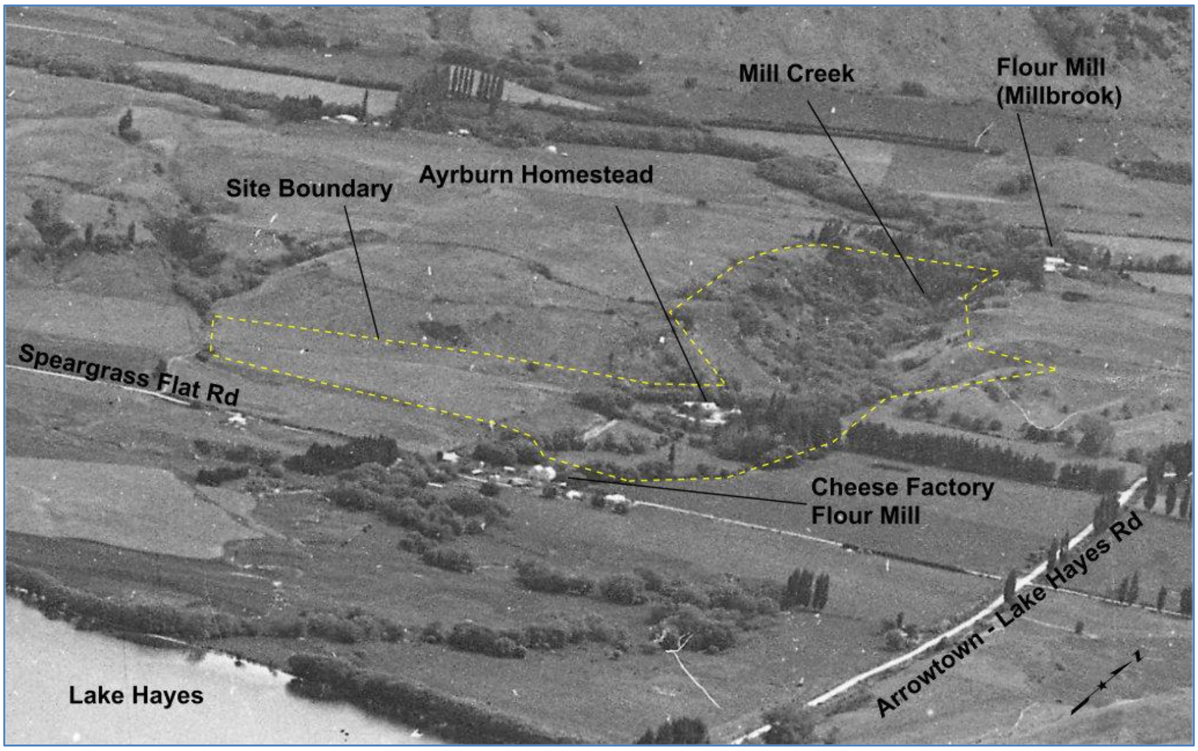

*Figure 8: The site (indicatively shown with yellow dashed line) and its surrounds in 1950 with key adjacent historical activities identified (Source VC Browne Archive).*

The land to the north of the site is now zoned "Resort" and is the site of the Millbrook Resort and Golf Course and Rural Lifestyle blocks. The land to the south along Speargrass Flat Road is also in rural lifestyle blocks, while to the east and west remains undeveloped rural land.

## 2.4 Previous and Associated Investigations

Enquiries of QLDC and ORC did not produce any information indicating that any previous or associated investigations have been undertaken for the site or adjacent land.

## 2.5 Current and Proposed Future Use

The main farm block and homestead are presently owned by Ayrburn Farm Estates Ltd while the Mill Creek Gorge and Waterfall Park blocks are owned by Pan Tai Holdings Ltd, and all are subject to a conditional agreement for sale to Waterfall Park Developments Ltd. The site is currently used entirely for pastoral farming. The majority of the site is zoned Rural General in the present Queenstown Lakes District Plan (QLDP) with the part within the Waterfall Park block zoned "Resort".

The proposed development is for residential use at mixed densities with higher density development proposed for the Mill Creek Gorge area at the northern end of the site and lower density development across the flatter parts of the site. It is proposed to make some commercial use of the area by the waterfall at the terminus of Waterfall Park Road. The concept plan is shown in Figures 9 and 10.


*Figure 9: Concept plan for proposed development in the Waterfall Park and Mill Creek Gorge I and II blocks, the latter of which is scheduled for a medium density residential neighbourhood.*


*Figure 10: The development concept for the Ayrburn farmyard and homestead precinct.*

## 2.6 Potential for Contamination

The information reviewed during this PSI, as described above, has provided evidence of past and/or present HAIL activity at or proximate to the site. Based on the findings above, the land use of key concern with respect to potential for contamination is summarised in Table 1 below, along with relevant HAIL Code and MfE description and potential associated contaminants. Some of the relevant activities at site were only discovered upon site inspection, discussed in a separate section below.

**Table 1: Summary of HAIL Land Use and Potential Associated Contaminants[1]**

| Land Use | HAIL Code and Description | Potential Contaminants |
|---|---|---|
| Sheep Dip, possible use of legacy pesticides | A8. Livestock dip or spray race operations | Arsenic, organochlorines (eg, aldrin, dieldrin, DDT, lindane) and organophosphates, carbamates, and synthetic pyrethroids |
| Fuel Storage Tanks (ASTs and UST) | A13. Petroleum or petrochemical industries including a petroleum depot, terminal, blending plant or refinery, or facilities for recovery, reprocessing or recycling petroleum-based materials, or bulk storage of petroleum or petrochemicals above or below ground | Hydrocarbons including BTEX, PAHs, and solvents; lead and other metals, particularly if waste oil handled |
| Engineering shop | D5. Engineering workshop with metal fabrication | Metals and oxides of iron, nickel, copper, chromium, magnesium and manganese; |

| | | |
|---|---|---|
| | | range of organic compounds used for cleaning including BTEX, solvents |
| Farm Landfill | G3. Landfill sites | Dependent on original waste composition, wide range of hydrocarbons and metals, organic acids, landfill gas, and Ammonia |

1. The item shaded in grey was not discovered during the desk-top study, and, although listed herein for completeness, is discussed in more detail in subsequent sections.

## 2.7 Integrity Assessment

The use history spans a period of 154 years and is intermittent over that period. The evidence supporting the use history includes LIM Reports, an Archaeological Report, the present farm manager's comments, a book, a newspaper article and historical photographs; based on the continuity and amount of evidence, the information available provides a reasonable, though incomplete, record of activity at the site, which reflects data integrity. Whether all activities at the property have been discovered cannot be answered with confidence. Given the known history of HAIL activities at the site, a programme of investigative sampling and analysis was undertaken as a part of this PSI, this initial sampling was followed by a second sampling program that focussed on issues identified from the initial sampling. Sampling and analysis provides a reliable indicator of the presence of contamination that might arise from prior and/or present land use. This provides an evidentiary basis from which to assess the site's status with respect to the HAIL and associated potential risks for human exposure, per the NES Soil[14].

# 3 Site Condition and Surrounding Environment

## 3.1 Site Inspection

A site walkover was undertaken by an EC Otago Senior Environmental Planner on the 28th of July, 2016, accompanied by the Mr Jason Glendining, the Ayrburn Farm Manager. A second site inspection and walkover was performed on the 1st of November, 2016. The property comprises approximately 50ha of gently sloping to rolling open pasture that run up to steeper slopes to the north. A narrow leg of land extends to the north from the main body of the site; this contains Mill Creek where it flows within a gorge incised into the hills to the north of the body of the site. The site inspection is discussed in three parts reflecting the different use histories and the distinct landforms involved in the site. The first part of the site inspection covers the "Farm Proper" (most of Ayrburn Farm, as shown in Figure 2), being the Speargrass Flat terrace and the valley floor of Mill Creek below the farmyard, all of which has been used for broad-scale farming and cropping. The second part of the site inspection covers the Mill Creek Gorge (blocks I and II, Figure 2) and the Waterfall Park block (Figure 2) upstream of the farmyard, the latter part of which has been used for the last forty-odd years for tourist activities. The third part, the "Homestead Area", contains the homestead and farm buildings and surrounding yards, i.e. this part is constituted of Ayrburn Homestead, as shown in Figure 2, as well as some proximal/immediately surrounding areas of Ayrburn Farm. This part of the site required detailed inspection because the history of



14 https://www.mfe.govt.nz/publications/rma/users-guide-nes-for-assessing-managing-contaminants-in-soil/ and https://www.mfe.govt.nz/publications/hazardous/contaminated-land-mgmt-guidelines-no2/

use is complex as it has been the base of farm operational activities for a century and a half. The distinct areas comprising the Farm Proper, Mill Creek Gorge/Waterfall Park and the Homestead Area are shown in photos herein and discussed further below. General features and locations from which some photos are taken are numbered and marked with black arrows on Figure 11. Additional photos of the Homestead Area at close range are presented later.

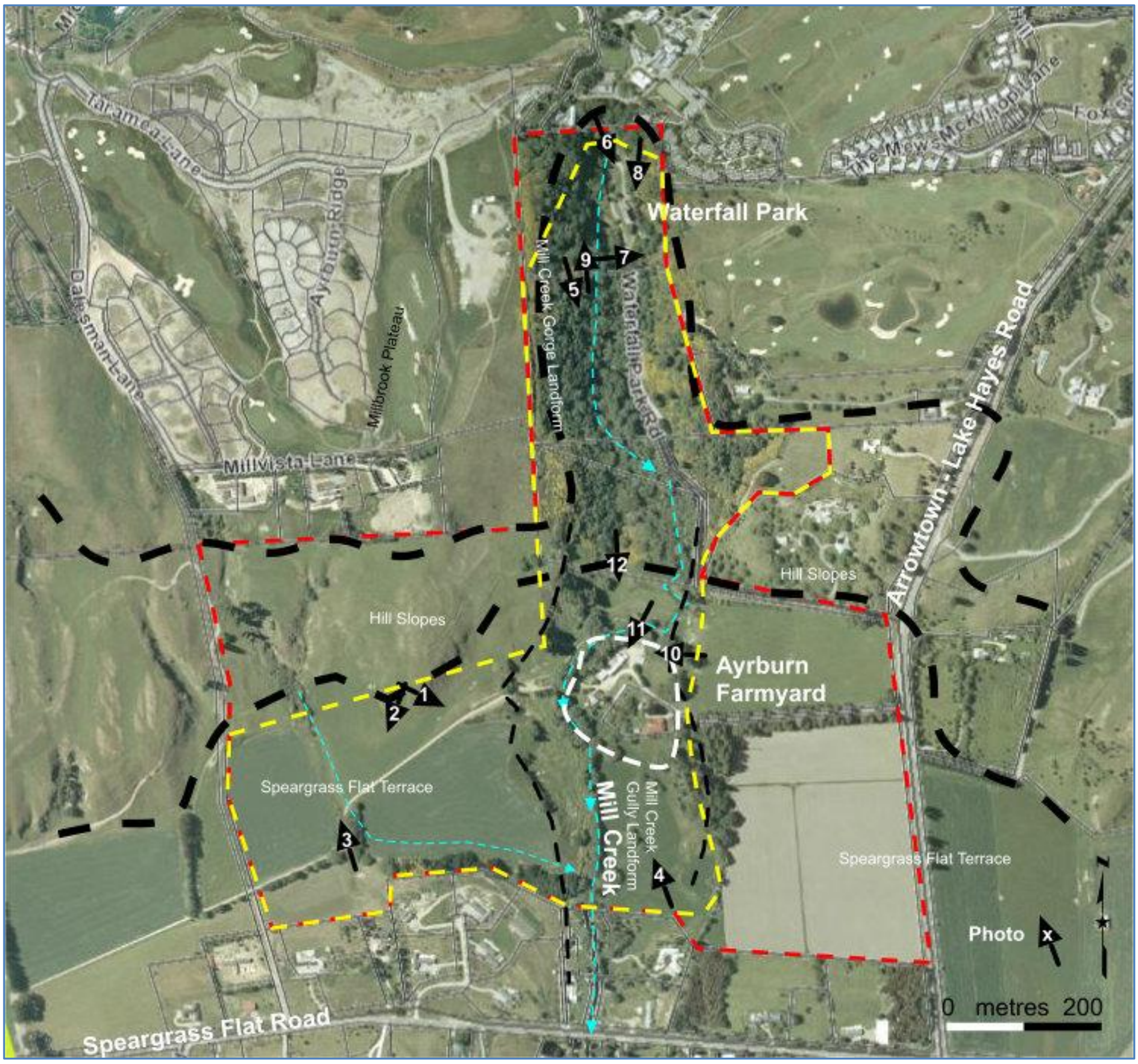


*Figure 11: Key features marked with reference to the site inspection. Photos of the Farm Proper and Mill Creek Gorge/Waterfall Park presented below are marked with black arrows and white numbers, with the arrows showing the photo location and direction of view.*

### 3.1.1 Ayrburn Farm ("Farm Proper")

Two areas of land marked as "Speargrass Flat Terrace" and "Mill Creek Gully Landform" in Figure 11 comprise much of the land to be developed for residential purposes (note, referring to Figure 2, only one of the two areas labelled Speargrass Flat Terrace above is within the site that is the subject of this report). The two areas of land that comprise Speargrass Flat Terrace are separated from one another by a low escarpment cut by Mill

Creek as it formed the flat gully floor that represents its historic erosional surface. The main terrace landform that is within the site is shown in Figure 12, Photos 1 – 3. Photo 4 was taken from the flat gully floor that represents the Mill Creek historic erosional surface. This part of the site is heavily close-cropped cultivated pasture that is traversed by a well-constructed farm road and is largely devoid of minor features, as can be seen in Photos 1 and 2. This cultivation has obliterated any potential evidence of earlier activity. A swale runs across the terrace, as marked by the light blue dashed line in Figure 11. This is an ephemeral channel that drains an area of 15 – 20ha of the terrace face and the upper terrace to the north of the site, and so can be expected to carry an intermittent flow during heavy rains. This swale discharges to Mill Creek. The land forming the valley floor of the gully in which the Mill Creek flows is also cultivated pasture, but not to the intensive level that is evident on the terrace land. Fossil meanders and flood channels created a gently undulating landform with mature willows lining the creek, which flows against the foot of the terrace on the southern side of the gully. A few scattered willows are present in the valley floor and the containing terrace slope on the northern side of the gully is covered in mixed woodland that forms a part of the farm homestead planting.

### 3.1.2 Mill Creek Gorge/Waterfall Park

Waterfall Park and the two Mill Creek Gorge blocks cover an area of almost 15ha, the majority of which area falls within a steep-sided valley (the Mill Creek Gorge) that runs roughly north-south and is incised to a depth of approximately 50m in the higher terrace to the north of the site. The floor of the Mill Creek Gorge Landform (ref Figure 11) comprises an area of some 8ha in addition to the 4ha of the Waterfall Park block. The floor of the gorge was until recently filled with mature willows, with a gravel road cut through to the waterfall at its upstream/northern end. The willows have now been cleared as is evident in the view downstream in Photo 5 in Figure 13; this clearance activity occurred between the two site inspections.

