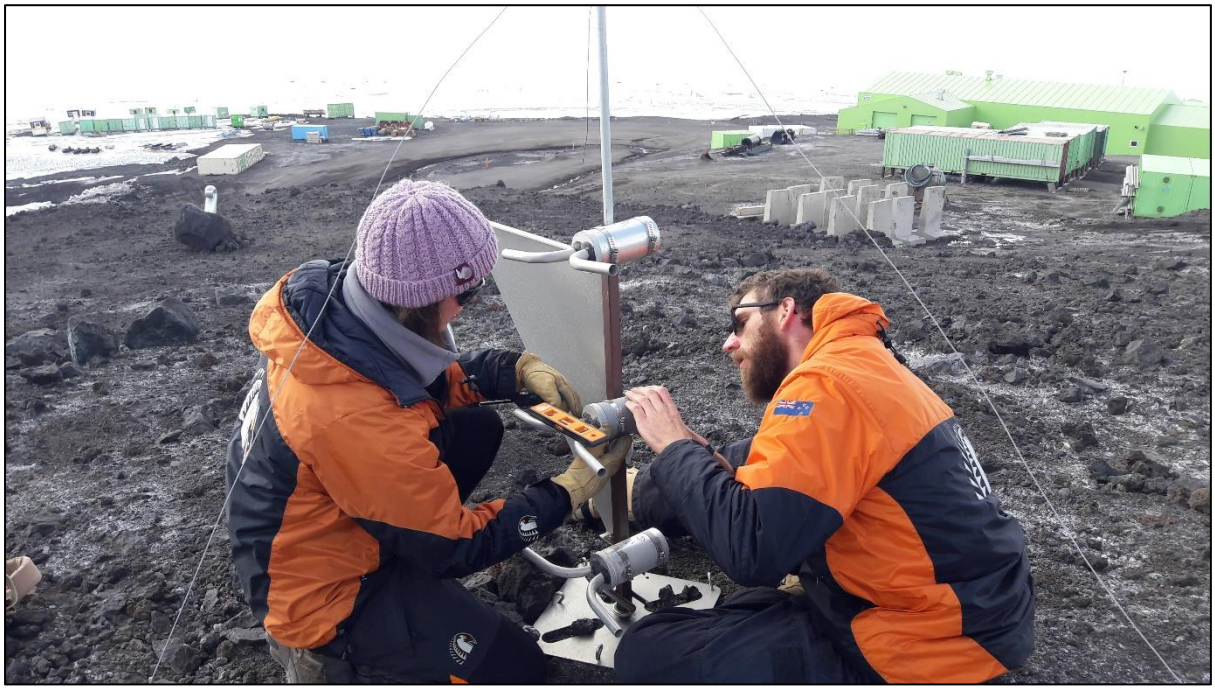
Scott Base Redevelopment
CEE environmental monitoring report: Year one (January 2019)



2019
ERI report number 139
Prepared for Antarctica New Zealand
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Cite report as:

O'Neill, T. 2019. Scott Base Redevelopment CEE environmental monitoring report: Year one (January 2019). *Environmental Research Institute Report No. 139*. Client report prepared for Antarctica New Zealand. Environmental Research Institute, The University of Waikato, Hamilton, New Zealand. 52pp. ISSN 2463-6029 (Print), ISSN 2350-3432 (Online).

Cover picture: Annual collection of dust from MWAC passive dust collector, Scott Base operational area, Ross Island, Antarctica. Photo: Tanya O'Neill.

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Contents

1. Background and aims

An understanding of the soils and the underlying permafrost surrounding Scott Base is important to detect impacts of environmental change or human activities, such as the redevelopment of Scott Base, on the unique soil communities and on geomorphological processes. The Scott Base Redevelopment (SBR) is the largest project ever undertaken by New Zealand in Antarctica. It is a requirement of the Environmental Protocol to the Antarctic Treaty and New Zealand's Antarctica (Environmental Protection) Act (1994) that an environmental impact assessment be completed prior to any activity taking place in Antarctica. A Comprehensive Environmental Evaluation (CEE) of the project is being completed in order to support decision-making with an assessment of predicted environmental impacts linked with the redevelopment. A comprehensive monitoring programme was set up to verify the accuracy of the environmental impact assessment presented in the CEE and to detect unforeseen impacts or impacts that are more significant than expected.

The soil monitoring sites were established in January 2019 to assess current levels of biodiversity and abundance of invertebrates and microbial communities, along with soil chemical characteristics, and visual characteristics within the wider Scott Base redevelopment area. These 25 soil monitoring plots establish a baseline against which future changes can be detected. My role in the project was to determine the chemical characteristics of soil from the monitoring plots, undertake visual site assessments around each monitoring plot, measure depth to ice-cement, and install 12 passive dust samplers adjacent to the monitoring plots.

This report will give background information on the general characteristics of Scott Base soils, including information on active layer, permafrost, soil moisture, soil organisms, and evidence of natural and human induced changes to the soil-permafrost environment. This will be followed by an explanation of the methodology, results and discussion, on my aspect of this multidisciplinary project.

2. General soil characteristics and environment

Soils of Pram Point, Hut Point Peninsula, the site of Scott Base, are formed from gently undulating scoriaeous basaltic lava flows of the McMurdo Volcanics Formation (Kyle *et al.* 1990), which have been considerably fractured by freeze-thaw processes (Sheppard *et al.* 2000). Soils comprise a seasonally thawed active layer of soil material over permafrost, and are generally classified as Typic Haplorthels (Soil Survey Staff, 2014).

In this subxerous soil moisture regime (Campbell and Claridge, 1969) where physical weathering dominates and chemical weathering is restricted due to cold temperatures and lack of liquid moisture, soils are generally shallow, loose, and soil texture ranges from coarse sand to bouldery gravelly sand. Like other dry environments where evaporation exceeds precipitation, salts accumulate and in the Hut Point Peninsula area occur as encrustations on rocks, as efflorescences on the soil surface, or precipitate as calcite on the underside of stones (Claridge, 1965; McCraw, 1967; O'Neill *et al.* 2012). Because of the low clay and low organic matter contents the soils have a low pH buffering capacity, and therefore the salts that accumulate have a strong effect on soil pH. Consequently salinity is highest at the surface, and soils are alkaline and range from about pH 8 to pH 10 (Campbell and Claridge, 1987; Campbell *et al*. 1998b; O'Neill, 2013). Compared with other areas in the Ross Sea region, Hut Point Peninsula does receive some precipitation falling as snow in the winter or occasional

summer snowfall events, and subsequently moisture from melting snow or down-slope flow does provide limited moisture to soil (Sheppard *et al.* 2000; Balks and O'Neill, 2016).

2.1 Active layer and permafrost

For much of the year Scott Base soils are at temperatures below 0°C, however, over the summer months (December-January) when sunshine is incident for 24 hours per day the soils are warmed at the surface. The black basalt surface soil absorbs radiant energy and soil surface temperatures often become higher (sometimes >15°C) than the ambient air temperatures which generally remain near or below 0°C (Balks and O'Neill, 2016). Heat is conducted downwards thawing the near-surface soil, known as the *active layer*. The depth to which soils thaw each summer is referred to as the active layer. Beneath the active layer is permafrost, defined as having a temperature of less than 0°C for at least two consecutive years (Grosse *et al*. 2011; Soil Survey Staff, 2014). A transitional layer is increasingly being recognised at the top of the permafrost which occasionally thaws during particularly warm summers (Bockheim, 2015b).

The maximum depth of thaw (active layer) varies both spatially and temporally with marked between season variability (Adlam *et al*. 2010; Carshalton *et al.* 2018). At Scott Base the active layer depth at maximum thaw ranges from 25 cm to 39 cm, with an average depth of 33 cm over the 19 year monitoring record (Carshalton et al. 2018); and also shows no significant warming or cooling trend. The maximum depth of thaw is greater in moist soils, such as on stream margins, as thermal conductivity of moist soil is greater than dry soil (Ikard *et al*. 2009; Gooseff *et al*. 2013). Topographic positon and soil surface albedo also impact on the soil thermal regime with lower soil temperatures on paler soils with higher albedo (Balks *et al.* 2002). Thus, the soils around Scott Base with dark parent material have a lower (6-10%) soil surface albedo; thus absorbing more heat (Balks *et al.* 2002). For a small part of the year (up to two months at some sites) soil surface temperatures are above 0°C for extended periods, providing some opportunity for liquid moisture and biological activity.