The clearing at the upstream end of the Mill Creek Gorge, by the base of the waterfall, is landscaped, grassed and paved, with a large A-Frame building located on an excavated bench above the valley floor, as shown in Photo 6 in Figure 14. This area at the base of the waterfall has been developed to host gatherings within several levelled areas in the valley floor. The grass appears well mown. All of the open spaces adjoining the stream and waterfall appear to have been cut into the natural surface, presumably at the time the road and the A-frame building were constructed. As such, the site surface will have been heavily disturbed, and is inferred to only have been exposed to human activity since this part of the site was developed in the mid-1970's.


*Figure 12: Panorama views of the main part of the Speargrass Flat Terrace at site in Photos 1 and 2. Photo 3 shows the western-most end of the site and Photo 4 shows the Mill Creek Gully looking north from the lower part of the site, with the farm manager's house in the centre of this view. The Mill Creek flows by the willows on the left of Photo 4. The terrace faces are approximately 5m high, as can be seen on the left of Photo 4.*

*Figure 13. Photo 5 – view downstream from the upstream western slopes of the Mill Creek Gorge showing the of the cleared valley floor and slopes and remnants of the willow woodland that until recently filled much of the valley floor.*

*Figure 14: Photo 6, taken at the head of the Mill Creek Gorge and showing the A-Frame "lodge" and the grounds adjacent to the building. The Mill Creek Falls are immediately to the right in the photo.*

There are five ancillary structures downstream (to the south) of the main A-frame building that are also cut into benches in the eastern slope of the valley wall; three of these are timber framed structures that appear to have been used either for garaging vehicles or to store equipment. One structure is an open framed "carport" style structure. One building cut into the bank a little downstream of the A-Frame has been a toilet block at some point. Another small structure beside the road, some 70m from the main building, is made of concrete block and has a footprint of roughly 2 by 1m (Figure 15 Photo 7). This contains a piece of mechanical equipment that has a small electrically driven hydraulic pump on its top and with external pipework and four solenoid valves which would suggest it was a delivery system for an oil fired heating plant, however there was no sign of any tank, fuel delivery point, oil burner, flue or reticulation of or heating plant associated with it. Both the main A-frame building and the ancillary structures are intact, but poorly maintained. A small relocatable shed is located next to the concrete block building. The sheds generally contain a disarray of inert wastes such as cardboard, timber and broken outdoor furniture.

There is large burner that appears to have been used to heat the A-frame building that is built against the wall of the building as is evident in Photo 8. On inspection this was found to contain a large grate that indicates that it appears to have been fuelled with firewood. There is no visible sign of any liquid fuel supply or fuel tank adjacent to the building. The building has external drainage and grease traps, but no evidence of a disposal field was observed. While the building is in a poorly maintained state, it remains sound. It is noted in the QLDC LIM that the roof of the building is fibre cement sheet and the site inspection confirmed this. The roof is sound and there is no evidence of broken sheet on the site surface in the vicinity of the A-frame building. A "plant room" associated with the A-frame building, as evident on a set of plans discussed in Section 2, was inspected and found to be a bare room with a wooden floor that was elevated well above the ground on pole foundations. No evidence of any past installation was evident either from within or underneath this room.

As a result of the willow clearance, an historic waterwheel-driven engineering workshop was discovered during the second site inspection at a location a little way downstream of the A-Frame building, near the base of the waterfall on the western bank of Mill Creek and on the western side of the valley floor. Some of the equipment that included a lathe is shown in Photo 9 in Figure 16. This equipment was driven by water from the Mill Creek water race that crosses the upper slopes of the valley on the western edge of the site. The fluming and the waterwheel that drove the equipment also remains. There is no historical record relating to this workshop. An engineering workshop from this era would be expected to be associated with the use of solder, thus lead contamination may be present at this site.

### 3.1.3 The Homestead Area

Figure 17 includes several photos of the upstream (northern) end of the farmyard as viewed from afar; the locations from which these photos were taken are given in Figure 11. While the homestead is proximal to the farmyard, it not in the view of some of these shots and/or is to the south of the main features in view. Photo 10 shows the farmyard area viewed from the top of the terrace face to the east of the farmyard; the features labelled correspond to those appearing in Figure 2 or otherwise mentioned in the desk-top study. Photo 11 is a view looking south and showing the northern end of the Barn/woolshed & Yards (per Figure 4 labels) overlooking the area where the old plunge-style sheep dip was located.

A concrete tank with a door that is used as a killing shed for butchering animals is located to the north of the barn; this feature was not discovered in the desk-top study. It is maintained and contains equipment for processing carcasses, but is otherwise empty.

Other features labelled and discussed further below include a UST and the drum store. Photo 12 is a view to the south overlooking the paddock immediately upstream of the farmyard. This area contains a trailer and mower and isolated piles of miscellaneous material including fencing, timber, and an unused dog kennel.


*Figure 15: Mill Creek Gorge/Waterfall Park photos with Photo 7 showing the equipment in the shed by the road near the entrance to Waterfall Park, which appears to be some form of fluid pump; Photo 8 shows the A-frame building and the heating furnace.*

*Figure 16: Photo 9 Equipment from the historic water powered engineering workshop located downstream of the Mill Creek Falls; the water wheel and fluming is located a little further upstream.*

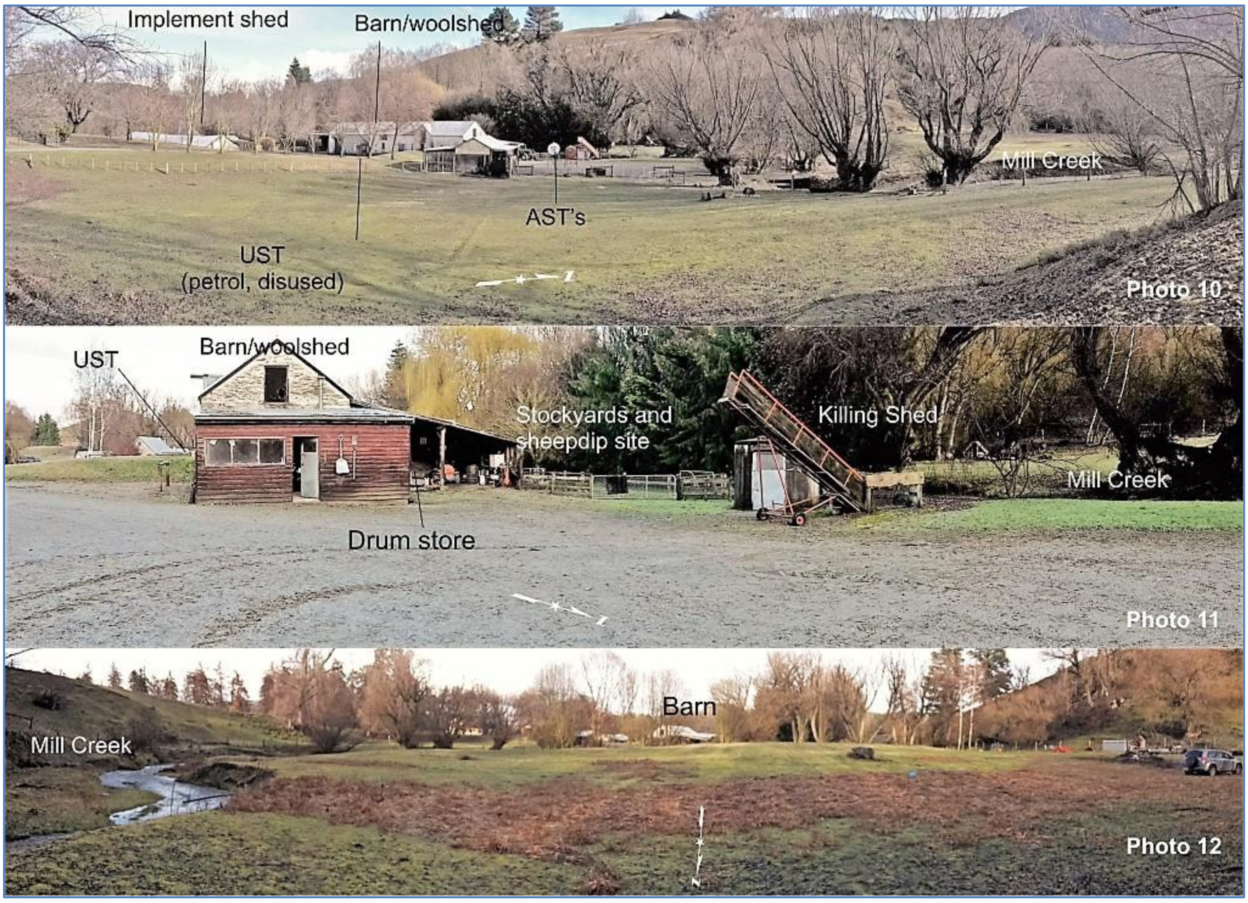


*Figure 17; Photos taken from upstream of the farmyard area (immediately proximal to the homestead). Photo 10 shows the farmyard area from the top of the terrace to the east. Photo 11 shows the land to the north of the Barn/woolshed that contains the former sheep dip site, while Photo 12 shows the valley floor upstream of the farmyard. The paddock in Photo 12 has some implements and materials stored in it and the farm manager confirmed that there may be a small farm landfill in a meander at the lower end of this flat immediately upstream from the barn.*

Figure 18 (Photos 13-16) shows a number of views of the main farmyard area). Photo 13 shows the farmyard, which is formed of an extensive gravel apron between buildings with mown grass verges alongside the two large historical sheds (the Barn/woolshed and Old Implement Shed as labelled in Figure 4). It appears from inspection that the structure on the left in these photos (Barn/Woolshed & Yards in Figure 4 and "Woolshed (stable)" in Figure 7), is only in partial use; in particular the portal-framed corrugated iron clad shed at it southern end in the foreground in Photo 13 is used for vehicle storage. A timber clad annex at the building's north end is just visible in the background in Photo 13. This annex appears to have been used as an office and is now a tool shed, while a lean-to adjoining this annex at the rear (west) of the main building is presently used as a lubricant store and garage for utility vehicles and storage of miscellaneous tools and farm hardware. Approximately 700l of lubricants are stored within the lean-to in their original containers on shelves and the floor; some of these are stored in drums, i.e. the lean-to is a lubricant and drum store. From inspection, the drum store appears to be kept in an orderly fashion, and no spillage is evident on the surrounding ground.

Two UST's were observed during the site inspection. One of these is located at the mid-point of the front wall of the Barn/Woolshed, a tank vent pipe and hand pump on an upstand were observed during the site inspection, and these features are associated with the UST mentioned in Section 2, which was discovered in interviewing the farm manager. The second UST was not discovered during the desk-top study, and was observed during the second site inspection within the structure shown on the far right of Photo 13 labelled "Old Implement Shed" in Figures 4 and 7. This building is now unused other than that a car covered by a dust sheet is stored in one bay. For this second UST, there is a UST tank fill point a pipe that appears to be a tank breather and some bolt holes and an imprint on the wall that is suggestive of an old hand petrol pump. The presence of this UST was not discovered during the desk-top study, as the farm manager was unaware of its presence. The building in the centre in Photo 13 is labelled as a Shed(stables) in Figure 4 (not labelled in Figure 7), and is discussed below.

In Photo 14 shows the farm manager's house (far right in the photo), two small sheds (to the left of and in front of the farm manager's house in the photo), and the Old Implement Shed (far left) with the gravel parking and hardstand that now forms the centre of the farmyard precinct in the foreground. Photo 15 shows stock yards against the rear (western) wall of the Barn/Woolshed. These are constructed of tanalised pine indicating that they are of relatively recent construction and these remain a part of the farm operation and are in good repair and well maintained. Photo 16 shows the farm manager's house and garden and two small sheds adjoining it from a similar but closer view than that in Photo 14. The first shed is a stone building, painted white, with a concrete floor that the Bonisch Map of the site (Figure 7) identifies as a dairy; the second adjacent shed is a wooden structure that appears from inspection to have been a milking byre. These old sheds appear largely unchanged from when they are inferred to have been built in the 1860's and, while still reasonably sound, are not currently in use. The farm managers house has a septic tank located within the lawn area on its southern side. The larger timber shed marked as Shed (stables) in Figure 4 and visible in the centre left of Photo 13 stands alone on the eastern side of the hardstanding area, and the interior of this structure is shown in Figure 19. It is presently used primarily for storing equestrian equipment and appears from inspection to have been erected for this purpose. Two ASTs, presently in use, are located to the north of this old Shed (stables) as seen in Photo 10, Figure 17. These two ASTs, are both in use and are well maintained. Light diesel staining is visible at their base, which is unbunded.


*Figure 18: Four close views of the farmyard. Photo 13 shows the eastern face of the Barn/Woolshed. A disused UST is located between the small shed built against the Barn wall and the earth ramp. The Old Implement Shed is on the left of Photo 14 and the farm manager's house on the right, with the milking byre and stone dairy located between the two. Photo 15 shows the Barn and the yards against its rear (western) wall. Photo 16 shows the farm manager's house, with the dairy (centre) and milking byre (left).*

*Figure 19: Interior of Shed/Stables showing equestrian equipment and general condition of shed interior.*

The farm homestead, its grounds and front garden are shown in Figure 20. The homestead is fenced off from the farm and has been a separate lot since it was subdivided from the farm in 1985. Is not proposed to be subdivide the homestead title or to change the use of the building and is therefore not technically required to be included in the site investigation report, it has however been included as its restoration will form part of the proposed development and it is necessary to appraise its status with regard to ground contamination accordingly. The homestead has not been occupied in recent years, but remains in a well-maintained state and the grounds surrounding it are also well maintained. An oil burner installation that was noted in the building consent records and a 500l above-ground heating fuel tank was confirmed during inspection to be located at the rear of the building. The location of this tank is shown in Figure 21. The ground under the tank shows evidence of localised oil staining.

*Figure 20: The Ayrburn homestead with the farm's original cottage to its right and the Barn/woolshed on the right-hand side of the photo. The main entrance to the site from Arrowtown – Lake Hayes Road crosses the foreground of the photo.*

*Figure 21: The homestead rear wall and back door with a 500l heating fuel tank on a stand in the recess beside the annex at the centre of the photo.*

A wooden outbuilding is located behind the homestead as shown in Figure 22. This building appears to be very old (is shown on both Figures 4 and 7) and comprises three rooms, all of which open to the outside. This building appears to have been used as a store shed and tool shed. One bay still contains an old 12gallon lubricant drum and a 20l container of Talon rodenticide.

*Figure 22: The homestead rear garden with outbuilding (to the right of the homestead in the photo).*

A concrete structure that appears to be a septic tank is located at the rear (south) of the homestead and appears to discharge over the bank to the lower terrace. There is a veneer of rubbish deposited across this slope that is embedded in the soils on the bank and this appears to date back a considerable period. Visible remnants of rusted metal containers and bottles are scattered across a quite wide area from the top to bottom of the slope shown in Figure 24. The septic tank structure is visible to the left of centre of this image with a pipe extending down slope from the top of the tank.