2.2 Soil moisture

Soil water controls plant growth and influences a variety of soil processes including erosion, chemical exchange, microbial activity (presence, abundance, and diversity of terrestrial biota), transport of solutes and water, and pedogenesis (Selbold *et al.* 2010). Antarctic ecosystem processes depend upon the proximity of water and the duration of liquid water availability (Barrett et al. 2006). Soil water availability and moisture recharge in Antarctic soils is dependent on whether snow and ice melts or sublimates. Soil field moisture contents ranged from 1–5% (by weight) in the upper 10 cm for soils at Scott Base (Balks *et al.* 2002), and up to 20% (by weight) at depth directly above the permafrost (Campbell *et al.* 1994). Gooseff *et al.* (2003) reported soil moisture values under snow patches in the Dry Valleys that ranged from 6.9–13.6% (by weight) compared to 0.4% (by weight) in bare soil.

Selbold *et al.* (2010) showed over a 10 year monitoring period at the Scott Base soil climate station site, there was generally one to about four wetting events per summer season that extended to at least 20 cm depth. The site does receive subsurface flow of water from upslope (snow melt) along the ice-cemented permafrost. The soil moistening effect tends to be brief as it takes about two weeks for the near-surface (0-10 cm depth) soil to dry again from saturated, back to less than 5% moisture (Campbell *et al.* 1998b). Because of the low humidity a large portion of the snow is lost directly to the atmosphere by sublimation, and thus the water is never available to the soil. There are

areas where runoff from snow melt occurs for a large portion of the summer months (such as near the Antenna Field at Scott Base). Here the soil will be saturated and ephemeral streams form. The water conducts heat into the soil and can provide an unusually deep active layer at the site (as at Granite Harbour where the active layer depth is greater than 90 cm; Adlam *et al.* 2010) and can harbour high levels of vegetation and biodiversity (Adams *et al.* 2006).

2.3 Soil organisms

Soil biological communities in the Ross Sea region include mosses, liverworts, lichens, cyanobacteria, algae, collembola, mites; mesofauna, including rotifers, tardigrades, and nematodes; and microorganisms, bacteria, fungi, and archaea (Waterhouse, 2001). Communities have had to adapt to an extreme environment of high levels of desiccation, high salinity, low nutrient levels, high summer UV radiation levels, and physical instability of the soil surface caused by katabatic winds and freeze-thaw cycles. As a consequence of the physical and chemical extremes imposed on life in the Ross Sea region, terrestrial ecosystems are predominantly abiotically-driven systems. Numerous studies have shown that soil pH, salinity, and available water content, and levels of inorganic carbon drive the abundance and structure biological communities (Cameron *et al.* 1970; Kennedy, 1993; Freckman and Virginia, 1997; Billi and Potts, 2002; Saul *et al.* 2005; Adams *et al*. 2006; 2014; Nkem *et al.* 2006; Aislabie *et al.* 2006a, 2008; Chong *et al.* 2009, 2012; Smith *et al.* 2010; Ball *et al*. 2011, 2012; O'Neill *et al.* 2013b, 2015). High spatial variability in abiotic factors, such as water content, can result in high variability in species diversity and community structure (Niederberger *et al.* 2015), yet recent studies have shown levels of endemism in Antarctica are incredibly high (Convey et al. 2011) and highly structured, genetically distinct communities exist (Stevens and Hogg, 2003; Beet *et al*. 2016). Consequently, natural climate perturbations and human induced changes to the physical and chemical soil environment may therefore effect the resident biological communities.

3. Natural and human-induced changes to the soil-permafrost environment

Evidence suggests that some landscapes in the Ross Sea Region are more dynamic than some researchers have assumed. The region has experienced short-lived erosion and depositional events resulting from warmer than average summers, or higher than average snowfall, which can lead to melting of subsurface ice. Such disturbances were documented by workers in the 1970s (Chinn, 1979), observed in the 1990s (Campbell *et al.* 1994, 1998), and again now in the early 21st century (Fountain *et al.* 2014; Balks and O'Neill, 2016). Chinn (1979) described a warm summer event with air temperature of 15°C recorded at Lake Vanda in January 1974, which caused extensive melting and water flow in the McMurdo Dry Valleys, having lasting impacts on the landscape, such as lakes and stream bank erosion. The 2000/01 summer was notably warmer than average in the MDVs (Barrett *et al*. 2008; Adlam *et al*. 2010) resulting in deeper than average penetration of the active layer at sites across the region and high meltwater flows with flooding and stream-bank erosion on the Onyx River and other streams. The pulse of meltwater impacted ecosystems in the Taylor Valley for several years afterwards (Barrett *et al*. 2008). Balks and O'Neill (2016) give two examples of erosion events, one at Cape Evans (same parent material, climate and general soils as at Scott Base) in early January 2009 and one in the Wright Valley north wall near the eastern end of Lake Vanda, observed late December 2009. Impacts of natural warming-induced increased melting of glaciers, snow patches, and melting of subsurface ice may potentially include changes in ecological habitats and microbial, moss, and lichen communities. However, given that the mean annual temperatures at Scott Base is -18°C, and

the permafrost temperatures are in the range of -18°C to -24°C, other than some deepening of the active layer, and resulting ice-melt as the depth to permafrost adjusts, major changes in permafrost regimes are unlikely to occur via natural or climate perturbations in the foreseeable future (Balks and O'Neill, 2016).

Human activities that impact on the thickness and stability of the active layer, generate dust, change local hydrology, shading, or snow patch distribution, can also invoke similar impacts. Detailed accounts of the history of human activity in Antarctica and resulting impacts on the soil environment are given in Campbell and Claridge (1987), Tin and *et al.* (2009), O'Neill *et al.* (2015) and O'Neill (2017). Such impacts have included landscape modification as a result of construction activities, geotechnical studies, and roading (Campbell *et al.* 1993, 1994; Harris 1998; Kiernan and McConnell 2001; Kennicutt *et al.*2010); disturbance to soil communities (Naveen 1996; Harris 1998; Tejedo *et al.* 2005, 2009; Tin *et al.* 2009 and references therein); local pollution from hydrocarbon spills (Aislabie *et al.* 2004 and references therein; Kim *et al.* 2006; Klein *et al.* 2012); waste disposal (Claridge *et al.* 1995; Sheppard *et al.* 2000; Snape *et al.* 2001; Santos *et al.* 2005); and the introduction of alien species (Frenot *et al.* 2005; Cowan *et al.* 2011; Chown *et al.* 2012).

The Hut Point Peninsula has been the site of the US and New Zealand Antarctic bases since the 1950s and therefore an area extensively and permanently impacted by operations. Repeated scraping and earthworks, has resulted in soil surface disturbances, permafrost retreat, land subsidence, and salinisation (Campbell *et al.* 1998). These disturbances have spread dust widely over snow covered surfaces, causing changes in albedo, and in turn, have caused snowfield retreat and accelerated water and sediment runoff (e.g. land between Scott Base and Observation Hill). A continuous human presence since the 1950s is also responsible for the introduction of a wide range of organic and inorganic wastes, fuel spills, rubbish, and debris, which have all impacted the base surrounds to some extent, including areas where hotspots of TPH and asbestos are found, heavy metals, and other changes in the chemical and organic content of soils.

The physical response to changes in the soil thermal regime depend largely on the form of the underlying permafrost, the severity of the disturbance (from the "norm"), and the climate regime of the site in question. For the soils of the Hut Point Peninsula containing ice-cemented permafrost, the removal or deepening of the active layer would lead to changes in the underlying permafrost. Where there is an ice-rich layer at the top of the permafrost, or within ice wedges, there will be an initial melting event and most of the moisture is likely to subsequently be evaporated from the soil (often forming salt efflorescences of the soil surface) and the soils are likely to form a new stable equilibrium with a deeper active layer. Where disturbance removes the active layer, melting of the underlying permafrost can occur resulting in surface slumping, until sufficient mineral material has accumulated at the ice surface to insulate the underlying ice from further melting or ablation (Fountain et al. 2014). Such effects can be easily observed in the proximity of McMurdo Station where, particularly during the 1980s and 1990s active layer soil material was regularly removed for road-fill from surfaces underlain by massive ice resulting in extensive ice melt-out, soil surface slumping and salt accumulation on the soil surface (Campbell and Claridge, 1987; Balks and O'Neill, 2016). Such disturbances can dramatically change the physical and chemical properties of the terrestrial habit for soil biota.

4. Scott Base redevelopment baseline survey

In January 2019 a multidisciplinary team was deployed to establish an environmental baseline against which future natural changes and changes attributable to the SBR can be measured. The Scott Base study area region of interest includes the current operational area and extending uphill from Scott Base to the SB-McMurdo Station road and the cliff edge towards Observation Hill. For sufficient spatial coverage of the study area, twenty-five biological monitoring plots were decided, and Pierre Roudier, Manaaki Whenua – Landcare Research, using GIS (including the LINZ Scott Base survey, 2014-15 USGS LiDAR survey, and a previous Scott Base vegetation survey) determined the optimal sampling sites using five environmental covariate layers:

1. Distance to the road (dist_road), as a proxy for the major source of dust;
2. Distance to the operational area of Scott Base (dist_operational_area), as a proxy for the distance from the general building operations;
3. Distance from the helicopter pads (dist_helo_pad), as a proxy for a major source of dust and environmental disruption;
4. The (modelled) global solar radiation received during summer (December, January, February) (glob_rad_djf, sb), as a proxy for soil temperature and associated melt; and
5. SAGA Wetness Index (swi), as a way to delineate areas that are likely to receive meltwater, as opposed to areas that are likely to shed meltwater.

The following reports methodology and results on the chemical characteristics of the soil monitoring plots, visual site assessments, depth to ice-cement, and details on the locations of the 12 passive dust collectors installed in season one.

5. Methods

Each of the 25 soil monitoring plots were located using GPS waypoints (Figure 1) and marked out using two orange marker poles to mark opposite ends of a 1 m^2 plot (representative of the landscape unit). Photos were taken of the plot area from different angles (looking inwards, from 0, 90, 180, 270 degrees), then directly above the plot with a 1 m measuring tape in place, to record current levels of vegetation, surface salts, and surrounding site characteristics. Whilst I undertook soil sampling and visual soil assessments, my colleague Clare Beets from Waikato University undertook an in-situ macroinvertebrate survey, took soil samples for microinvertebrate analysis at the Crary Lab at McMurdo Station and DNA sequencing, and undertook a vegetation survey along transects at selected soil monitoring plot sites.

5.1 Soil sampling

Using a trowel marked with 2 cm and 5 cm depth increments, soils were sampled directly adjacent to the SM plot (within 1 m). Two soil depths were taken, 0-2 cm and 2-5 cm, and sampling consisted of at least 10 subsamples were homogenized from numerous spots adjacent to the plot to ensure a representative bulk sample (e.g. if the plot had a lot of salt efflorescence on the surface, the same adjacent soils were sampled. Alternatively if the plot appeared visibly salt-free, salt was avoided in the representative bulked sample). Approximately 400 g of soil was homogenised from two depths. These soils were to be analysed for pH and electrical conductivity (salt) at Waikato University (standard method in Appendix 1). Beyond the scope of this initial work, but related, transects from

the SB-McMurdo station road centre, back into the area behind Scott Base, both in the prevailing wind direction and into the prevailing wind towards Crater Hill, we sampled and analysed for pH and EC and will be analysed with XRF for elemental composition.

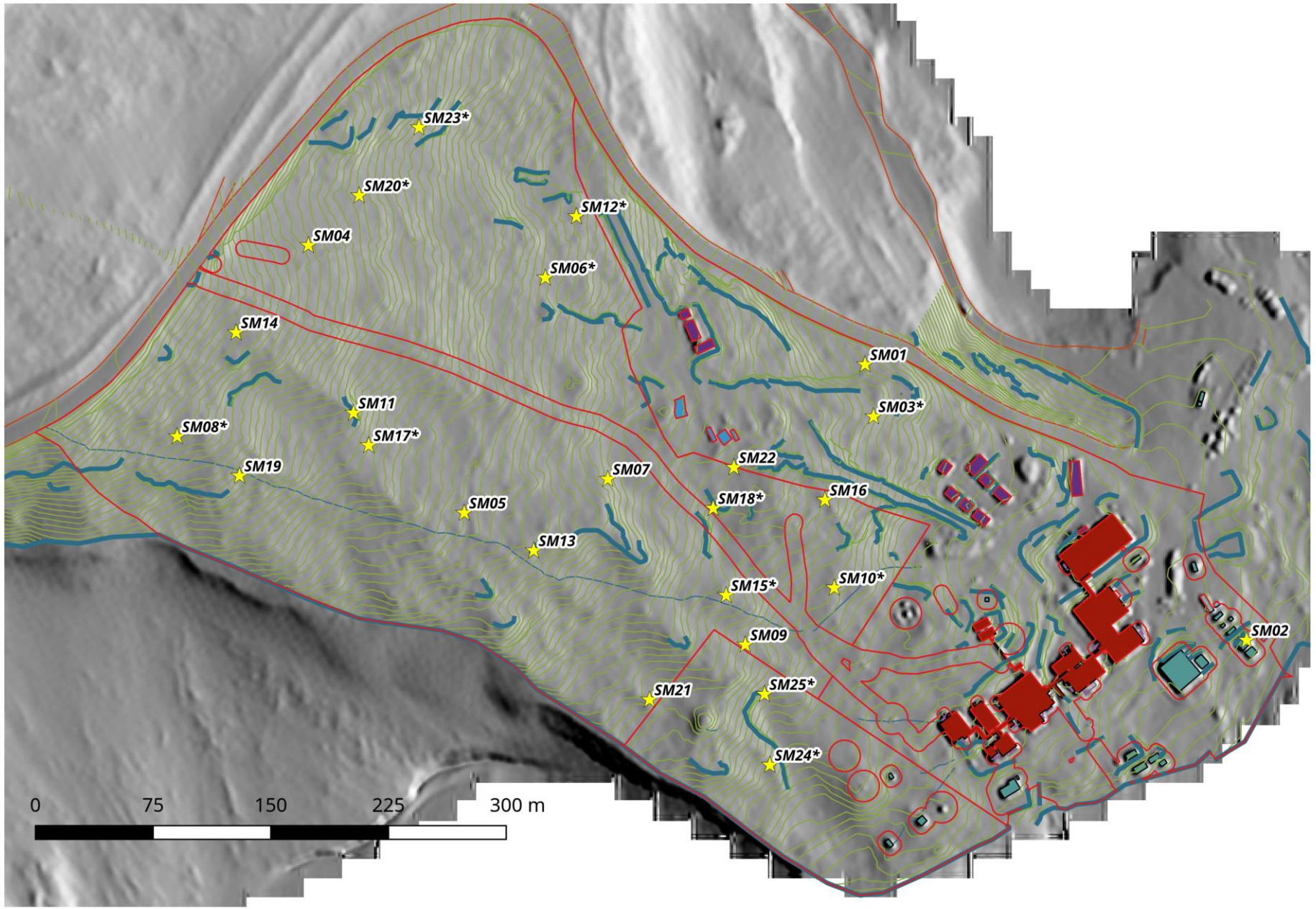

Figure 1: Map of operational area and the 25 soil monitoring plots (provided by Pierre Roudier of Manaaki Whenua, Landcare Research. *means MWAC dust sampler is adjacent to the monitoring plot.

5.2 Visual site assessments

The VSA method of Campbell *et al.* (1993) was used to assess the present-day visual impacts at a representative area at each site. The VSA method of Campbell *et al.* (1993) is a rapid visual evaluation of terrestrial impacts and rates the extent of surface disturbance against 11 impact assessment criteria, such as extent of disturbed surface stones, evidence of boot imprints, and evidence of foreign objects, as a means of comparing disturbance severity across different sites (see Campbell et al. 1993 for full methods and illustrations). A modified version of the original VSA which included an additional six criteria: evidence of salt deposition, stratigraphic disturbance, textural disturbance, presence of rock cairns (see Kiernan and McConnell, 2001 and O'Neill *et al.* 2013a), % change in vegetative cover and evidence of exotic species; removal of 'other surface impressions' (as captured by many of the other criteria); and the modification of evidence of 'walking tracks' to include 'walking or vehicle tracks', to give a total of 16 impact assessment criteria. Criteria are rated between one and four, one being no visible impact, and four being the most severe.

A VSA was undertaken at each soil monitoring plot and scale of visually disturbed area noted as criteria D as <5 m^2, 5-20 m^2, 20-100 m^2 or >100 m^2. Some criteria were compared with an adjacent equivalent control, or less disturbed site in the case of the Scott Base environment.

5.3 Depth to ice-cement or maximum thaw

Three measurements of depth to ice cement (or maximum thaw of active layer at that point in time) were taken immediately adjacent to the soil monitoring plots using a mallet and orange pole, and replicates averaged.

5.4 Dust sampler installation

Twelve Modified Wilson and Cooke (MWAC) dust samplers were installed in the immediate vicinity of Scott Base, 11 of which were immediately adjacent to the biological soil monitoring plots (Figure 1). Locations of these dust samplers where chosen to give good spatial coverage, including varying proximity to road, both sides of the base (prevailing wind direction), two close to the most vegetated area etc; and form a number of transects from high dust input areas (McMurdo-Scott Base road) to areas of lesser dust input. The reason being one of the potential environmental effects of the Scott Base reconstruction is generation of dust, and its impact on vegetation and soil biology. A number of parameters were collected at each MWAC site including, GPS coordinates, elevation, and vegetative cover (as well as soil samples, VSA, and depth to ice cement already done in association with the soil monitoring plot itself). A MWAC installation and collector replacement guide was produced by O'Neill and Sitter.