*Figure 23: Rubbish on the slope at rear of homestead. Concrete structure and pipe to the left of centre appears to be a septic tank.*

Figure 24 below summarises key features of the Homestead Area/proximal farmyard (marked with a green dot and labelled) that are discussed in Section 2 and Section 3 and identifies loci of potentially contaminating activities (marked with a red star and labelled).


*Figure 24: The Homestead Area showing buildings (marked with green dots) and potentially contamainting activities (marked with red stars) identified during investigation and site inspection. The location of some of the photos cited in this section of the report are marked with black arrows and numbered as referenced (Photo Source QLDC GIS). Some features labelled are described in Section 2; all other features are noted in the text in this section.*

## 3.2 Conditions at Site Boundaries

To the east and west of the site the terrace landscape continues and the land is in cultivated pasture. To the north of the site the land is in hill country dryland pasture and this rises to the upper terrace and the Millbrook Resort development and associated lifestyle residential development, which is 500m or more from the main body of the site. This more steeply slowing land containing the site to the north is devoid of significant features other than farm tracks and a disused water race. The site's southern boundary adjoins a rural residential area on the northern side of Speargrass Flat Road (see Figure 2). The farm fencing is all in sound condition, but the site boundaries, as a result of being internal to the property in some locales (ref Figure 2), are not fully fenced.

## 3.3 Signs of Contamination

The site inspection conducted in conjunction with the site soil sampling found no olfactory evidence of potential for contamination. The visual cues suggesting possible contamination are locus specific and relate to the Barn/woolshed and the farmyard precinct. There are some long-established stockyards against the western wall of the Barn from which it would be reasonable to expect that sheep drenching or dipping would have occurred in closely proximity to this facility. Five fuel tanks, three ASTs (two for diesel, Figure 17, and one for heating oil, Figure 22) and two USTs, were observed. These have been mentioned above save for the second UST and heating oil AST, the former of which was identified/observed within the Old Implement Shed during site inspection and the latter of which was observed at the rear of the homestead. The visual evidence indicating the existence of the second UST is shown Figure 25. This UST is expected to predate the installation by the barn/woolshed both by the fact that the hand pump has been removed (while it remains in place on the other UST installation) and by the cap on the filling point, which appears to be of a much older style than that on the filling point on the UST by the Barn/woolshed. The location of this UST within the Old Implement Shed is also suggestive of a very early date for its establishment because it appears well integrated with the interior structure of this building. Closer views of some of some other visual indicators observed at the site are shown in Figure 26.

*Figure 25: Fill point, tank breather and mounting point for pump against an internal wall in the Old Implement Shed, all serving as indicators of the presence of a second UST at site.*

With regard to landfilling, because of the long history of farming on the site and from Mr. Glendining's comments regarding landfilling during the site walkover, a comparison of historical aerial photography has been made of landforms over time to ascertain whether these provide any indication that any landfilling or other significant earth shaping may have occurred within the farm. This comparison suggests that fill may have been placed in two locations. The first is beside Mill Creek, just upstream of the Barn/woolshed & Yards, as shown on Figure 27, outlined by a red dashed line.


*Figure 26: Photos of some of the visual cues for potential contamination that were observed during the site visit; left – drum store adjoining the Barn/woolshed/; top right – the two diesel ASTs by the Shed(stables); and bottom right – evidence of the UST against the eastern wall of the Barn/woolshed.*

During site inspection there was no evidence of this discovered on the ground, however the aerial photos suggest that the landform has been altered sometime after 21/10/2006. During the same period, an area of land north of the yards and barn was excavated and a gravel apron was laid, as also indicated in Figure 27 (yellow dashed line). There is a track through Mill Creek between the two locations as well, which lend support to an assumption that material was excavated from one location and placed in the other as fill. Mr Glendining when asked about landfilling at this location advised the old fencing and similar materials may have been buried at this location but that he had no knowledge as to whether other material had been disposed to this location particularly relating to the disposal of the remains of the sheep dip and surrounds. The landform that is evident from the dry mound visible in the photo in the lower right hand of Figure 27 indicates a more substantial body of fill at this location. The "tail" that connects this landform with the farm track to its' left that is visible in both of the post-2010 photos is also suggestive of heavy vehicle tracking having occurred at this location. If this location has been used to dispose of material cut from the vicinity of the barn and yards it could represent a significant deposit of contaminated material.

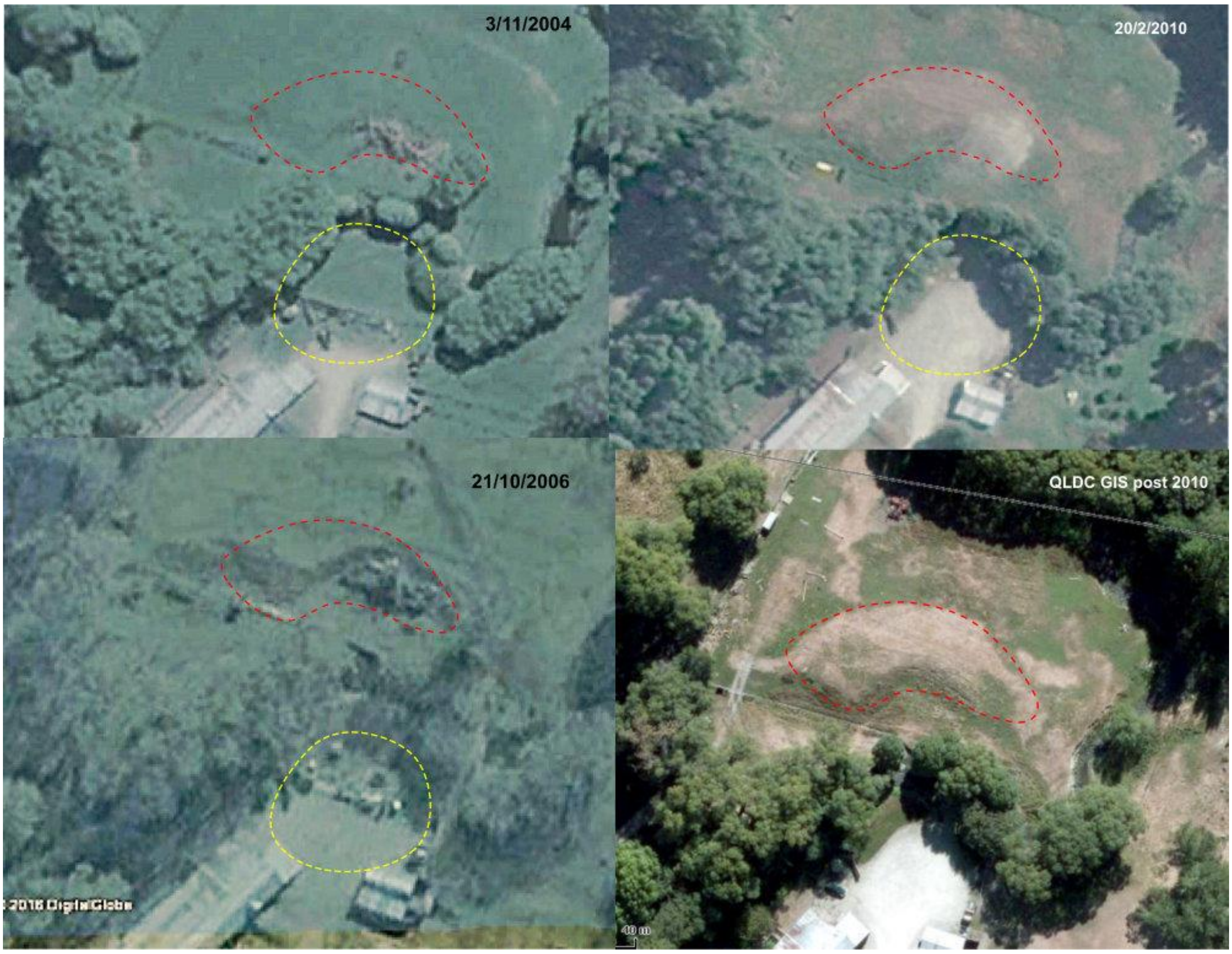


*Figure 27: Sequence of four photos of a possible fill area near the Barn/woolshed & Yards. The photo sequence is top left, 2004; bottom left, 2006; top right, 2010; bottom left, from the QLDC, undated but post-2010 (all other photos from Google Earth). This sequence suggests that the area outlined in red has been filled sometime over this period, which is also contemporaneous with the excavation and metaling of an extensive area adjoining the northern end of the Barn/woolshed & Yards. This excavation is an area of the site that is closely associated with potentially contaminating activities.*

Mr Glendining also advised that metal scraps have sometimes surface when he grades the farm road to the west of a bridge where the road runs through a cutting in the terrace face. He considered that this may indicate an old farm landfill in the area. There was no evidence of landfilling at this location during site inspection, but a comparison of aerial photographs from 1959, 1981 and from the QLDC GIS (which is undated but expected to be post 2010) shows that in 1981 there what appears to be a small disturbed or excavated area adjoining the farm track, and that this has been covered over since that time. This feature is marked on the three dated photos in Figure 28. This feature should be subject to investigation prior to development.

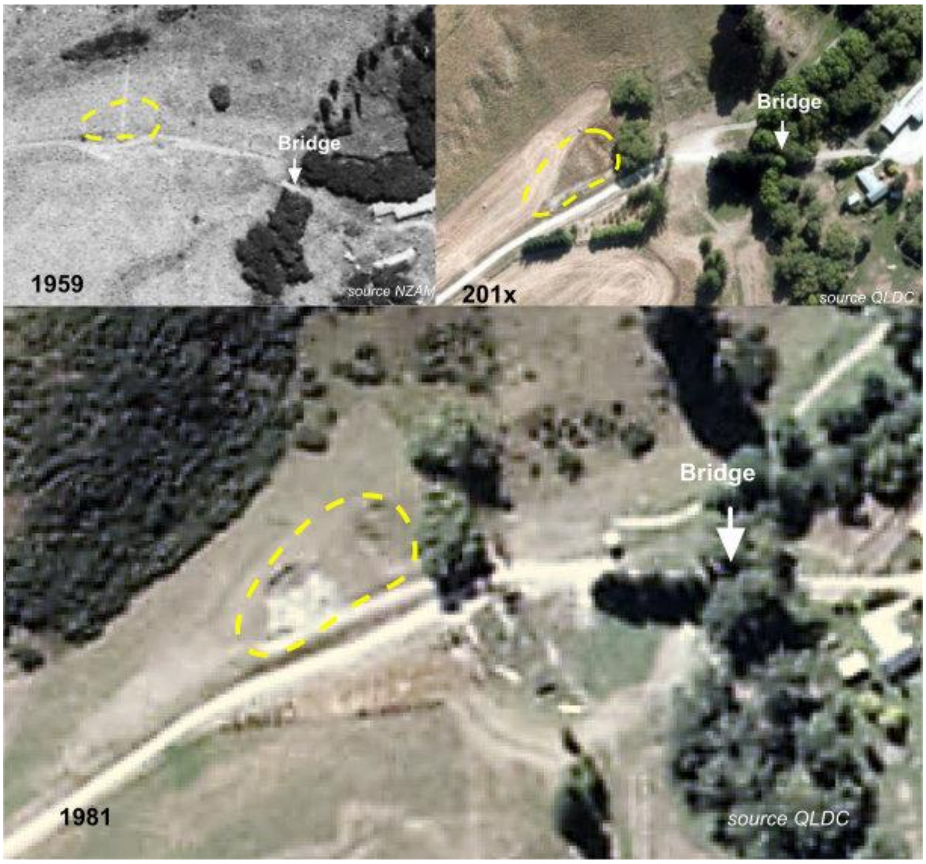

*Figure 28: Possible farm landfill site (outlined in yellow dashed line) located by the main farm track west of the farmyard.*

Surficial rubbish scattered across the bank below the homestead that is shown in Figure 24 is the only area where visual evidence of rubbish disposal was observed/confirmed during site inspection.

## 3.4 Geology and Hydrology

In the area where the site is located, surficial deposits form a discontinuous cover on a basement of Otago Schist, and on the basis of depositional origin have been broadly subdivided into three groups: (i) glacial deposits; (ii) stream, river and lake deposits; and (iii) slope deposits. On the flanks of the ranges which surround the basin of the site locale, slope deposits comprising landslides and colluvium predominate, with some remnants of glacial, stream, river and lake deposits which are thought to generally predate the last glaciation. The floor of the basin is mantled by glacial, stream, river and lake deposits, which are thought to have been laid down during and since the last glaciation.[15]

With reference to hydrology, in Arrowtown about 779mm of precipitation falls annually. The precipitation varies between 33mm between the driest month and the wettest month.[16]



[15] Barrell, D.J.A.; Riddolls, B.W.; Riddolls, P.M.; Thomson, R. 1994 Surficial geology of the Wakatipu Basin, Central Otago, New Zealand. Lower Hutt: Institute of Geological & Nuclear Sciences Institute of Geological & Nuclear Sciences science report 94/39 31p.
[16] https://en.wikipedia.org/wiki/Queenstown,_New_Zealand#Geography_and_climate

Mill Creek flows through the site from north to south. An ephemeral channel drains the majority of the site to the west of Mill Creek and the steeper slopes immediately to the north of the site, discharging into Mill Creek at the southern site boundary as shown in Figure 11. Mill Creek is fed by a catchment of approximately 40km$^2$ comprising the southern slopes of Coronet Peak and the flat land west of Arrowtown adjoining Malaghans Road. The farm has current surface water take consent (RM12.113.01). The QLDC Hazard Map shows the lower lying land within the Mill Creek Gully landform as being flood prone however the GIS hazard boundary is identified as being indicative. The QLDC Hazard Map also shows the parts of the site immediately below the slopes to the north as being an active alluvial fan. Mr Glendining commented that there has not been any flooding outside of the creek channel in the twelve years he has been managing the farm.

The site overlies the Wakatipu Basin Aquifer as identified in the ORC Groundwater Maps. The ORC Bore Hole database notes three bores are present within 500m of the site. One bore identified as F41/0193 is located at the western end of the site. It is cut to 21m depth and the log shows sandy gravels to 18m with fine sand and then silty pug to 21m. A second bore identified as F41/0196 lies immediately to the south of the site and is cut to 18m through sand and sandy gravels. The third bore is some distance further to the south. The depth to water table is not recorded for any of the bores. An ORC study into the Wakatipu Aquifers[17] identifies the groundwater level in the Mid Mill Creek Aquifer as being at between 335 and 340m across the site which is 10m below the bed of Mill Creek at the farmyard. In the past the Farm held a bore construction consent (2006.410) that has expired.