6. Results and discussion

We established 25 soil monitoring plots spread across the Scott Base operational and wider area that incorporated a range of site characteristics (see section 4). Sites SM01, SM02 and SM03 were located in the current operational area and the remainder extending uphill from Scott Base to the SB-McMurdo station road and the cliff edge towards Observation Hill (Figure 1).

6.1 Soil chemical analysis

Soil pH and soil electrical conductivity (EC), a measure of salt, were measured at two depths (0-2 cm and 2-5 cm) at all soil monitoring sites (Table 1). pH of the top 0-2 cm ranged from 8.22 to 10.14 and in the material beneath (2-5 cm) ranged from 8.56 to 9.96. EC varied considerably across the monitoring plot sites, was always highest the top 2 cm, ranging from 135.5 to 5400.0 µS/cm in the 0-2 cm samples, to 36.0 to 5180.3 µS/cm in the 2-5 cm soil samples (Table 1). EC tended to be higher in more disturbed sites (SM01, SM03, SM06) and on closer to the SB to McMurdo station road (Appendix 2: tables 2.1 and 2.2). Transect 1 (T1) from the road centre, back into the area behind Scott Base in the prevailing wind direction, showed a significant relationship between pH and proximity to road (Figure 2 and Appendix 2: figure 2.1). Note pH is a logarithmic scale and as a result, each whole pH unit is ten times more alkaline than the one below e.g. a pH of 10 is 10 times more alkaline than a pH of 9, or a pH of 10 is 100 times (10 x 10) more alkaline than a pH of 8. It was noted that a very fine road dust blanketed T1 back to 10 m off the road (ranging from 40% cover of a $1m^2$ plot, 2 m and 5 m from the road, to 20% of a $1m^2$ plot 10 m from the road) (Appendix 2: figure 2.2), also corresponding to the highest pH and EC at the road centre and 2 m back (Appendix 2: table 2.1) and fine road dust extended more than 50 m from the road centre in the prevailing wind direction. Conversely, Transect 2 (T2), positioned upwind towards Crater Hill, there was some visible road dust at 2 m (less than 10% cover of a $1m^2$ plot), but beyond that, nothing visible (Appendix 2: figure 2.3, table 2.2), and pH and EC appeared closer to background levels. Further investigations are required to determine what, if anything, the road is treated with, and elemental analysis of the composition of the fine dust as within increased SBR related traffic on the SB to McM station road there could be further extension of road dust impacts across the monitoring sites.

Table 1: Soil pH and electrical conductivity of soil monitoring plot sites. #Data are the average of duplicate samples. 1 millisiemens/centimetre (mS/cm) = 1000 microsiemens/centimetre (µS/cm. *MWAC associated with monitoring plot.

Monitoring plot id	**Longitude**	**Latitude**	**Soil sample 0-2 cm#**		**Soil sample 2-5 cm#**	
			EC (µS/cm)	**pH**	**EC (µS/cm)**	**pH**
SM01	166.7636	-77.8474	3020.5	9.06	702.0	9.46
SM02	166.77196	-77.84943	786.5	10.05	163.3	9.80
SM03*	166.7635	-77.8477	5400.0	9.08	5180.3	8.79
SM04	166.74965	-77.84601	457.0	9.27	120.1	9.15
SM05	166.7521	-77.8477	312.0	10.14	122.4	9.22
SM06*	166.7557	-77.8465	3550.0	8.22	1209.5	8.56
SM07	166.7561	-77.8477	201.9	9.14	52.5	9.22
SM08*	166.7450	-77.8469	1268.5	9.29	628.5	9.96
SM09	166.7587	-77.8488	210.3	9.67	117.8	9.63
SM10*	166.7614	-77.8486	542.5	9.46	227.8	9.83
SM11	166.7498	-77.8470	204.3	9.24	36.0	8.73
SM12*	166.7569	-77.8462	947.5	9.04	218.6	9.73
SM13	166.7537	-77.8480	285.0	9.76	93.5	9.71
SM14	166.7472	-77.8464	1208.5	9.16	208.3	9.85
SM15*	166.7585	-77.8485	152.0	9.64	114.3	9.38
SM16	166.7617	-77.8481	234.1	9.72	89.7	9.44
SM17*	166.7500	-77.8472	135.5	9.24	60.7	9.01
SM18*	166.7587	-77.8480	2489.5	8.51	215.4	9.15
SM19	166.7464	-77.8472	255.2	9.73	222.7	9.54
SM20*	166.7513	-77.8458	678.0	8.67	137.5	9.03
SM21	166.75583	-77.84898	675.5	9.66	158.4	9.81
SM22	166.7595	-77.8478	1657.5	9.53	200.3	9.48
SM23*	166.7533	-77.8455	206.4	9.78	230.5	9.49
SM24	166.7586	-77.8495	255.3	9.38	185.5	9.19
SM25*	166.7589	-77.8491	238.6	9.42	43.0	9.11

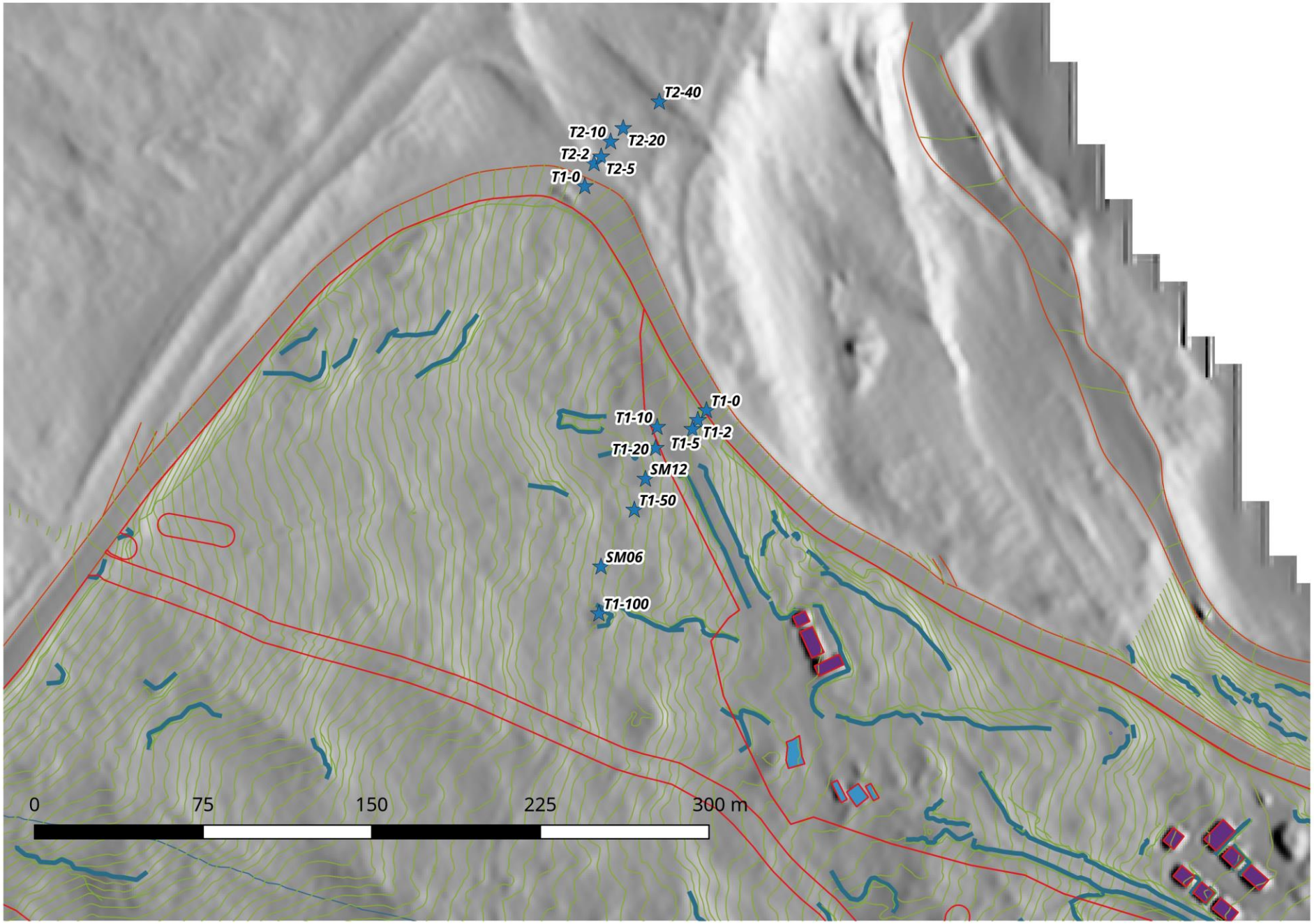

Figure 2: Map showing location of two dust sampling transects. T1 is downwind between Scott Base to McMurdo station road (T1-0 m to T1-100 m) and T2 is windward, from T1-0 m to T2-40 m (map provided by Pierre Roudier of Manaaki Whenua, Landcare Research).