## 3.5 Sensitive Receptors

Lake Hayes and the lower reaches of Mill Creek are significant sensitive receptors. Lake Hayes has an identified history of degradation from discharges into the catchment[18] and enhancement of the water quality discharges to the catchment is required to protect and restore the lake. The mid Mill Creek aquifer lies beneath the site and is also identified as being under stress and over allocated[19]. Discharges that affect the aquifer will also contribute to the degradation of Lake Hayes. Further sensitive receptors include residents on the and adjoining the land, primarily those who are resident downslope of the site.



[17] Investigation into the Wakatipu Basin Aquifers ORC July 2014
[18] Lake Hayes Management Strategy ORC/QLDC September 1995
[19] Investigation into the Wakatipu Basin Aquifers ORC July 2014

# 4 Soil Sampling and Analysis for Contamination

## 4.1 Overview

According to the MfE's Guidelines for contaminated land investigations, sampling and analysis are considered to be optional in a PSI, with information on this to be provided "as available". Ultimately however the disposition of any contamination can only be confirmed with results from field sampling and analysis for contaminants. For this study detailed sampling, analysis, and interpretation of results has been undertaken in order to provide an evidentiary basis from which to assess the site's status with respect to the HAIL and associated potential risks for human exposure, per the NES Soil. As part of the process of assessing risk from potential contaminants, which is the primary data quality objective, results from analysis must be compared to Soil Contaminant Standards (SCSs) or appropriate Soil Guideline Values (SGVs), which reflect acceptable risk for levels of contamination in soil for different use scenarios[20].

## 4.2 Site Sampling and Analysis Plan

Two rounds of soil sampling were undertaken across the site. The initial/first sampling was a broad-scale programme designed to identify areas where contamination is present within the site. The site, being more than 40ha in extent, required a considerable number of samples, and the initial sampling programme included the collection of a total of 75 samples. To achieve cost-effective sampling and analysis, a mix of individual and composite samples were collected in clusters of four, each of which is designated as a set of one individual sample and three subsamples that were composited. Sampling was nominally based on a random grid, however, grid density was varied such that sampling density was higher where historical activities have been more complex or suggestive of potential contamination, i.e. in the vicinity of the Homestead Area's farm buildings and yards. Lower sampling densities were used in the Farm Proper pastures where historical use appears to have been consistent and broad-scale. All samples were collected from the surface soils at a depth of less than 10cm. A total of 14 sets of samples were collected from the Homestead Area and Farm Proper, with an additional 2 sets of samples collected from the part of the property to the immediate east of the farmyard (to provide a more complete picture of the state of local soils) and 1 set of samples was collected from within the Mill Creek Gorge/Waterfall Park area in the locale of Waterfall Park. A second and third set of samples was scheduled for collection in the Mill Creek Gorge area downstream of Waterfall Park, however this was not possible because the land in this area proved to be comprised of compacted gravels or otherwise covered in dense willows at the time of sampling. In addition to the sample sets described above, a further 7 samples were collected for individual analysis from the immediate area of the Homestead Area's farmyard. The initial sampling locations are shown on the aerial photos in Figures 29 and 30, which show locations as recorded to GPS logging during sampling. The location of the gate post at the entrance to the property was also logged as a landmark reference.



[20] https://www.mfe.govt.nz/publications/rma/users-guide-nes-for-assessing-managing-contaminants-in-soil/ and https://www.mfe.govt.nz/publications/hazardous/contaminated-land-mgmt-guidelines-no2/

The analytes scheduled for analysis for the first round of soil sampling were those typically associated with farming and cropping and included OCPs (DDT, Dieldrin etc) arsenic, cadmium, lead, and mercury.


*Figure 29: Site sampling plan, first sampling round, showing the Mill Creek Gorge/Waterfall Park area soil sampling locations. The original sampling plan had proposed taking another two sample sets (sets B and C) however this was not possible for reasons described in the text. Sample and subsample locations in the figure are marked with a white circle with quadrants and the site boundary is marked with a yellow dashed line. Sample A was scheduled for individual analysis and subsamples A1-3 were lab composited (Google Earth Image).*


*Figure 30: Site sampling plan, first sampling round, showing sampling locations across the Farm Proper (Ayrburn Farm) and Homestead Area parts of the site, as well as two areas on adjacent land. Sample and subsample locations in the figure are marked with a white circle with quadrants and the site boundary is marked with a yellow dashed line. Sample names are indicated, where a letter represents a sample scheduled for individual analysis and a letter with a number indicates a subsample used in lab sample compositing (Google Earth Image). Sample series D through N and P-R are from the areas described herein as the Farm Proper and the Homestead/farmyard areas; sample series O and S are from adjacent land.*

Consequent to the results from the first round of sampling, EC Otago were instructed to further investigate the parts of the site that showed signs of contamination and also to undertake sampling of additional aspects of the property that were identified from the initial sampling and site inspection as warranting more detail investigation. As with the first programme, a mix of individual and composite samples were collected though the second programme, being highly detailed sampling, focused more on individual samples. Sampling for the second round was judgmental based on a combination of the results of the desk-top study and the first round of sampling and analysis. The second sampling programme included multiple samples through the soil profile down to 70cm in key locations identified by the first programme and to 40cm in areas peripheral to the identified areas of contamination. Beyond the farmyard precinct samples were collected to represent the shallow soils in the range 0-20cm below the ground surface. The <10cm samples collected in the initial sampling programme are useful for quickly assessing a site for contamination in respect of the most proximal exposure path to humans, however the <20cm samples coupled with deeper sampling provide a more comprehensive understanding of the 3-dimensional extent of contamination particularly with respect to planning for site remediation, i.e. the volume of contaminated soil. As well, depth sampling may provide clues as to site history; if soils have been undisturbed, it is more likely that contamination shows a consistent vertical gradation as a function of depth. Contamination at surface may transport to depth, though, as the activities that are inferred to have been most likely to cause contamination occurred between 75 and 150 years ago, and the intervening use of the area would be expected to have caused soil to have accumulated since then, the surface layer cannot be assumed to present highest risk.

In this area the second sampling programme was designed to further investigate the following: 1) features that were not accessible in the first round of sampling, namely the upstream parts of the site that has been cleared of willows subsequent to the initial soil sampling programme, 2) the sheep dip site and surrounding farmyard to provide a more detailed assessment of the extent of potential contamination that, from the first round, seemed likely associated with that former activity, 3) the immediate curtilage of the homestead, 4) the status of the Mill Creek stream bank sediments to assess whether the release of material from the sheep dip had affected these sediments, and 5) the areas identified as having been possibly subject to landfilling. The second sampling programme included collection of an additional 91 soil samples and subsamples, not including field QA/QC samples.

For the Mill Creek Gorge/Waterfall Park area, in the second round of sampling an additional five sets of samples were collected, with a set being as described above (one individual sample and three subsamples for laboratory compositing), i.e. 20 samples in total, the locations of which are shown in Figure 31. This included on individual sample from the site of the historic waterwheel driven engineering workshop. As the initial sampling in this area did not suggest the presence of high levels of contaminants (cadmium, mercury, and OCPs having been below analytical limits of detection or LOD), composite samples were used to provide greater sampling coverage in a cost-effective manner. The specific locations of these samples are shown in Figure 31.


*Figure 31: Partial site sampling plan, second sampling round, showing the Mill Creek Gorge/Waterfall Park area soil sampling locations. Sample and subsample locations in the figure are marked with a white circle with quadrants and the site boundary is marked with a yellow dashed line; sample names appear in white alongside quadrant markers. The label "lathe" is added for reference as the location of the engineering workshop that was found on the second site inspection.*

A further 57 samples were taken from the Homestead/Farmyard Area, and these were taken to effect a more detailed investigation of the sheep dip site and surrounding farm yard and to sampling the immediate curtilage of the homestead. Samples were collected at 29 locations adjoining the barn and yards, enumerated FY2 through FY30, and were taken in a roughly concentric pattern around the area that both the desk-top study and results from the first round of sampling suggest as the most likely former locale of the sheep dip (and surrounding area that the first round suggested might have been affected, i.e. samples from locations FY25-27). Some locations were sampled at as much as three depths (reported below), and a total of 51 samples were taken. The depth ranges for these samples were planned to be 0-20, 20-40, and 50-70cm, however, some samples were taken at 15-30, 30-50, 40-50, 40-55, 50-60, 50-65, and 60-70cm; the wide range of variability in sampling depth was a result of ground conditions, such as hard subsurface gravel lenses in some spots.  The locations of these samples are shown in Figures 32 and 33 (because of the density of samples, some sampling locations are not clear in Figure 32, hence also refer to Figure 33).

Petroleum-related hydrocarbons were not included in the contaminant analysis as the two loci (the two UST's) were very old installations and buried at depth.  Given that both of these were petrol tanks and were in active use during the era when petrol contained organic lead compounds, if there was a contamination footprint with these it would likely be evident through locally elevated lead levels.  This investigation, being at preliminary level. was not able to intrusively investigate the tank surrounds sufficiently due to impenetrable gravels to provide a complete assessment, and these two installation are more appropriately investigated during removal.


*Figure 32: Partial site sampling plan, second sampling round, showing remaining sampling locations outside of the Mill Creek Gorge/Waterfall Park, parts of the site.  Sample locations in the figure are marked with a white circle with quadrants and the site boundary is marked with a yellow dashed line.  Sample and subsample locations in the figure are marked with a white circle with quadrants and the site boundary is marked with a yellow dashed line; sample names appear in white alongside quadrant markers.  A more detailed view of sampling in the Barn/woolshed & Yards area is shown in Figure 33 below (Google Earth Image).*


*Figure 33: Closer view of sampling locations around the Barn/woolshed & Yards environs showing the sampling pattern in the inferred/most likely location of the former sheep dip. Sample locations in the figure are marked with a white circle with quadrants and sample names appear in white alongside quadrant markers (Google Earth Image).*

A total of six samples were taken from surficial (0-20cm) soils in the area immediately surrounding the homestead, including one set of samples (an individual sample and three subsamples for compositing, series FY1) randomly distributed to the north of the homestead, as well as two additional individual samples, "Rearwall" and "Housedump", taken for preliminary assessment of the areas around the homestead rear wall to assess the effects of paint weathering and the area wherein rubbish was observed scattered across the bank below the homestead, respectively (ref Section 3). The locations of these samples are shown in Figure 32.

A preliminary investigation was made of the sediments in Mill Creek comprising six samples were collected (ref Figure 32). One sample set (MC1 and MC1A-C, the latter being a composite of three subsamples), and two additional individual samples (MC2 and MC3) were collected. The latter two individual samples were located in Mill Creek abeam and proximal to the inferred location of the former sheep dip, whereas the other samples were collected downstream of the farmyard area.

Both of the areas identified as having been possibly subject to landfilling (farm dumps or landfills, ref Section 3.3) were sampled (locations in Figure 32). The first of these is a possible fill area near the Barn/woolshed & Yards, shown in Figure 27. Six individual samples, referred to as "Barnfill" were taken in this locale, with the original intention being to sample at three depths (0-20cm, 20-40cm, and 50-70 cm). Sampling occurred at three locations laterally across the possible fill body. Due to the stony nature of the material only one location wherein three samples could be collected to 70cm. For the other two locations, at one location one sample was collected at 0-20cm and at the other location two samples were collected at 0-20cm and 20-40cm. The second potential farm landfill is near a bridge on the farm (Figure 28), and 2 individual samples, referred to as "Bridgefill", were collected in this location. These were both collected from the same location at the base of a swale draining the area and included samples from 0-20cm and 20-40cm depths.

Two QA/QC samples, (field splits), were also collected.

Analysis for the second round of sampling included arsenic cadmium, chromium copper lead, nickel, zinc and 15 shallow samples were also analysed for OCP's. One sample (in addition to soil samples) was also collected of the fibrous cement tile roofing material from the A-frame building at Waterfall Park, and this was subject to analysis for the presence of asbestos.

## 4.3 Sampling and Analysis Methods

Soil samples for the first sampling programme were collected from the topsoil layer immediately beneath the turf mat (<10cm) with a stainless steel trowel using a freshly gloved hand from the base of turf dug with a steel spade at each of the sampling locations. Decontamination between samples was performed by wiping tools clean with a disposable paper towel and washing with filtered water and Decon 90 applied with a portable pressure sprayer. In the second sampling programme all but one sample were collected using an Edelman geologist's hand auger with a 70*200mm clay auger head. The auger was wiped clean with a paper towel and washed with a portable pressure sprayer and filtered water and Decon 90 between samples as shown in Figure 34. Samples were removed from the auger head with a freshly gloved hand.

*Figure 34: The sampling auger being washed with a pressure sprayer.*

One sample (FY13) was collected by hand from mixed material cut from a hole with a 75mm power auger.  This sample was collected from within the locale of the sheep dip and was taken primarily for comparative purposes to assess the effectiveness of this means of collecting samples against the hand auger in the ground conditions present at the site.

Clean, contaminant-free containers provided by the testing laboratory were filled with soil samples and immediately placed into a chilly bin cooled with icepacks.  During sampling, photographic logs were taken of samples collected and the date, time and location of collection were recorded; a Garmin 62s hand-held GPS unit was used to log sample locations.  Containers were labelled with sample name, date and time on both label and lid as the samples were taken. Chain of custody forms were completed during field operations, and samples were returned to Dunedin and dispatched to the analytical laboratory on completion of the sampling.  The samples were processed by Hill Laboratories, which is appropriately certified for the analyses to be undertaken.

# 5 Results from Sampling and Analysis

## 5.1 Soil Acceptance Criteria

As part of the process of determining acceptable risk from potential contaminants, results from analysis are compared to SCSs or SGVs for the appropriate use scenario[21]. The land where the site is located is zoned Rural General in the greater part and Resort within the valley including the former Waterfall Park facility. The proposed use will be primarily for residential activities, hence the MfE SCSs/SGVs used herein are chosen to best reflect this use. For some analytes, the MfE has not established SCSs or SGVs; for such cases, SGVs from another source may be used according to an established hierarchy specified by the MfE.[22] For all analytes or contaminants recognized as so-called priority contaminants by the MfE, i.e. contaminants with a high or specific toxicity of concern, recently developed SCSs that are targeted to human health risks in a New Zealand context (i.e., per the NES Soil) must be used in the first instance. Further detail on the assumptions regarding acceptable risk, the derivation of guideline values, and the consequent limitations of same, are detailed in literature cited herein, with specific concerns addressed below if relevant.

## 5.2 Results of Analysis

Full results from chemical analysis of the first sampling round are given in Appendix D (Hill Laboratories Analysis Report), and results from the second round of sampling are given in Appendix E. Details concerning methods of sample preservation and analysis, hold times, limits of detection and other relevant details are included in the Laboratory Analysis Report or are available from the testing laboratory. Results are first considered below in terms of the sampling rounds, with summary evaluation given with the second round results.

### 5.2.1 Initial results

In Table 2 it can be seen that levels of contaminants are low across much of the site, with some exceptions, notably for arsenic and lead, for which there four exceedances each for individual samples. All of the composite samples are in exceedance of the relevant SCS for arsenic, and these are likely so-called technical exceedances, i.e. artefactual, and these are discussed further below. There is one arsenic exceedance for sample Fc, arsenic levels for which are greater than the SCS for individual analysis and this does represent an actual SCS exceedance as explained below; of the three subsamples composited into Fc, one is located in the vicinity of the main farmyard around and near the barn, i.e. the proximity of this subsample to the Z-series sampling area is consistent with an actual exceedance for sample Fc. Other contaminants, while not exhibiting any exceedances, are also high in the area where Z-series samples were taken. Figure 35 shows the area from which the Z-series samples were taken, with indications of the sampling locations for which analysis showed exceedances. Due to relatively localised nature of contamination at the site, statistics in Table 2 are reported for the Farm Proper and the farmyard area separately (note: statistics, other than averages, are only applicable to samples analysed individually, and only such samples were used in Table 2 calculations). Precision (reported as relative standard



[21] https://www.mfe.govt.nz/publications/rma/users-guide-nes-for-assessing-managing-contaminants-in-soil/ and https://www.mfe.govt.nz/publications/hazardous/contaminated-land-mgmt-guidelines-no2/

[22] Contaminated Land Management Guidelines No. 5 Site Investigation and Analysis of Soils (Revised 2011)

deviation or RSD) is much better for the Farm Proper samples than the farmyard samples, which is reasonable given that the former likely represent something close to geochemical background and hence display less variability than samples from an area subject to random contamination. Values for the 95% upper confidence limit (UCL) for Farm Proper samples are in all cases below or well below Residential SCSs, whereas UCLs for arsenic and lead in the farmyard are, approximately and respectively, 9 and 5 times the Residential SCS.

The problem of technical exceedance occurs as a result of the MfE's requirement to adjust SCSs for composite samples; SCSs for individual samples must be divided by the number of subsamples composited together to yield composite SCSs. This ensures that if one or more subsamples have high levels of contaminants present, these high levels are not masked by the averaging effect of compositing. On the other hand, when there is a natural or ambient baseline, such as there often is with arsenic and lead, the baseline itself may already approach or exceed a composite SCS, i.e. yielding a technical exceedance. In Table 2, generally, results from analysis of composites are in reasonable agreement with corresponding individual samples, suggesting that composite samples are mostly reflecting results from analysis of individual samples, and also suggesting that all samples are near baseline. This in turn suggests that many of the exceedances for composites in Table 2 are technical. The exception is Fc, which, being higher than the exceedance for individual analysis, perforce represents an actual exceedance, by virtue of one Fc subsample being proximal to the Barn / farmyard areas (Z-series sampling area).

Except for dieldrin, results for OCPs (priority pollutants that include DDT and its isomers and dieldrin), were non-detectable in all samples except for sample A, hence are not included in Table 2. For sample A, the level of DDE was just above detection (0.013 mg/kg).

**Table 2: Results from Analysis of the Initial Soil Samples from 341 -345 Arrowtown – Lake Hayes Rd.**[1]

| Sample Name: | Arsenic | Cadmium | Mercury | Lead | Dieldrin |
|---|---|---|---|---|---|
| Results from analysis of composite samples | | | | | |
| Ac | 10 | ND | ND | 16.6 | ND |
| Dc | 7 | ND | ND | 15.2 | ND |
| Ec | 15 | ND | ND | 21 | ND |
| Fc | **22** | ND | ND | 39 | ND |
| Gc | 9 | ND | ND | 14.7 | ND |
| Hc | 9 | ND | ND | 16.5 | ND |
| Ic | 9 | ND | ND | 17 | ND |
| Jc | 9 | ND | ND | 16.7 | ND |
| Kc | 9 | ND | ND | 14.4 | ND |
| Lc | 8 | ND | ND | 14.2 | ND |
| Mc | 6 | ND | ND | 13.4 | ND |
| Nc | 7 | ND | ND | 14.8 | ND |
| Oc | 8 | ND | ND | 13.3 | ND |
| Pc | 10 | ND | ND | 28 | ND |
| Qc | 8 | ND | ND | 18.1 | ND |
| Rc | 9 | ND | ND | 16.2 | ND |
| Sc | 7 | 0.1 | ND | 13.6 | ND |
| Composite Avg | 12 | ND | ND | 20 | ND |

| | | | | | |
|---|---|---|---|---|---|
| **Composite SCS** | **6.7** | **1** | **103** | **70** | **0.87** |
| Results from analysis of individual samples | | | | | |
| A | 13 | 0.11 | ND | 24 | ND |
| D | 7 | ND | ND | 22 | ND |
| E | 11 | 0.1 | ND | 18.5 | ND |
| F | 16 | ND | ND | 17 | ND |
| G | 6 | 0.15 | ND | 14.1 | ND |
| H | 10 | ND | ND | 14.9 | ND |
| I | 9 | 0.1 | ND | 14.2 | ND |
| J | 8 | ND | ND | 13.8 | ND |
| K | 9 | ND | ND | 15.6 | ND |
| L | 6 | 0.12 | ND | 12.1 | ND |
| M | 9 | ND | ND | 14.5 | ND |
| N | 6 | ND | ND | 12 | ND |
| O | 8 | ND | ND | 11.3 | ND |
| P | 9 | ND | ND | 31 | ND |
| Q | 10 | ND | ND | 17.8 | ND |
| R | 9 | 0.11 | ND | 14.8 | ND |
| S | 7 | 0.12 | ND | 12.4 | ND |
| ZA | **21** | ND | ND | 30 | ND |
| ZB | 10 | 0.14 | ND | 43 | 0.05 |
| ZC | 10 | 0.14 | ND | **260** | 0.22 |
| ZD | **36** | 0.28 | ND | **710** | 0.113 |
| ZE | **165** | 0.5 | 0.14 | **780** | 0.5 |
| ZF | **23** | 0.42 | 0.73 | **520** | 0.029 |
| ZG | 6 | 0.23 | ND | 44 | 0.018 |
| **Farm Proper** | | | | | |
| **Average** | 9 | 0.08 | ND | 16 | 0.05 |
| **RSD** | 29% | 45% | NA | 31% | 19% |
| **UCL** | 15 | 0.15 | NA | 27 | 0.07 |
| **Farmyard** | | | | | |
| **Average** | 39 | 0.25 | 0.16 | 341 | 0.05 |
| **RSD** | 146% | 64% | 158% | 96% | NA |
| **UCL** | 177 | 0.65 | 0.78 | 1141 | NA |
| **Residential SCS** | **20** [2] | **3** [2] | **310** [2] | **210** [2] | **2.6** [2] |

1. All results in mg/kg; location of samples are identified in the sampling diagram in Figures 29 and 30, all samples were collected from <10cm. Composite samples are indicated by the inclusion of a lower case letter "c" in the sample name. ND signifies non-detectable (below limits of detection) and NA indicates non-applicable.
2. MfE, 2012. *Users' Guide, National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health*. Wellington. Note: Soil contaminant standards (SCSs) reflect a use scenario for residential use.


*Figure 35: Sampling locations with exceedances of the Residential SCS for arsenic and lead. Arsenic exceedances exist at the locations with orange symbols and lead exceedances exist at the locations with red sample name labels.*

### 5.2.2 Second round results

The results of analysis of the second set of samples are given in summary form in Table 3, along with selected statistics that also, as appropriate, include results from the first round.

**Mill Creek Gorge/Waterfall Park Area**

For the Mill Creek Gorge/Waterfall Park samples the results from both the initial and second round of sampling in this part of the site reflect an unmodified state with results for metals being within a range likely to be at or, at least close to, natural background values. Precision (as RSD) for these varies, and RSDs, which vary from 29 to 62%, might normally be expected to be lower if these values do indicate geochemical background, however, in view of the low levels, it the higher RSDs may result from the variable depositional environment across locations tested. It should be noted that arsenic background in this area might normally be expected to be higher than in some other areas of New Zealand due to the proportion of schists present as parent rock. There are several exceedances for arsenic in composite samples, however, the composite average closely resembles the individual sample average, hence these are most likely technical exceedances.

**Sheep dip and farmyard area**
For the sheep dip area and farmyard area to the west of the barn there is a significant arsenic and lead hotspot associated with the sheep dip site at the northern and of the Woolshed/barn. There are also exceedances within the stock yards and surrounding areas that may originated from traffic of dipped animals or resulting from rain washing contamination downslope from the sheep dip. A gravel layer is present through the stockyards at a depth of between 20 and 40cm that is not present to the west of the yards. This is possibly a gravel/hard surface created when the Barn/woolshed was first built. Arsenic levels are higher at 20-40cm in samples FY10 and FY11 than they are in the shallower soils. The state of the soils below the gravel layer is unknown but should be considered as being potentially contaminated. There is also some indication of localised lead contamination adjoining the Barn/Woolshed that is not obviously associated with the former sheep dip site.

If the Mill Creek Gorge samples are indicative of geochemical baseline, then the Barn/Woolshed and implement shed precinct is generally also affected by cadmium and zinc, however, values are well below applicable SCSs/SGVs. with a very substantial localised exceedance of the Residential SCS throughout the site to the north and the west of the Barn/Woolshed where an historical sheep dip was located.

OCP results for the second round of sampling and analysis were mainly below limits of detection, except for occasional low levels of dieldrin, the highest of which was 0.113 mg/kg in surface sample FY10 near the former sheep dip and suggesting that dieldrin was used as an animal treatment at some time in the past. The levels found provide no trigger to indicate further investigation for OCPs is warranted.

Two samples (FY22 and FY23 0-20cm) from the vicinity of the pump upstand on the UST beside the barn/woolshed were tested for PAHs as indicators of hydrocarbon contamination. Neither of these samples produced evidence of PAH at levels above the limits of detection.

**Homestead/farmyard Area and Homestead Immediate Curtilage**
Sampling in the Homestead immediate curtilage found significant exceedances of the Residential SCS for lead in all the samples, locations for which cover a large part of the garden area surrounding the homestead. The results also show cadmium and zinc approaching the Residential SCS at one location. Cadmium and lead are used as pigments in older paints and lead was also used in primers. The limited sampling adjacent to the homestead does however suggest that the lead contamination is far more extensive than a "paint shadow" usually is, even for an old site. More detailed sampling and analysis, including sampling at depth, would be required to provide any more substantive conclusion with regards to the site conditions adjacent to the homestead.

The rubbish dump on the bank to the south of the homestead also warrants further investigation as it is the only evident site where rubbish has been dumped within the farm and it would not be unexpected that containers for agricultural chemicals were stored in the utility buildings behind the homestead, which leads then to the possibility that empty containers have been disposed over the bank. While one arsenic exceedance is observed, this is for a composite sample and is likely a technical exceedance (compare for instance to results for the Mill Creek Gorge/Waterfall Park results).

Contour plots (not shown) of the Barn/woolshed, farmyard, and immediate Homestead curtilage area indicate that it is not possible to rule out that the entire area is contiguous with respect to lead and arsenic contamination, however, this is not to suggest that there were not two or even multiple sources for contamination in these areas. Similarly, patterns at depth cannot be differentiated on a disaggregated scale, hence statistics in Table 3 were calculated for all samples FY1-FY30, and all depths, also including Z samples in Table 2, however excluding samples FY25-27, which nominally appear to be outside of the affected zone. Summary statistics indicate that both the regional average and UCLs for arsenic and lead in this area exceed the respective SCSs; UCLs are many times the SCSs. Results for lead and arsenic in the area for which these statistics apply are summarised visually in Figures 36 and 37.

**Mill Creek Sediments and Barnyard and Bridgefill Potential Farm Landfill Sites**
Results for Mill Creek Sediments and the two possible landfill areas in Table 3 show that heavy metals levels in these areas are all well below acceptance criteria, and RSDs and averages suggest that these levels are near background. Field QA/QC results are well within acceptable limits, with an average relative percent difference (RPD) across all results of 8%.

As a result of the additional sampling, results herein suggest that arsenic averages 9 mg/kg in unaffected areas, which is probably geochemical baseline; based on this, the 90% and 95% UCLs suggest that values exceeding 16 and 18, respectively, for composite samples are actual rather than technical exceedances. Based on this, there is only one composite exceedance for arsenic found in this study (Table 2).