6.2 Visual site assessments

Twenty-five visual site assessments were undertaken as part of the baseline survey. Site descriptions, VSA data and a VSA summary are given for each soil monitoring site in Appendix 3. Generally, all sites showed some evidence of low to moderate level disturbance, however sites SM01-SM03, within the current operational zone showed greatest disturbance (including many to abundant disturbed surface stones, impressions of removed rocks, moderate colour contrast with surrounds, visible to abundant salt deposition, stratigraphic disturbance and moderate to very obvious textural change in the material (Appendix 3). Soil monitoring sites in close proximity to the Hillary Trail (SM05, SM13, SM15, SM19) all showed signs of disturbance, commonly many to abundant disturbed surface stones and obvious cumulative impact, and to a lesser extent (further from the Hillary Trail) SM08, and SM09. Similarly sites close to the cable that runs between Scott Base and the SB-McMurdo station road (SM07, SM14 and SM18) showed signs of low level disturbance, litter, few -many to abundant disturbed stones, and some weakly evident cumulative impact (SM18) from cable maintenance.

6.3 Depth to ice-cement

Three measurements of depth to ice cement (or maximum thaw of active layer at that point in time) were taken immediately adjacent to the soil monitoring plots, and replicates averaged. Depth to ice-cement ranged from 5 cm to 36 cm across the 25 monitoring plot sites (Appendix 3). This active layer depth varies spatially and temporally. In moist environments, such as SM24, where there was a small stream running through the site, depth to ice-cement could not be measured, however, we would expect a significantly greater active layer depth as thermal conductivity of moist soil is greater than dry soil (Ikard *et al*. 2009; Gooseff *et al*. 2013). Similarly SM25, a moist site located in the antenna farm area had an active layer depth of 36 cm; and SM20, a site below a snow patch with some running water, had an active layer depth of 31 cm. All soil monitoring sites have a similar low albedo due the black basaltic parent material absorbing heat, so active layer depth would be comparable in this regard (Balks et al. 2002). It was noticed that the shallowest active layer depths occurred in highly disturbed and often recently bulldozed sites (SM01 = 5 cm and SM02 = 5 cm), which also had abundant surface salts, which likely indicates melting of the underlying permafrost, evaporation of moisture from the soil, leaving surface salt efflorescences. Depth to ice-cement tend to increase we move uphill of Scott Base with some of the deepest active layers at the highest elevations, close to the SB to McMurdo station road (SM04 = 30 cm; SM20 = 31 cm; SM23 = 32 cm) (Appendix 3).

7. Conclusions

Twenty-five soil monitoring plots were established in the current Scott Base operational and wider area in January 2019. Sites SM01-03 were located in the current operational area and the remainder extending uphill from Scott Base to the SB-McMurdo station road and the cliff edge towards Observation Hill. Soil was analysed at two depths, 0-2 cm and 2-5 cm, for chemical characteristics such as pH and EC. pH ranged from 8.22 to 10.14 in the 0-2 cm samples, and in the material beneath (2-5 cm) ranged from 8.56 to 9.96. EC varied considerably across the monitoring plot sites, and was always highest the top 2 cm, ranging from 135.5 to 5400.0 µS/cm in the 0-2 cm samples, to 36.0 to 5180.3 µS/cm in the 2-5 cm soil samples. There was a significant relationship between proximity to the Scott Base to McMurdo station road and pH and EC, with higher values for both in the prevailing wind direction, with fine dust extending more than 50 m from the road. Further investigations are required to determine the composition of the road dust.

Visual site assessments showed low to moderate level disturbances at all soil monitoring plots, however sites within the current operational zone (SM01, SM02, SM03) showed greatest disturbance, followed by sites within 10 m from the Hillary Trail (SM05, SM13, SM15, SM19) and then to a lesser extent, sites close to the cable that runs between Scott Base and the SB-McMurdo station road (SM07, SM14, SM18) showed signs of low level disturbance.

Depth to ice-cement or active layer depth ranged from 5 cm to 36 cm across the soil monitoring plots. SM24, an active stream site, was unable to be measured by would likely be considerably deeper than 36 cm from the ground surface due to the thermal conductivity of moist soil. Likewise, more moist soils (SM20 and SM25) had greater active layer depths. Recently bulldozed sites, and sites where the former active layer had been severely disturbed or removed (SM01 and SM02) had very shallow active layers and abundant salt deposition, potentially indicating past melting of underlying permafrost, loss of moisture and deposition of surface salts. There may be a relationship between elevation and active layer depth, with greater depth to ice-cement at higher elevations but this, and whether there is a relationship between road dust thickness/distance from road, and active layer thickness, needs to be explored further in season two.

Twelve dust samplers were installed in the immediate vicinity of Scott Base, 11 of which were immediately adjacent to the biological soil monitoring plots. Dust samplers are located at varying proximity to road, both sides of the base (upwind and downwind of prevailing wind direction), two close to the most vegetated area, and form a number of transects from high dust input areas (McMurdo-Scott Base road) to areas of lesser dust input. Year one dust data has not been retrieved and quantified.

Data provided in this report and from others in the greater baseline survey team, will serve as a useful and sensitive baseline against which future changes attributable to the Scott Base redevelopment can be measured. It is my recommendation that in year two several soil monitoring plots and dust samplers be established at an appropriate control site (Cape Evans) to be able to differentiate between any redevelopment impacts and changes to all measured parameters due to natural climate perturbations.

APPENDIX 1: Soil pH and electrical conductivity standard methods

Appendix 2 – Dust transect data and photos

Table 2.1 Descriptions and soil chemical analyses of Transect 1. Soil chemistry analysed on 0-2 cm depth

Distance from Road	Longitude	Latitude	Description	EC* (µS/cm)	pH*
0 m	166.75832	-77.84599	Elevation 48 m. Ice cement 5 cm (road compaction). Very fine brown uniform silt.	2353	10.15
2 m	166.75812	-77.84602	Elevation 50 m. Ice cement 23 cm (hill slope). Visible road dust. Road dust cover 40%, angular fill pebbles 60%, 40% salt cover.	1512	10.43
5 m	166.75798	-77.84605	Elevation 51 m. Ice cement 31 cm (hill slope). Visible road dust, similar to R2, road dust 40%, angular fill pebbles 60%, 40% salt cover.	1443	10.34
10 m	166.75734	-77.84601	Elevation 53 m. Ice cement 36 cm (flat). Visible road dust (approximately 20%). Dead algae? Recent snow patch (solifluction). Pebbles (55%) and larger clasts (25% >3 cm) more embedded into fine dust material. Salt cover 30%.	762	10.09
20 m	166.75722	-77.84609	Elevation 56 m. Ice cement 37 cm (bottom of hill slope). Near SM12, MWAC8. Cobble material, less visible road dust (approximately 10%), although cobbles (50%, >10 cm), large clasts (20%, > 3 cm) and pebbles (20%, <2 cm) embedded into dust, salt <2% cover.	385	9.92
50 m	166.75656	-77.84631	Elevation 56 m. Ice cement 22 cm (side of patterned ground crack). Still visible road dust but less (approximately 10%), surface cover 60% 0.5 cm pebbles, slight crust, moving to 40% large cobbles nearer patterned ground crack. No salt.	492	9.76
100 m	166.75546	-77.84668	Elevation 58 m. Ice cement 15 cm (hill slope 1 m below flat with MWAC9). No visible road dust. Surface similar to R50, 85% small 0.5 cm pebbles, slight crust, 15% 5-10 cm cobble, <5% salt cover.	674	9.23

Table 2.2 Descriptions and soil chemical analyses of Transect 2. Soil chemistry analysed on 0-2 cm depth

Distance from Road	Longitude	Latitude	Description	EC* (µS/cm)	pH
0 m	166.75705	-77.84501	Elevation 89 m. Ice cement 3 cm (road compaction). Very fine brown uniform silt.	2353	10.15
2 m	166.75732	-77.84493	Elevation 66 m. Ice cement 33 cm (road side). Visible road dust but not like downwind side. Road dust cover 10%, angular fill pebbles 30% (>2 cm), 60% pebbles (<1 cm).	671	10.19
5 m	166.75748	-77.84491	Elevation 62 m. Ice cement 33 cm. No visible road dust. Angular fill pebbles 75% (2-6 cm), 25% pebbles (<1 cm).	146.6	9.89
10 m	166.75772	-77.84486	Elevation 64 m. Ice cement 18 cm. No visible road dust. 50% angular fill (2-6 cm), 50% pebbles (<1 cm).	132.8	9.97
20 m	166.75801	-77.84482	Elevation 59 m. Ice cement 23 cm. No visible road dust. 75% angular fill (4-10 cm, some cobbles), 10% angular (2-4 cm), 15% pebbles (<1 cm).	163.9	9.87
40 m (pipeline)	166.75879	-77.84475	Elevation 59 m. Ice cement 10 cm. No visible road dust. 20% large cobbles (>10 cm), 75% pebbles (<2 cm), 5% salt cover.	287.0	9.82

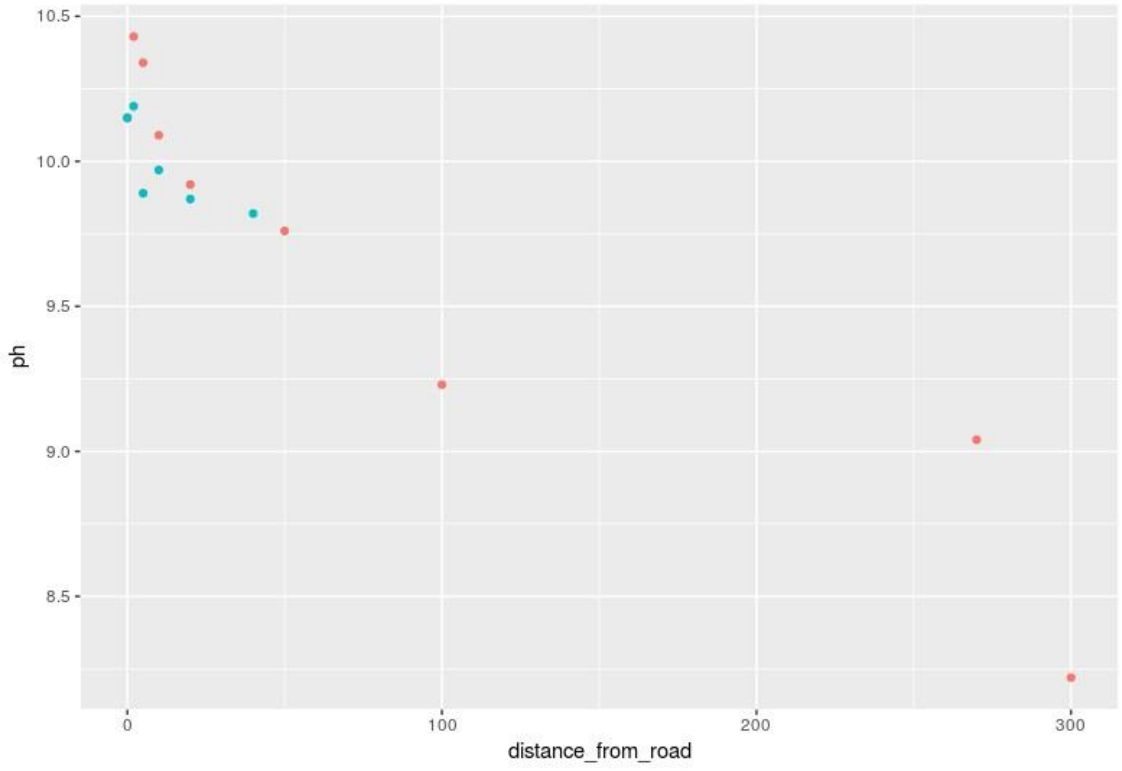

Figure 2.1: Relationship between distance from Scott Base to McMurdo station road and soil pH of two transects, T1 (pink dot) is downwind of the road from 0 m (middle of road) to 100 m (then SM12 (270 m) and SM06 (300 m) from road; and T2 (blue dot) is upwind from 0 m (road) to 40 m from road.

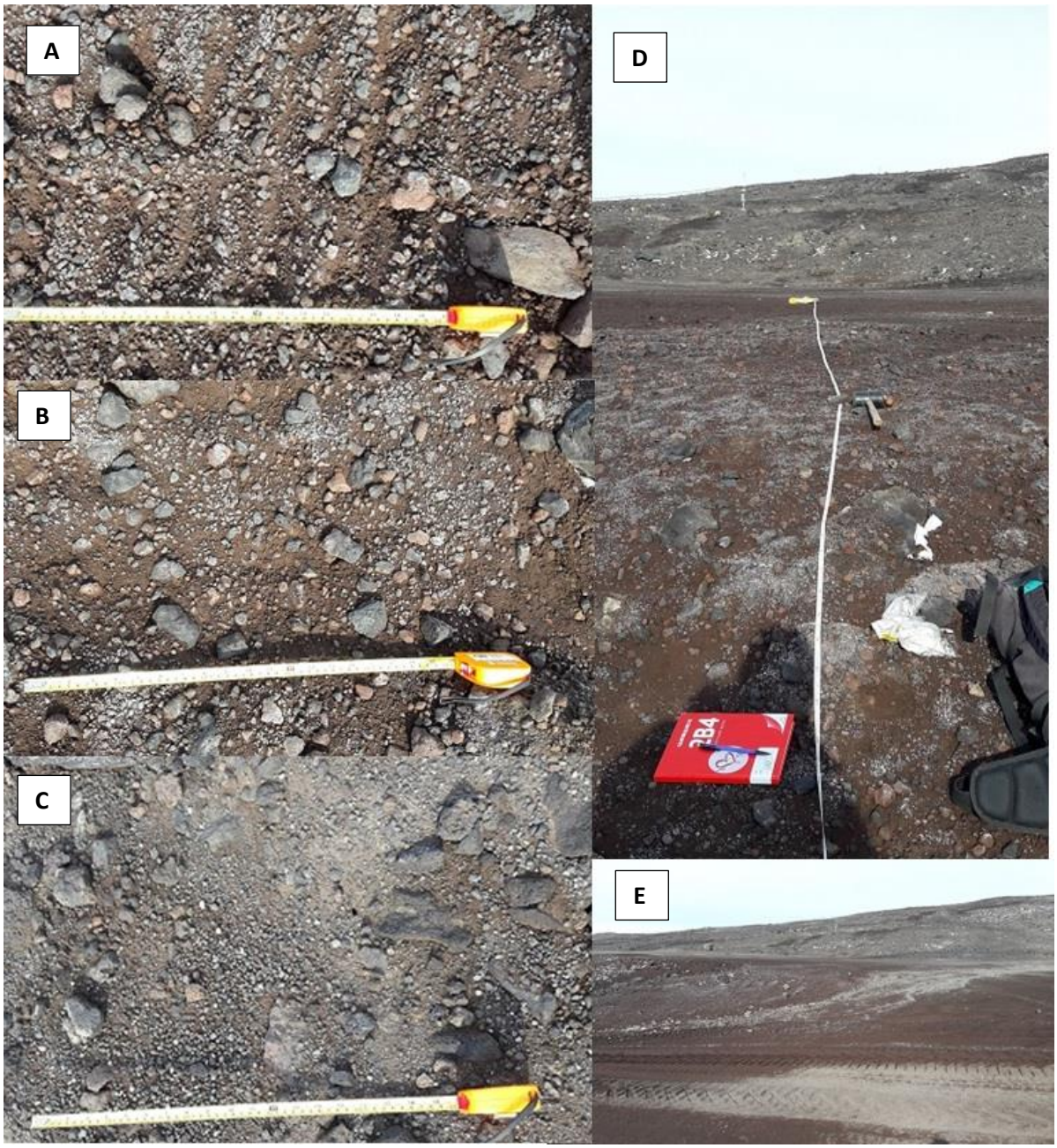

Figure 2.2: Collage of photos from dust transect 1. A = 2 m off road (40% dust cover), B = 5 m off road (40% dust cover), C = 50 m off road (no visible dust), D = view up transect from T1- 2m to T1-10 m, E = view from middle of road along transect.