**Table 3: Results from Analysis of Soil Samples of the second sample set from 341 -345 Arrowtown – Lake Hayes Rd.**[1]

| Sample Name: | Arsenic | Cadmium | Chromium | Copper | Lead | Nickel | Zinc |
|---|---|---|---|---|---|---|---|
| **Additional Sampling of Mill Creek Gorge/Waterfall Park Area:** | | | | | | | |
| WF1A-Cc (0-20cm) | **11** | ND | 13 | 25 | 23 | 15 | 59 |
| WF2A-Cc (0-20cm) | 6 | ND | 9 | 14 | 12.6 | 10 | 44 |
| WF3A-Cc 0-20cm) | **8** | ND | 6 | 11 | 14 | 8 | 35 |
| WF4A-Cc (0-20cm) | 6 | ND | 7 | 13 | 13.8 | 9 | 56 |
| WF5A-Cc (0-20cm) | **8** | ND | 7 | 8 | 10.8 | 7 | 31 |
| **Composite average (all results)** | 8 | ND | 8 | 14 | 15.1 | 10 | 45 |
| WF1 (0-20cm) | 3 | ND | 6 | 7 | 5.1 | 7 | 26 |
| WF2 (0-20cm) | 11 | ND | 15 | 29 | 19.8 | 16 | 56 |
| WF3 (0-20cm) | 8 | ND | 9 | 11 | 12.7 | 9 | 44 |
| WF4 (0-20cm) | 11 | ND | 8 | 13 | 14.2 | 10 | 35 |
| WF5 (0-20cm) | 8 | ND | 7 | 10 | 11.2 | 8 | 35 |
| **Individual average (all results)** | 8 | ND | 9 | 14 | 12.6 | 10 | 39 |
| **RSD** | 40 | NA | 39 | 62 | 42 | 35 | 29 |
| **Homestead/farmyard Area – Detailed Sampling at Inferred Former Sheep Dip Location:** | | | | | | | |
| FY13c (0-75cm) | **420** | 0.45 | 9 | 41 | **560** | 10 | 350 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| FY2 (0-20cm) | **78** | 0.54 | 14 | 36 | **730** | 10 | 270 |
| FY2 (40-50cm) | **270** | 0.34 | 10 | 52 | **710** | 11 | 220 |
| FY2 (50-70cm) | **91** | 0.14 | 9 | 28 | **290** | 10 | 125 |
| FY3 (0-20cm) | **88** | ND | 9 | 24 | 148 | 13 | 81 |
| FY3 (30-50cm) | 12 | ND | 7 | 11 | 13.1 | 9 | 29 |
| FY3 (60-70cm) | 13 | ND | 5 | 7 | 7 | 6 | 20 |
| FY4 (0-20cm) | **62** | 0.33 | 12 | 31 | **2000** | 10 | 490 |
| FY4 (20-40cm) | **139** | 0.18 | 9 | 22 | 122 | 10 | 490 |
| FY5 (0-20cm) | **28** | 0.36 | 7 | 30 | **570** | 9 | 250 |
| FY5 (20-40cm) | **20** | 0.66 | 9 | 46 | **300** | 12 | 530 |
| FY5 (50-70cm) | 5 | ND | 5 | 8 | 57 | 6 | 32 |
| FY6 (0-20cm) | 9 | 0.14 | 10 | 21 | 40 | 13 | 109 |
| FY6 (20-40cm) | 9 | 0.13 | 12 | 24 | 25 | 15 | 117 |
| FY6 (50-70cm) | 17 | ND | 11 | 20 | 49 | 13 | 69 |
| FY7 (0-20cm) | 10 | 0.22 | 10 | 23 | 101 | 13 | 191 |
| FY9 (0-20cm) | **21** | 0.59 | 9 | 38 | **940** | 9 | 420 |
| FY10 (0-20cm) | 15 | 1.25 | 8 | 25 | 200 | 7 | 670 |
| FY10 (20-40cm) | **84** | 0.35 | 8 | 10 | 40 | 7 | 186 |
| FY11 (0-20cm) | 17 | 0.34 | 8 | 20 | 110 | 7 | 230 |
| FY11 (20-40cm) | **45** | 0.14 | 7 | 22 | 68 | 9 | 140 |
| FY12 (0-20cm) | 6 | 0.9 | 6 | 14 | 36 | 8 | 570 |
| FY14 (0-20cm) | 19 | 1.15 | 19 | 45 | **260** | 11 | 530 |
| FY15 (0-20cm) | **24** | 0.64 | 8 | 22 | **310** | 8 | 360 |
| FY15 (20-40cm) | **49** | 0.32 | 7 | 21 | **240** | 8 | 490 |
| FY15 (40-55cm) | **102** | 0.25 | 10 | 36 | **470** | 16 | 490 |
| FY16 (0-20cm) | **37** | 0.19 | 8 | 15 | 32 | 7 | 148 |
| FY16 (20-40cm) | **44** | ND | 7 | 10 | 11.8 | 7 | 46 |
| FY16 (50-65cm) | **65** | ND | 7 | 8 | 8.2 | 7 | 27 |
| FY17 (0-20cm) | 13 | 0.16 | 9 | 12 | 86 | 7 | 140 |
| FY17 (20-40cm) | 11 | ND | 10 | 14 | 16.4 | 12 | 53 |
| FY17 (50-70cm) | 9 | ND | 9 | 12 | 10.4 | 10 | 41 |
| FY19 (0-20cm) | 8 | 0.43 | 7 | 124 | 61 | 5 | 420 |
| FY19 (20-40cm) | 9 | 0.16 | 6 | 23 | 43 | 6 | 157 |
| FY20 (0-20cm) | 15 | 0.12 | 8 | 12 | 21 | 8 | 123 |
| FY21 (0-20cm) | 11 | 0.19 | 6 | 11 | 23 | 6 | 142 |
| FY22 (0-20cm) | 11 | 0.1 | 7 | 12 | 22 | 10 | 114 |
| FY22 (20-40cm) | 11 | ND | 8 | 13 | 27 | 8 | 70 |
| FY23 (0-20cm) | 10 | ND | 7 | 11 | 43 | 7 | 60 |
| FY23 (15-30cm) | 12 | ND | 10 | 15 | 28 | 9 | 60 |
| FY24 (20-40cm) | 10 | 0.13 | 8 | 17 | 44 | 9 | 67 |
| FY24 (50-60cm) | 10 | ND | 8 | 10 | 9.9 | 8 | 41 |
| FY25 (0-20cm) | 14 | ND | 10 | 18 | 55 | 11 | 97 |
| FY25 (20-40cm) | 8 | ND | 12 | 23 | 22 | 15 | 71 |
| FY26 (0-20cm) | 12 | ND | 10 | 16 | 31 | 11 | 57 |
| FY26 (20-40cm) | 11 | ND | 8 | 15 | 14.8 | 10 | 42 |
| FY27 (0-20cm) | 16 | ND | 9 | 13 | 27 | 10 | 57 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| FY27 (20-40cm) | 18 | ND | 10 | 14 | 20 | 10 | 49 |
| FY28 (0-20cm) | 15 | 0.14 | 8 | 15 | 29 | 9 | 76 |
| FY29 (0-20cm) | **24** | 0.2 | 9 | 27 | 112 | 10 | 98 |
| FY30 (0-20cm) | 11 | 1.14 | 13 | 26 | **270** | 11 | 640 |
| **Homestead Immediate Curtilage:** | | | | | | | |
| FY1A-Cc (0-20cm) | **10** | 0.37 | 10 | 28 | **530** | 9 | 160 |
| FY1 (0-20cm) | 13 | 0.3 | 12 | 28 | **1620** | 9 | 195 |
| Rearwall (0-20cm) | 8 | 1.13 | 11 | 43 | **530** | 10 | 990 |
| Housedump (0-20cm) | 4 | 0.43 | 21 | 178 | **500** | 10 | 230 |
| **Statistics Homestead/farmyard Area and Homestead Immediate Curtilage, Individual Samples (all results):** | | | | | | | |
| Average | **43** | 0.28 | 53 | 24 | **221** | 9 | 219 |
| RSD | 166 | 106 | 301 | 79 | 157 | 28 | 87 |
| UCL | **186** | 0.87 | 371 | 61 | **918** | 15 | 603 |
| **Mill Creek Sediments:** | | | | | | | |
| MC1A-Cc (0-20cm) | 5 | ND | 7 | 11 | 12.9 | 9 | 35 |
| MC1 (0-20cm) | 3 | ND | 8 | 8 | 15.3 | 7 | 24 |
| MC2 (0-20cm) | 4 | ND | 8 | 11 | 11.3 | 8 | 35 |
| MC3 (0-20cm) | 5 | ND | 10 | 10 | 10.3 | 10 | 43 |
| Average | 4 | NA | 9 | 10 | 12.3 | 8 | 34 |
| RSD | 25 | NA | 13 | 16 | 21 | 18 | 28 |
| **Barnfill and Bridgefill Potential Farm Landfill Sites:** | | | | | | | |
| Barnfill 1 (0-20cm) | 7 | ND | 8 | 8 | 10.7 | 9 | 34 |
| Barnfill 2 (20-40cm) | 7 | ND | 8 | 8 | 13.9 | 8 | 64 |
| Barnfill 3 (0-20cm) | 6 | ND | 8 | 7 | 10.7 | 8 | 40 |
| Barnfill 4 (0-20cm) | 4 | ND | 7 | 6 | 7.2 | 6 | 27 |
| Barnfill 5 (20-40cm) | 7 | 0.10 | 8 | 10 | 29 | 8 | 70 |
| Barnfill 6 (50-70cm) | 7 | ND | 7 | 12 | 15.5 | 8 | 48 |
| Bridgefill 1 (0-20cm) | 6 | ND | 8 | 7 | 10.7 | 8 | 40 |
| Bridgefill 2 (20-40cm) | 7 | ND | 6 | 9 | 9.5 | 7 | 23 |
| Average | 6 | NA | 7 | 8 | 13.4 | 8 | 43 |
| RSD | 17 | NA | 10 | 23 | 51 | 11 | 39 |
| **Acceptance Criteria, SCSs/SGVs:** | | | | | | | |
| **Residential Composite SCS** | **6.7** | **1** | **153** | **>3,300[2]** | **70** | **77** | **2000** |
| **Residential SCS** | **20 [2]** | **3 [2]** | **460 [2]** | **>10,000[2]** | **210[2]** | **230[3]** | **6000[4]** |
| **Field QA/QC:** | | | | | | | |
| FY8 (0-20cm, duplicate of FY7) | 10 | 0.21 | 8 | 21 | 96 | 12 | 182 |
| FY18 (0-20cm, duplicate of FY17) | 13 | 0.18 | 9 | 13 | 96 | 8 | 158 |
| RPD FY7/FY8 | 0 | 5 | 22.22222 | 9 | 5 | 8 | 5 |
| RPD FY17/FY18 | 0 | 12 | 0 | 8 | 11 | 13 | 12 |

1. All results in mg/kg; location of samples are identified in the sampling diagram in Figures 31-33. All samples were collected from depth identified in the table. Composite samples are indicated by the inclusion of a lower case letter "c" in the sample name. ND signifies non-detectable (below limits of detection) and NA indicates non-applicable. Values in grey shaded cells and bold text represent exceedances. Black bold text is for individual exceedances, and blue represents composite exceedances.
2. MfE, 2012. *Users' Guide, National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health*. Wellington. Note: Soil contaminant standards (SCSs) reflect a use scenario for residential use.
3. DEFRA/UK Environment Agency, 2009. Soil Guideline Values for Nickel in Soil (Residential), Science Report SC050021.

4. NEPM/NEPC 2014. National Environment Protection Measures of Australia (http://www.scew.gov.au/node/941). Note: The Australian SGVs are under review for updating; this is a Health Investigation Level targeted at human health for a use scenario for Residential, with limited produce consumption, and is a SGV closely aligned with the New Zealand SCS approach, i.e. in kind. As a Residential SGV, the value is lower than might be deemed acceptable for High Density Residential use.

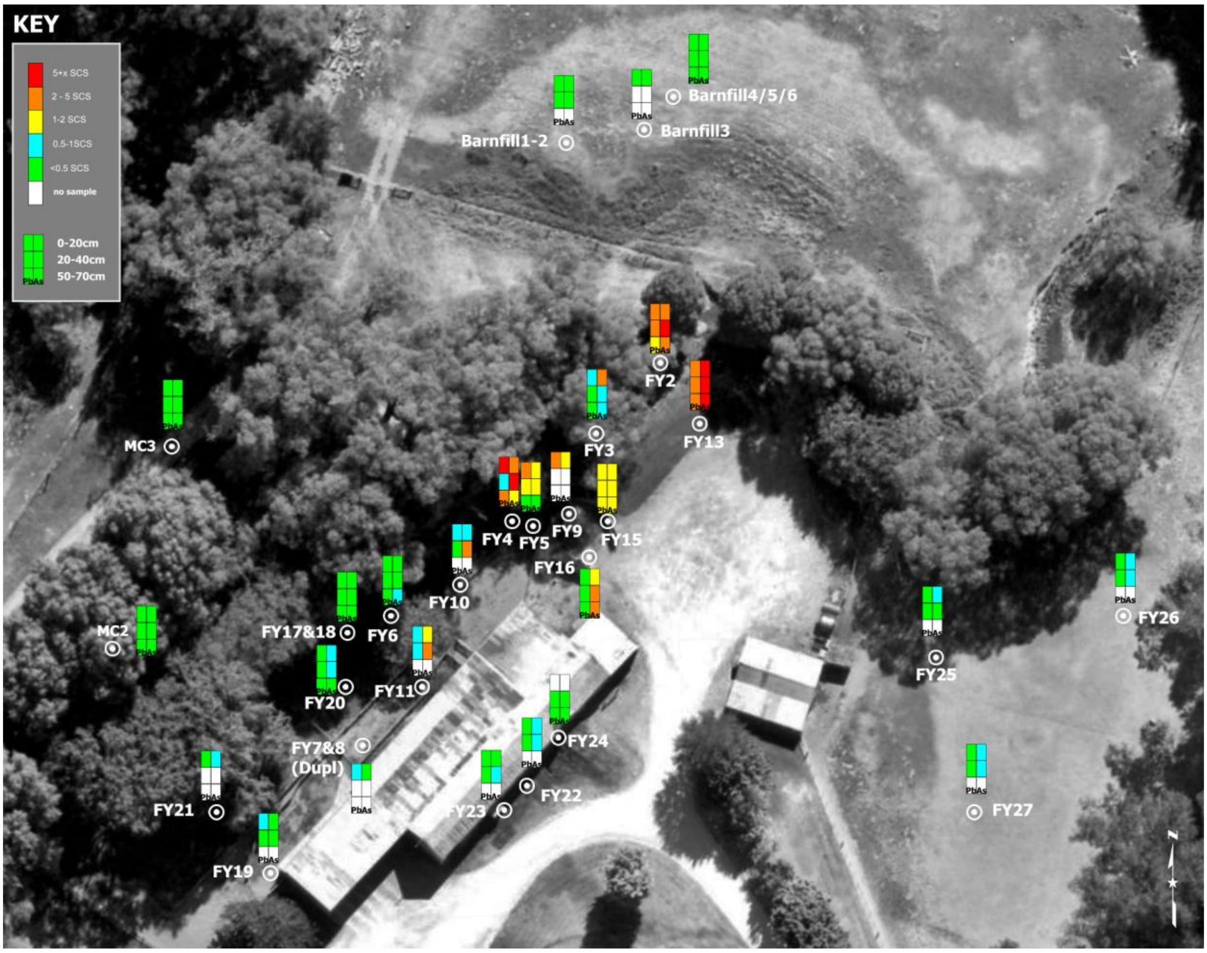


*Figure 36: Sampling results from the second round of sampling shown for arsenic and lead for samples at the northern end of the farmyard and showing the high levels of arsenic and lead at the location of the former sheep dip at the northern end of the Barn/woolshed (image QLDC GIS).*

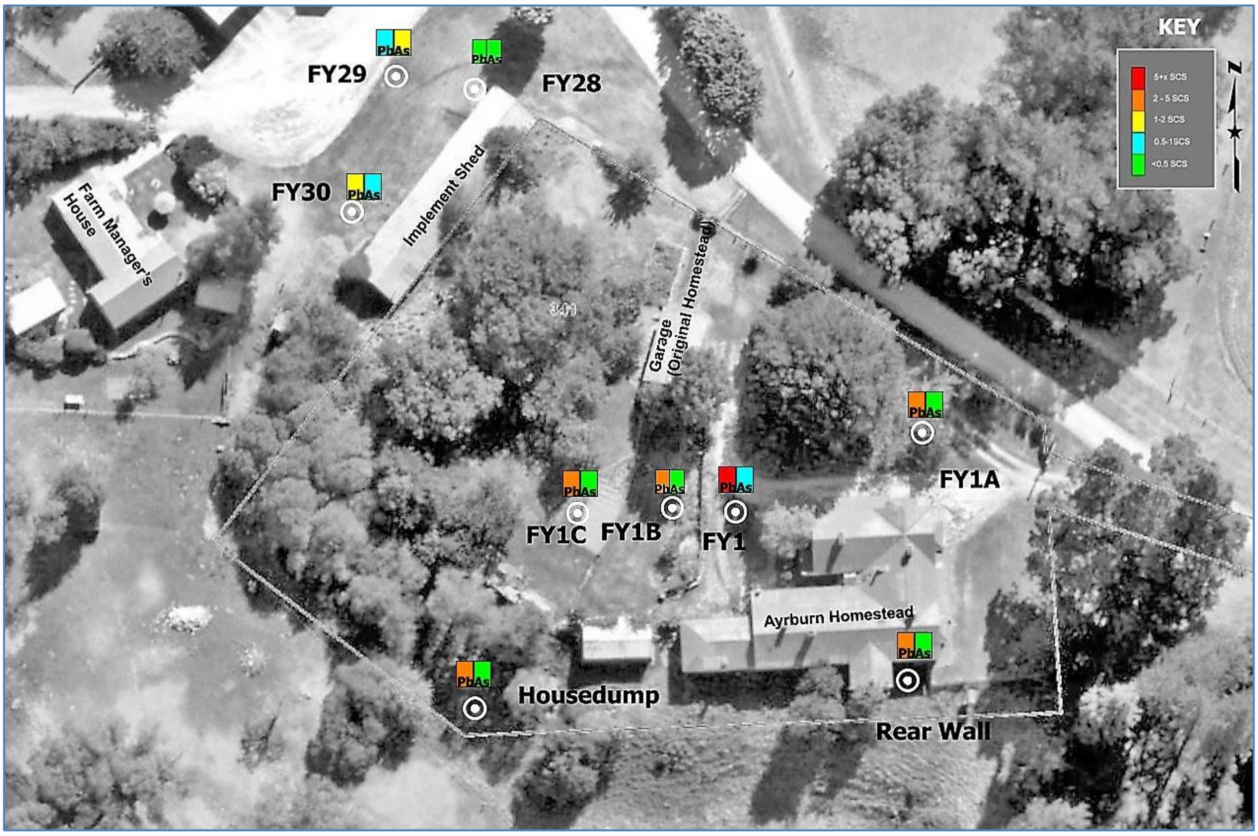


*Figure 37: Site sampling in the southern part of the farmyard (Old Implement Shed area) and the Homestead immediate curtilage; results show lead exceedances across the homestead grounds (Image QLDC GIS).*