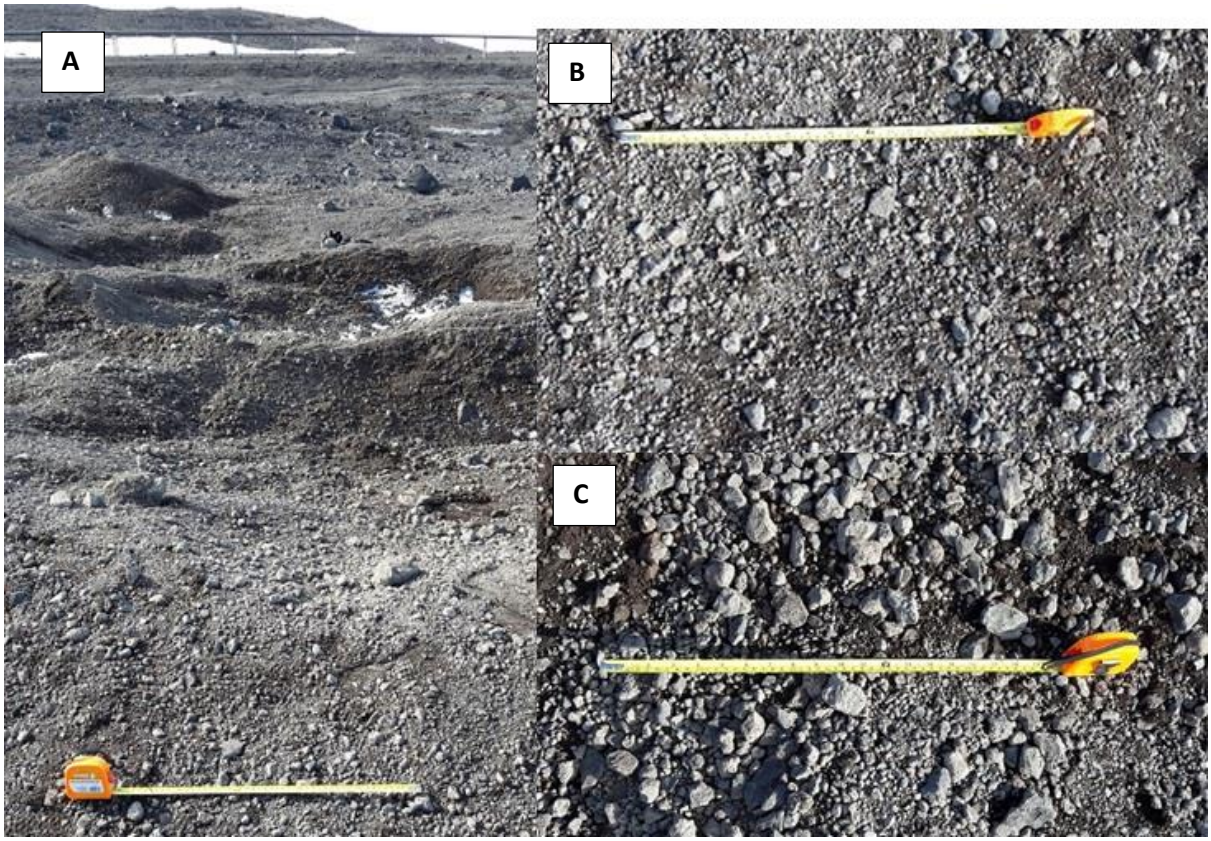

Figure 2.3: Collage of photos from dust transect 2. A = view up transect from 2 m from road to 40 m, B = 2 m off road (<10% dust cover), C = 5 m off road (no visible dust).

APPENDIX 3: Visual Site Assessments

Table II. Impact assessment criteria scoring system used for Visual Site Assessment (modified from Campbell *et al.* (1993), and Kiernan & McConnell (2001)).

Impact assessment criteria		Severity and extent of impacts (class)			
		1	2	3	4
A	Disturbed surface stones	none visible (0)	few (< 10)	many (10–25)	abundant (> 25)
B	Impressions of removed rocks	none visible	just visible	distinct	fresh
C	Boot imprints	none visible	just visible	distinct	fresh
D	Visibly disturbed area	< 5 m^2	5–10 m^2	20–100 m^2	> 100 m^2
E	Surface colour difference (Munsell units difference)	none visible (0)	weak contrast (-1)	moderate contrast (-2)	strong contrast (> 3)
F	Other surface impressions (e.g. hollows from backfilled excavations)	none visible	weakly visible	distinct	very fresh
G	Walking tracks	not visible	weakly defined	moderately defined	strongly defined
H	Foreign objects	none visible (0)	few (< 10)	some (10–25)	many (> 25)
I	Visible fuel spills	none visible	faintly distinguished	visible	very obvious
J	Salt deposition	none visible	faintly distinguished	visible	abundant
K	Visual biological disturbance	none visible	< 1 m^2	1–5 m^2	> 5 m^2
L	Cumulative impact	disturbance not visible	weakly evident	clearly visible	disturbed and very obvious
M	Stratigraphic disturbance	negligible	within one unit	within two units	multiple units
N	Morphological or textural change	negligible	just evident	moderate change	very obvious
O	Rock cairns	none	rare or small	moderately common	very common
P	Other disturbances (e.g. paint marks)	none	rare or small	moderately obvious	very obvious

Site: SM01

Sampled on 19/01/19 at 1330

GPS: 166.7636 -77.84735

Wind: 4kt, Cloud: 65%, Temperature: -5°C

Site description:

Highly disturbed site located approximately 7 m from the SB-MCM road, 10 m from Erebus memorial. Exposed to high levels of dust. Soil is very salty, recently scraped surface appears to have been bulldozed in the past few years. Ground is very hard with no visible vegetation. Elevation = 26 m.

Soil characteristics:

Moisture content = 1.8% g/g

pH (0-2 cm) = 9.06

pH (2-5 cm) – 9.46

EC (0-2 cm) = 3020.5 µS/cm

EC (2-5 cm) = 702.0 µS/cm

Depth to ice-cement = 5 cm

Visual site assessment:

Site	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
SM01	4	2	1	2	3	1	1	1	4	1	3	3	4	1	1	1

Impact Assessment Criteria: A = disturbed surface stones; B = impressions of removed rocks; C = boot imprints; D = visibly disturbed area; E = surface colour difference; F = walking or vehicle tracks; G = litter; H = visible fuel spills; I = salt deposition; J = biological disturbance; K = cumulative impact; L = stratigraphic disturbance; M = textural change; N = rock cairns; O =% change in vegetation cover; P = evidence of exotic species. **Severity and Extent of Impacts**: rating of 1 is least disturbed/impacted, rating of 4 is severely disturbed/impacted.

Visual site assessment summary:

Abundant disturbed surface stones, just visible impressions of removed rocks, 5-10 m^2 visibly disturbed area, moderate surface colour contrast c.f. surrounds (covered in road dust), abundant salt deposition, clearly visible cumulative impact, stratigraphic disturbance within two units, very obvious surface textural change.

Site: SM02

Sampled on 19/01/19 at 1358

GPS: 166.7719 -77.84963

Wind: 4kt, Cloud: 75%, Temperature: -5°C

Site description:

Highly disturbed site located behind I-hut, 20 m from HFC and 15 m from sea-edge. Some evidence of nails and wood scattered around. No visible vegetation although parts of the soil were quite green, possibly evidence of some cyanobacterial influence. Soils could be periodically exposed to liquid water from nearby snowpack melt and runoff from the roof of I-hut. Elevation = -3 m

Soil characteristics:

Moisture content = 7.5% g/g

pH (0-2 cm) = 10.05

pH (2-5 cm) = 9.80

EC (0-2 cm) = 786.5 µS/cm

EC (2-5 cm) = 163.3 µS/cm

Depth to ice-cement = 5 cm

Visual site assessment:

Site	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
SM02	3	3	1	3	1	1	4	1	4	1	3	3	3	1	1	1

Impact Assessment Criteria: A = disturbed surface stones; B = impressions of removed rocks; C = boot imprints; D = visibly disturbed area; E = surface colour difference; F = walking or vehicle tracks; G = litter; H = visible fuel spills; I = salt deposition; J = biological disturbance; K = cumulative impact; L = stratigraphic disturbance; M = textural change; N = rock cairns; O =% change in vegetation cover; P = evidence of exotic species. **Severity and Extent of Impacts**: rating of 1 is least disturbed/impacted, rating of 4 is severely disturbed/impacted.

Visual site assessment summary:

Many disturbed surface stones, distinct impressions of removed rocks, 20-100 m^2 visibly disturbed area, many litter, abundant salt deposition, clearly visible cumulative impact, stratigraphic disturbance within two units, moderate surface textural change.

Site: SM03

Sampled on 19/01/19 at 1303

GPS: 166.7635 -77.84767

Wind: 4kt, Cloud: 30%, Temperature: -5°C

Site description:

Disturbed site located approximately 30 m from the SB-MCM road positioned on a hillslope in old bulldozer tracks. 80 m downhill of storage containers. Soils appeared dry and very salty with no visible vegetation. Subsoil is very pale and salty. Elevation = 34 m.

Soil characteristics:

Moisture content = 2.2% g/g

pH (0-2 cm) = 9.08

pH (2-5 cm) = 8.79

EC (0-2 cm) = 5400.0 µS/cm

EC (2-5 cm) = 5180.3 µS/cm

Depth to ice-cement = 20 cm

Visual site assessment:

Site	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
SM03	2	1	1	2	3	4	1	1	3	1	3	3	3	1	1	1

Impact Assessment Criteria: A = disturbed surface stones; B = impressions of removed rocks; C = boot imprints; D = visibly disturbed area; E = surface colour difference; F = walking or vehicle tracks; G = litter; H = visible fuel spills; I = salt deposition; J = biological disturbance; K = cumulative impact; L = stratigraphic disturbance; M = textural change; N = rock cairns; O =% change in vegetation cover; P = evidence of exotic species. **Severity and Extent of Impacts**: rating of 1 is least disturbed/impacted, rating of 4 is severely disturbed/impacted.