# 6 Site Characterisation

## 6.1 Type of Environmental Contamination

Sampling and analysis for HAIL contaminants was conducted at the site as described herein, and, by the terms of the New Zealand NES Soil, based on the findings above, exceedances of the Residential acceptance criterion for arsenic and lead were observed in the vicinity of the Woolshed/barn, by the Old Implement Shed, and throughout the Homestead grounds. Elevated levels of other contaminants are collocated with these exceedances, in accord with a general understanding of the historical site use of this area for agricultural purposes and with a sheep dip and sheds where agrichemicals might have been stored being the locus of observed exceedances. For many samples in these areas, exceedances are well above relevant SCSs/SGVs, and for a large area the average levels exceed SCSs for arsenic and lead, with UCLs in the same areas many times the arsenic and lead SCSs.

## 6.2 Extent of Environmental Contamination

As noted above, the Homestead/farmyard Area, including the Woolshed/barn & Yards and the area around the Homestead itself are the locus of exceedances of the Residential SCS for lead and arsenic. The Farm Proper, i.e. outside of the operational area of the farm buildings, did not exhibit any exceedances for individual samples and most of the composite exceedances are likely technical exceedances. Exceptions are samples Ec and Fc from the first round of sampling (one is an actual exceedance and one is likely actual). The second round of sampling in the area of the sheep dip and yards was limited to a maximum of

75cm. It may be that contamination at or greater than the levels encountered in this sampling exists at depth in the vicinity of the dip and the yards.

It is possible that spoil excavated during construction of the metalled area north of the barn is present somewhere on the farm, however sampling of potential disposal areas did not produce any evidence of the deposition of contaminated soil. This or other dumping could create a localised hotspot that may not be evident at the sampling density of an initial investigations such as this. It is also possible that other localised deposits of contaminated material are on-site or buried within the site such that it might be redistributed disturbed by earthworks.

The sheep dip is expected to have been discharged to Mill Creek and this is surmised as being a potential source of contamination in the creek bed sediments. Sampling of the stream bed was not undertaken in the first stage of investigation but was undertaken in the second sampling round, and no evidence was found of any accumulation of arsenic or lead in the immediate environs of Mill Creek.

Both of the UST's present on the site were from the period when organic lead additives were in use and lead contamination is expected to occur in the immediate locale of these tanks. As the tanks have been unused for more than a decade, priority hydrocarbons that may have been released to the surrounding ground might or might not have weathered or dissipated, however lead would persist. The three AST installations exhibit localised hydrocarbon staining at the base of the tank stands.

## 6.3 Potential for Degradation and Interaction

Given that arsenic and lead do not degrade and that both are highly toxic, and high levels of both are present in some locations, there is a possibility for additive or synergistic effects.

## 6.4 Exposure Routes and Risks to Exposed Populations

The exposure routes include direct ingestion of soil (through gardening, children playing on the land), inhalation (of dust during land disturbance, for during site excavations), or dermal contact. The possibility of erosional transmission also exists should the stream bank be disturbed in the vicinity of the barn and yards and its vulnerability to erosion increased. Due to the high levels of lead and arsenic in some locations, and the toxicity of both of these, particularly to vulnerable populations (and in the case of lead the high neurotoxicity of lead for children), parts of the site present a distinct human exposure risk. The level of arsenic and possibly lead in the vicinity of the former sheep dip are also anticipated to potentially present a risk to site workers undertaking any disturbance of the site soils in that part of the site.

# 7 Conclusions Recommendations

EC Otago's preliminary investigation of the site is summarised as follows:

- Previous HAIL land use at site is confirmed and includes HAIL Categories A8 (Livestock dip or spray race operations), A13 (bulk storage of petroleum or petrochemicals above or below ground), D5 (Engineering workshop), G3 (Landfill sites, landfilling at or near the site);
- Details of previous sampling and analysis were not discovered;
- Two rounds of site soil sampling and analysis were performed in the course of this investigation with a total of 166 soil samples having been analysed over both rounds;
- For the analytes tested, which included the most relevant contaminants to the HAIL categories stipulated herein, lead and arsenic were found to be present at levels that exceeds the Residential SCS in a number of locations;
- The affected areas include the Homestead/farmyard area, including the Homestead immediate curtilage;
- Waterfall Park and the Mill Creek Gorge area did not exhibit elevated levels of contaminants; and
- Neither the farm pastures nor the sediment in the bed of Mill Creek exhibited elevated levels of the contaminants covered in the analysis.

Based on these findings, EC Otago forms the following conclusions:

- By the metrics of evaluation in use, the levels of contaminants found do represent a significant human exposure risk in a part of the site; it appears from the data collected that the main risk area is in the Homestead/farmyard area, however, this conclusion is subject to some uncertainties related to the limitations and assumptions described herein;
- There is no trigger for further investigation of areas outside of the identified affected area; and
- Further detailed investigation would be needed before a remediation plan could be prepared for the affected area.
- A resource consent will be required under cl11.1 of the NES for earthworks (disturbance) of the contaminated areas adjacent to the Barn/woolshed and Farm Homestead

Based on the findings of this investigation, EC Otago recommends the following:

- Based on the comments regarding exposure risk to humans in our conclusions above (and within the limitations stipulated herein), the proposed residential development of the site represents suitable land use by current standards over the greater part of the site, however the Homestead/farmyard Area is not suited to this activity without further investigation and remediation.

- USTs and ASTs will require removal and a concurrent site sampling and removal report undertaken at that for these (i.e. limited basis and extent for confirmatory purposes) at that time.
- If earthworks occur during the course of or in preparation for development, a site soil management plan should be prepared based on information herein and from the additional investigation outlined above.

# 8 Appendices

**Appendix A: Certificates of Title**
**Appendix B: Archaeologists Report**
**Appendix C: Extracts from QLDC LIM Reports and ORC Contaminated Site Report**
**Appendix D: Hill Laboratories Analysis Report**
**Appendix E: Hill Laboratories Analysis Report**

Hill Laboratories
TRIED, TESTED AND TRUSTED

R J Hill Laboratories Limited
28 Duke Street Frankton 3204
Private Bag 3205
Hamilton 3240 New Zealand

T 0508 HILL LAB (44 555 22)
T +64 7 858 2000
E mail@hill-labs.co.nz
W www.hill-laboratories.com

# ANALYSIS REPORT



| | | | |
|---|---|---|---|
| **Client:** | Environmental Consultants Otago Limited | **Lab No:** | 1847278 SPv1 |
| **Contact:** | Ciaran Keogh | **Date Received:** | 21-Sep-2017 |
| | C/- Environmental Consultants Otago Limited | **Date Reported:** | 28-Sep-2017 |
| | PO Box 5522 | **Quote No:** | 87811 |
| | Dunedin 9058 | **Order No:** | |
| | | **Client Reference:** | Ayrburn |
| | | **Submitted By:** | Ciaran Keogh |

**Sample Type: Soil**

| Sample Name: | | FH1 0-10 19-Sep-2017 12:00 pm | FH2 0-10 19-Sep-2017 12:05 pm | FH3 0-10 19-Sep-2017 12:10 pm | FH4 0-10 19-Sep-2017 12:15 pm | FH5 0-10 19-Sep-2017 12:20 pm |
|---|---|---|---|---|---|---|
| **Lab Number:** | | 1847278.1 | 1847278.2 | 1847278.3 | 1847278.4 | 1847278.5 |
| Heavy Metals, Screen Level | | | | | | |
| Total Recoverable Arsenic | mg/kg dry wt | 17 | 9 | 14 | 13 | 10 |
| Total Recoverable Cadmium | mg/kg dry wt | < 0.10 | 0.14 | < 0.10 | < 0.10 | < 0.10 |
| Total Recoverable Chromium | mg/kg dry wt | 7 | 10 | 7 | 8 | 7 |
| Total Recoverable Copper | mg/kg dry wt | 12 | 15 | 17 | 14 | 15 |
| Total Recoverable Lead | mg/kg dry wt | 169 | 123 | 270 | 147 | 118 |
| Total Recoverable Nickel | mg/kg dry wt | 7 | 8 | 7 | 8 | 6 |
| Total Recoverable Zinc | mg/kg dry wt | 69 | 88 | 58 | 67 | 71 |

| Sample Name: | | FH6 0-10 19-Sep-2017 12:25 pm | FH6 10-20 19-Sep-2017 12:30 pm | FH7 0-10 19-Sep-2017 12:35 pm | FH8 0-10 19-Sep-2017 12:40 pm | FH8 10-20 19-Sep-2017 12:45 pm |
|---|---|---|---|---|---|---|
| **Lab Number:** | | 1847278.6 | 1847278.7 | 1847278.8 | 1847278.9 | 1847278.10 |
| Heavy Metals, Screen Level | | | | | | |
| Total Recoverable Arsenic | mg/kg dry wt | 11 | 11 | 11 | 12 | 12 |
| Total Recoverable Cadmium | mg/kg dry wt | 0.34 | 0.25 | 0.16 | 0.15 | 0.14 |
| Total Recoverable Chromium | mg/kg dry wt | 11 | 9 | 8 | 11 | 10 |
| Total Recoverable Copper | mg/kg dry wt | 21 | 19 | 16 | 31 | 26 |
| Total Recoverable Lead | mg/kg dry wt | 770 | 720 | 250 | 220 | 164 |
| Total Recoverable Nickel | mg/kg dry wt | 8 | 8 | 8 | 10 | 9 |
| Total Recoverable Zinc | mg/kg dry wt | 220 | 199 | 112 | 127 | 122 |

| Sample Name: | | FH9 0-10 19-Sep-2017 12:50 pm | FH10 0-10 19-Sep-2017 12:55 pm | FH10 10-20 19-Sep-2017 1:00 pm | FH11 0-10 19-Sep-2017 1:05 pm | FH12 0-10 19-Sep-2017 1:10 pm |
|---|---|---|---|---|---|---|
| **Lab Number:** | | 1847278.11 | 1847278.12 | 1847278.13 | 1847278.14 | 1847278.15 |
| Heavy Metals, Screen Level | | | | | | |
| Total Recoverable Arsenic | mg/kg dry wt | 9 | 8 | 9 | 8 | 8 |
| Total Recoverable Cadmium | mg/kg dry wt | 0.25 | 0.15 | 0.13 | 0.10 | 0.10 |
| Total Recoverable Chromium | mg/kg dry wt | 9 | 9 | 9 | 9 | 9 |
| Total Recoverable Copper | mg/kg dry wt | 20 | 18 | 18 | 18 | 16 |
| Total Recoverable Lead | mg/kg dry wt | 490 | 137 | 114 | 177 | 149 |
| Total Recoverable Nickel | mg/kg dry wt | 9 | 9 | 8 | 9 | 8 |
| Total Recoverable Zinc | mg/kg dry wt | 151 | 97 | 83 | 91 | 101 |

| Sample Name: | | FH12 10-20 19-Sep-2017 1:15 pm | FH13 0-10 19-Sep-2017 1:20 pm | FH14 0-10 19-Sep-2017 1:25 pm | FH14 10-20 19-Sep-2017 1:30 pm | FH15 0-10 19-Sep-2017 1:35 pm |
|---|---|---|---|---|---|---|
| **Lab Number:** | | 1847278.16 | 1847278.17 | 1847278.18 | 1847278.19 | 1847278.20 |

## Sample Type: Soil

| Sample Name: | | FH12 10-20<br>19-Sep-2017 1:15 pm | FH13 0-10<br>19-Sep-2017 1:20 pm | FH14 0-10<br>19-Sep-2017 1:25 pm | FH14 10-20<br>19-Sep-2017 1:30 pm | FH15 0-10<br>19-Sep-2017 1:35 pm |
|---|---|---|---|---|---|---|
| Lab Number: | | 1847278.16 | 1847278.17 | 1847278.18 | 1847278.19 | 1847278.20 |
| Heavy Metals, Screen Level | | | | | | |
| Total Recoverable Arsenic | mg/kg dry wt | 7 | 9 | 8 | 7 | 8 |
| Total Recoverable Cadmium | mg/kg dry wt | < 0.10 | < 0.10 | < 0.10 | < 0.10 | < 0.10 |
| Total Recoverable Chromium | mg/kg dry wt | 9 | 9 | 10 | 9 | 10 |
| Total Recoverable Copper | mg/kg dry wt | 15 | 18 | 13 | 11 | 10 |
| Total Recoverable Lead | mg/kg dry wt | 108 | 159 | 77 | 49 | 91 |
| Total Recoverable Nickel | mg/kg dry wt | 9 | 8 | 9 | 8 | 8 |
| Total Recoverable Zinc | mg/kg dry wt | 104 | 86 | 84 | 67 | 64 |

| Sample Name: | | FH16 0-10<br>19-Sep-2017 1:40 pm | FH16 10-20<br>19-Sep-2017 1:45 pm | FH17 0-10<br>19-Sep-2017 1:50 pm | FH18 0-10<br>19-Sep-2017 1:55 pm | FH18 10-20<br>19-Sep-2017 2:00 pm |
|---|---|---|---|---|---|---|
| Lab Number: | | 1847278.21 | 1847278.22 | 1847278.23 | 1847278.24 | 1847278.25 |
| Heavy Metals, Screen Level | | | | | | |
| Total Recoverable Arsenic | mg/kg dry wt | 15 | 14 | 13 | 8 | 7 |
| Total Recoverable Cadmium | mg/kg dry wt | 0.26 | 0.12 | 0.15 | < 0.10 | < 0.10 |
| Total Recoverable Chromium | mg/kg dry wt | 10 | 7 | 10 | 9 | 10 |
| Total Recoverable Copper | mg/kg dry wt | 23 | 15 | 19 | 15 | 15 |
| Total Recoverable Lead | mg/kg dry wt | 460 | 154 | 167 | 107 | 89 |
| Total Recoverable Nickel | mg/kg dry wt | 8 | 7 | 8 | 8 | 10 |
| Total Recoverable Zinc | mg/kg dry wt | 177 | 97 | 175 | 76 | 67 |

| Sample Name: | | FH19 0-10<br>19-Sep-2017 2:05 pm | FH20 0-10<br>19-Sep-2017 2:10 pm | FH21 0-10<br>19-Sep-2017 2:30 pm | FH22 0-10<br>19-Sep-2017 2:35 pm | FH23 0-10<br>19-Sep-2017 2:40 pm |
|---|---|---|---|---|---|---|
| Lab Number: | | 1847278.26 | 1847278.27 | 1847278.28 | 1847278.29 | 1847278.30 |
| Heavy Metals, Screen Level | | | | | | |
| Total Recoverable Arsenic | mg/kg dry wt | 7 | 13 | 11 | 10 | 7 |
| Total Recoverable Cadmium | mg/kg dry wt | < 0.10 | < 0.10 | 0.16 | 0.15 | 0.15 |
| Total Recoverable Chromium | mg/kg dry wt | 10 | 9 | 11 | 9 | 9 |
| Total Recoverable Copper | mg/kg dry wt | 13 | 14 | 24 | 12 | 13 |
| Total Recoverable Lead | mg/kg dry wt | 135 | 167 | 280 | 69 | 51 |
| Total Recoverable Nickel | mg/kg dry wt | 9 | 8 | 9 | 8 | 8 |
| Total Recoverable Zinc | mg/kg dry wt | 87 | 89 | 142 | 92 | 186 |

# SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

## Sample Type: Soil

| Test | Method Description | Default Detection Limit | Sample No |
|---|---|---|---|
| Heavy Metals, Screen Level | Dried sample, < 2mm fraction. Nitric/Hydrochloric acid digestion US EPA 200.2. Complies with NES Regulations. ICP-MS screen level, interference removal by Kinetic Energy Discrimination if required. | 0.10 - 4 mg/kg dry wt | 1-30 |

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.



Ara Heron BSc (Tech)
Client Services Manager - Environmental

Hill Laboratories
TRIED, TESTED AND TRUSTED

R J Hill Laboratories Limited
28 Duke Street Frankton 3204
Private Bag 3205
Hamilton 3240 New Zealand

T 0508 HILL LAB (44 555 22)
T +64 7 858 2000
E mail@hill-labs.co.nz
W www.hill-laboratories.com

# ANALYSIS REPORT



| | | | |
|---|---|---|---|
| **Client:** | Environmental Consultants Otago Limited | **Lab No:** | 1847279 SPv1 |
| **Contact:** | Ciaran Keogh | **Date Received:** | 21-Sep-2017 |
| | C/- Environmental Consultants Otago Limited | **Date Reported:** | 27-Sep-2017 |
| | PO Box 5522 | **Quote No:** | 87811 |
| | Dunedin 9058 | **Order No:** | |
| | | **Client Reference:** | Ayrburn |
| | | **Submitted By:** | Ciaran Keogh |

**Sample Type: Soil**

| **Sample Name:** | | FH24 0-10 19-Sep-2017 2:45 pm | FH25 0-10 19-Sep-2017 2:50 pm | FH26 0-10 19-Sep-2017 2:55 pm | FH27 0-10 19-Sep-2017 3:00 pm | FH28 0-10 19-Sep-2017 3:05 pm |
|---|---|---|---|---|---|---|
| **Lab Number:** | | 1847279.1 | 1847279.2 | 1847279.3 | 1847279.4 | 1847279.5 |
| Heavy Metals, Screen Level | | | | | | |
| Total Recoverable Arsenic | mg/kg dry wt | 7 | 7 | 14 | 13 | 8 |
| Total Recoverable Cadmium | mg/kg dry wt | 0.27 | 0.34 | 0.38 | 0.27 | 0.11 |
| Total Recoverable Chromium | mg/kg dry wt | 10 | 10 | 20 | 10 | 9 |
| Total Recoverable Copper | mg/kg dry wt | 20 | 22 | 36 | 20 | 13 |
| Total Recoverable Lead | mg/kg dry wt | 76 | 119 | 310 | 400 | 59 |
| Total Recoverable Nickel | mg/kg dry wt | 9 | 8 | 10 | 8 | 7 |
| Total Recoverable Zinc | mg/kg dry wt | 147 | 220 | 168 | 250 | 81 |

| **Sample Name:** | | FH29 0-10 19-Sep-2017 3:10 pm | FH30 0-10 19-Sep-2017 3:15 pm | FH31 0-10 19-Sep-2017 3:20 pm | FH32 0-10 19-Sep-2017 3:25 pm | FH33 0-10 19-Sep-2017 3:30 pm |
|---|---|---|---|---|---|---|
| **Lab Number:** | | 1847279.6 | 1847279.7 | 1847279.8 | 1847279.9 | 1847279.10 |
| Heavy Metals, Screen Level | | | | | | |
| Total Recoverable Arsenic | mg/kg dry wt | 9 | 9 | 9 | 16 | 10 |
| Total Recoverable Cadmium | mg/kg dry wt | 0.13 | 0.37 | 0.41 | 0.17 | 0.32 |
| Total Recoverable Chromium | mg/kg dry wt | 11 | 12 | 10 | 11 | 10 |
| Total Recoverable Copper | mg/kg dry wt | 17 | 26 | 40 | 38 | 30 |
| Total Recoverable Lead | mg/kg dry wt | 62 | 390 | 68 | 230 | 440 |
| Total Recoverable Nickel | mg/kg dry wt | 9 | 10 | 12 | 9 | 8 |
| Total Recoverable Zinc | mg/kg dry wt | 95 | 260 | 470 | 126 | 185 |

| **Sample Name:** | | FH34 0-10 19-Sep-2017 3:35 pm | FH35 0-10 19-Sep-2017 3:40 pm | FH36 0-10 19-Sep-2017 3:45 pm | FH37 0-10 19-Sep-2017 3:50 pm | FH38 0-10 19-Sep-2017 3:55 pm |
|---|---|---|---|---|---|---|
| **Lab Number:** | | 1847279.11 | 1847279.12 | 1847279.13 | 1847279.14 | 1847279.15 |
| Heavy Metals, Screen Level | | | | | | |
| Total Recoverable Arsenic | mg/kg dry wt | 14 | 13 | 7 | 7 | 8 |
| Total Recoverable Cadmium | mg/kg dry wt | 0.82 | 0.76 | 0.53 | 0.14 | 0.15 |
| Total Recoverable Chromium | mg/kg dry wt | 22 | 15 | 18 | 9 | 11 |
| Total Recoverable Copper | mg/kg dry wt | 63 | 62 | 41 | 23 | 15 |
| Total Recoverable Lead | mg/kg dry wt | 1,420 | 540 | 300 | 85 | 174 |
| Total Recoverable Nickel | mg/kg dry wt | 11 | 15 | 12 | 10 | 10 |
| Total Recoverable Zinc | mg/kg dry wt | 570 | 550 | 340 | 98 | 155 |

| **Sample Name:** | | FH39 0-10 19-Sep-2017 4:00 pm | FH40 0-10 19-Sep-2017 4:05 pm | FH40 10-20 19-Sep-2017 4:10 pm | PIT 1A 20-Sep-2017 | PIT 1B 20-Sep-2017 |
|---|---|---|---|---|---|---|
| **Lab Number:** | | 1847279.16 | 1847279.17 | 1847279.18 | 1847279.19 | 1847279.20 |

| Sample Type: Soil | | | | | | |
|---|---|---|---|---|---|---|
| **Sample Name:** | | FH39 0-10 19-Sep-2017 4:00 pm | FH40 0-10 19-Sep-2017 4:05 pm | FH40 10-20 19-Sep-2017 4:10 pm | PIT 1A 20-Sep-2017 | PIT 1B 20-Sep-2017 |
| **Lab Number:** | | 1847279.16 | 1847279.17 | 1847279.18 | 1847279.19 | 1847279.20 |
| Heavy Metals, Screen Level | | | | | | |
| Total Recoverable Arsenic | mg/kg dry wt | 9 | 9 | 8 | 5 | 9 |
| Total Recoverable Cadmium | mg/kg dry wt | 1.77 | 0.23 | < 0.10 | < 0.10 | < 0.10 |
| Total Recoverable Chromium | mg/kg dry wt | 18 | 11 | 12 | 7 | 6 |
| Total Recoverable Copper | mg/kg dry wt | 163 | 31 | 24 | 7 | 15 |
| Total Recoverable Lead | mg/kg dry wt | 580 | 240 | 69 | 11.4 | 9.7 |
| Total Recoverable Nickel | mg/kg dry wt | 15 | 11 | 12 | 8 | 11 |
| Total Recoverable Zinc | mg/kg dry wt | 560 | 196 | 89 | 80 | 28 |

| **Sample Name:** | | PIT 1D 20-Sep-2017 | PIT 2A 20-Sep-2017 | PIT 2B 20-Sep-2017 | PIT 2C 20-Sep-2017 | PIT 2D 20-Sep-2017 |
|---|---|---|---|---|---|---|
| **Lab Number:** | | 1847279.21 | 1847279.22 | 1847279.23 | 1847279.24 | 1847279.25 |
| Heavy Metals, Screen Level | | | | | | |
| Total Recoverable Arsenic | mg/kg dry wt | 7 | 12 | 6 | 14 | 10 |
| Total Recoverable Cadmium | mg/kg dry wt | 0.13 | < 0.10 | < 0.10 | < 0.10 | < 0.10 |
| Total Recoverable Chromium | mg/kg dry wt | 8 | 8 | 9 | 10 | 6 |
| Total Recoverable Copper | mg/kg dry wt | 8 | 8 | 10 | 33 | 15 |
| Total Recoverable Lead | mg/kg dry wt | 96 | 9.9 | 8.1 | 12.4 | 7.9 |
| Total Recoverable Nickel | mg/kg dry wt | 7 | 7 | 9 | 20 | 12 |
| Total Recoverable Zinc | mg/kg dry wt | 131 | 28 | 35 | 55 | 25 |

| **Sample Name:** | | PIT 3A 20cm 20-Sep-2017 | PIT 3B 80-90cm 20-Sep-2017 | PIT 4A 20cm 20-Sep-2017 | PIT 4B 60-70cm 20-Sep-2017 | PIT 7A 40cm 20-Sep-2017 |
|---|---|---|---|---|---|---|
| **Lab Number:** | | 1847279.26 | 1847279.27 | 1847279.28 | 1847279.29 | 1847279.30 |
| Heavy Metals, Screen Level | | | | | | |
| Total Recoverable Arsenic | mg/kg dry wt | 17 | 174 | 670 | 150 | 8 |
| Total Recoverable Cadmium | mg/kg dry wt | < 0.10 | 0.82 | < 0.10 | < 0.10 | < 0.10 |
| Total Recoverable Chromium | mg/kg dry wt | 8 | 9 | 10 | 9 | 11 |
| Total Recoverable Copper | mg/kg dry wt | 12 | 43 | 36 | 17 | 20 |
| Total Recoverable Lead | mg/kg dry wt | 10.2 | 510 | 68 | 11.4 | 20 |
| Total Recoverable Nickel | mg/kg dry wt | 10 | 10 | 10 | 11 | 13 |
| Total Recoverable Zinc | mg/kg dry wt | 36 | 290 | 182 | 62 | 61 |

| **Sample Name:** | | PIT 7B 1m 20-Sep-2017 | PIT 8A 50cm 20-Sep-2017 | PIT 8B 1m 20-Sep-2017 | PIT 5A 60cm 20-Sep-2017 | PIT 5B 60cm 20-Sep-2017 |
|---|---|---|---|---|---|---|
| **Lab Number:** | | 1847279.31 | 1847279.32 | 1847279.33 | 1847279.34 | 1847279.35 |
| Heavy Metals, Screen Level | | | | | | |
| Total Recoverable Arsenic | mg/kg dry wt | 139 | 6 | 7 | 6 | 15 |
| Total Recoverable Cadmium | mg/kg dry wt | 0.26 | 0.14 | < 0.10 | < 0.10 | 0.55 |
| Total Recoverable Chromium | mg/kg dry wt | 58 | 8 | 6 | 6 | 7 |
| Total Recoverable Copper | mg/kg dry wt | 115 | 9 | 15 | 5 | 13 |
| Total Recoverable Lead | mg/kg dry wt | 26 | 43 | 31 | 43 | 10.5 |
| Total Recoverable Nickel | mg/kg dry wt | 11 | 8 | 10 | 6 | 8 |
| Total Recoverable Zinc | mg/kg dry wt | 250 | 106 | 57 | 120 | 680 |

| **Sample Name:** | | PIT 5C 40cm 20-Sep-2017 | PIT 6A 60cm 20-Sep-2017 | PIT 6B 80-90cm 20-Sep-2017 | FH33 10-20 19-Sep-2017 | PIT 1C 20-Sep-2017 |
|---|---|---|---|---|---|---|
| **Lab Number:** | | 1847279.36 | 1847279.37 | 1847279.38 | 1847279.39 | 1847279.40 |
| Heavy Metals, Screen Level | | | | | | |
| Total Recoverable Arsenic | mg/kg dry wt | 49 | 52 | 12 | 7 | 9 |
| Total Recoverable Cadmium | mg/kg dry wt | 1.32 | < 0.10 | < 0.10 | < 0.10 | < 0.10 |
| Total Recoverable Chromium | mg/kg dry wt | 7 | 8 | 4 | 6 | 9 |
| Total Recoverable Copper | mg/kg dry wt | 19 | 8 | 4 | 22 | 16 |
| Total Recoverable Lead | mg/kg dry wt | 28 | 8.8 | 5.0 | 191 | 9.4 |
| Total Recoverable Nickel | mg/kg dry wt | 10 | 9 | 5 | 7 | 12 |
| Total Recoverable Zinc | mg/kg dry wt | 890 | 37 | 23 | 79 | 40 |

# SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

**Sample Type: Soil**

| Test | Method Description | Default Detection Limit | Sample No |
|---|---|---|---|
| Heavy Metals, Screen Level | Dried sample, < 2mm fraction. Nitric/Hydrochloric acid digestion US EPA 200.2. Complies with NES Regulations. ICP-MS screen level, interference removal by Kinetic Energy Discrimination if required. | 0.10 - 4 mg/kg dry wt | 1-40 |

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.



Carole Rodgers-Carroll BA, NZCS
Client Services Manager - Environmental