Visual site assessment summary:

Few disturbed surface stones, 5-10 m^2 visibly disturbed area, moderate surface colour contrast c.f. surrounds (pale subsoil when disturbed), strongly defined bulldozer track, visible salt deposition, clearly visible cumulative impact, stratigraphic disturbance within two units, moderate surface textural change.

Site: SM04

Sampled on 17/01/19 at 1519

GPS: 166.7497 -77.84605

Wind: 0kt, Cloud: -%, Temperature: -5℃

Site description:

Located approximately 50 m from the SB-MCM, 50 m from the cable road, in a depression in old bulldozer tracks. Limited inactive moss present with soils appearing pretty dry. Site is likely subject to water runoff from the road. Elevation = 83 m.

Soil characteristics:

Moisture content = 6.6% g/g

pH (0-2 cm) = 9.27

pH (2-5 cm) = 9.15

EC (0-2 cm) = 457.0 µS/cm

EC (2-5 cm) = 120.1 µS/cm

Depth to ice-cement = 30 cm

Visual site assessment:

Site	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
SM04	4	1	1	2	2	4	2	1	3	1	4	3	3	1	1	1

Impact Assessment Criteria: A = disturbed surface stones; B = impressions of removed rocks; C = boot imprints; D = visibly disturbed area; E = surface colour difference; F = walking or vehicle tracks; G = litter; H = visible fuel spills; I = salt deposition; J = biological disturbance; K = cumulative impact; L = stratigraphic disturbance; M = textural change; N = rock cairns; O =% change in vegetation cover; P = evidence of exotic species. **Severity and Extent of Impacts**: rating of 1 is least disturbed/impacted, rating of 4 is severely disturbed/impacted.

Visual site assessment summary:

Abundant disturbed surface stones, 5-10 m^2 visibly disturbed area, weak surface colour contrast c.f surrounds, strongly defined bulldozer track, few litter, visible salt deposition, disturbed and obvious visible cumulative impact, stratigraphic disturbance within two units, moderate surface textural change.

Site: SM05

Sampled on 17/01/19 at 0936

GPS: 166.7521 -77.84767

Wind: 5kt, Cloud: 30%, Temperature: -2℃

Site description:

Disturbed site located on the edge of old bulldozer tracks, 10 m from Hillary Trail. Some dried algae present along with small amounts of moss and lichen. Elevation = 58 m.

Soil characteristics:

Moisture content = 6.6% g/g

pH (0-2 cm) = 10.14

pH (2-5 cm) = 9.22

EC (0-2 cm) = 312.0 µS/cm

EC (2-5 cm) = 122.4 µS/cm

Depth to ice-cement = 28 cm

Visual site assessment:

Site	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
SM05	4	1	1	2	1	4	1	1	2	1	3	3	4	1	1	1

Impact Assessment Criteria: A = disturbed surface stones; B = impressions of removed rocks; C = boot imprints; D = visibly disturbed area; E = surface colour difference; F = walking or vehicle tracks; G = litter; H = visible fuel spills; I = salt deposition; J = biological disturbance; K = cumulative impact; L = stratigraphic disturbance; M = textural change; N = rock cairns; O =% change in vegetation cover; P = evidence of exotic species. **Severity and Extent of Impacts**: rating of 1 is least disturbed/impacted, rating of 4 is severely disturbed/impacted.

Visual site assessment summary:

Abundant disturbed surface stones, 5-10 m^2 visibly disturbed area, strongly defined bulldozer track, faint salt deposition, clearly visible cumulative impact, stratigraphic disturbance within two units, very obvious surface textural change.

Site: SM06

Sampled on 19/01/19 at 1020

GPS: 166.7557 -77.84649

Wind: 4kt, Cloud: 40%, Temperature: -5°C

Site description:

Hillslope site, rather hummocky, incipient gully system, approximately 200 m downhill of SB-MCM road. Site had no visible vegetation but appeared to be recently wetted presumably from a melted snowpack. Elevation = 58 m.

Soil characteristics:

Moisture content = 2.7% g/g

pH (0-2 cm) = 8.22

pH (2-5 cm) = 8.56

EC (0-2 cm) = 3550.0 µS/cm

EC (2-5 cm) = 1209.5 µS/cm

Depth to ice-cement = 30 cm

Visual site assessment:

Site	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
SM06	2	1	1	1	1	1	1	1	3	1	1	1	1	1	1	1

Impact Assessment Criteria: A = disturbed surface stones; B = impressions of removed rocks; C = boot imprints; D = visibly disturbed area; E = surface colour difference; F = walking or vehicle tracks; G = litter; H = visible fuel spills; I = salt deposition; J = biological disturbance; K = cumulative impact; L = stratigraphic disturbance; M = textural change; N = rock cairns; O =% change in vegetation cover; P = evidence of exotic species. **Severity and Extent of Impacts**: rating of 1 is least disturbed/impacted, rating of 4 is severely disturbed/impacted.

Visual site assessment summary:

Few disturbed surface stones, < 5 m^2 visibly disturbed area, visible salt deposition (along PG cracks).

Site: SM07

Sampled on 19/01/19 at 1117

GPS: 166.7561 -77.84768

Wind: 4kt, Cloud: 20%, Temperature: -5°C

Site description:

Rocky hillslope site on a former snow patch, with weakly formed patterned ground. Approximately 200 m downhill from the SB to McM road, 15 m from cable. Good drainage area with a moderate amount of vegetation primarily moss. Some <2% lichen and/or algae growing on the surface of moss.

Soil characteristics:

Moisture content = 9.5% g/g

pH (0-2 cm) = 9.14

pH (2-5 cm) = 9.22

EC (0-2 cm) = 201.9 µS/cm

EC (2-5 cm) = 52.5 µS/cm

Depth to ice-cement = 23 cm

Visual site assessment:

Site	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
SM07	2	1	1	1	1	1	2	1	2	1	1	1	1	1	1	1

Impact Assessment Criteria: A = disturbed surface stones; B = impressions of removed rocks; C = boot imprints; D = visibly disturbed area; E = surface colour difference; F = walking or vehicle tracks; G = litter; H = visible fuel spills; I = salt deposition; J = biological disturbance; K = cumulative impact; L = stratigraphic disturbance; M = textural change; N = rock cairns; O =% change in vegetation cover; P = evidence of exotic species. **Severity and Extent of Impacts**: rating of 1 is least disturbed/impacted, rating of 4 is severely disturbed/impacted.

Visual site assessment summary:

Few disturbed surface stones, < 5 m^2 visibly disturbed area, few litter, faint salt deposition.

Site: SM08

Sampled on 17/01/19 at 1110

GPS: 166.7450 -77.84689

Wind: 5kt, Cloud: 20%, Temperature: -2℃

Site description:

Site located on a rubbly hillslope approximately 10 m from the Hillary Trail, 20 m from the SB to McM road, and close to a bulldozed track, although site relatively undisturbed. Highest soil monitoring plot above Scott Base. Some biological soil crusts observed with lichens and a fair amount of salt present. Elevation = 83 m. Site of MWAC#5.

Soil characteristics:

Moisture content = 2.2% g/g

pH (0-2 cm) = 9.29

pH (2-5 cm) = 9.96

EC (0-2 cm) = 1268.5 µS/cm

EC (2-5 cm) =628.5 µS/cm

Depth to ice-cement = 25 cm

Visual site assessment:

Site	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
SM08	2	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1

Impact Assessment Criteria: A = disturbed surface stones; B = impressions of removed rocks; C = boot imprints; D = visibly disturbed area; E = surface colour difference; F = walking or vehicle tracks; G = litter; H = visible fuel spills; I = salt deposition; J = biological disturbance; K = cumulative impact; L = stratigraphic disturbance; M = textural change; N = rock cairns; O =% change in vegetation cover; P = evidence of exotic species. **Severity and Extent of Impacts**: rating of 1 is least disturbed/impacted, rating of 4 is severely disturbed/impacted.

Visual site assessment summary:

Few disturbed surface stones, < 5 m^2 visibly disturbed area, faint salt deposition.

Site: SM09

Sampled on 16/01/19 at 1445

GPS: 166.7587 -77.84879

Wind: 4kt, Cloud: 30%, Temperature: -2℃

Site description:

Site located on a hillslope on the edge of the antenna farm restricted area approximately 15 m from the Hillary Trail. Very limited vegetation present with about 10% of the 1 m plot covered in salt.

Soil characteristics:

Moisture content = 1.5% g/g

pH (0-2 cm) = 9.67

pH (2-5 cm) = 9.63

EC (0-2 cm) = 210.3 µS/cm

EC (2-5 cm) =117.8 µS/cm

Depth to ice-cement = 23 cm

Visual site assessment:

Site	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
SM09	4	1	1	1	1	1	1	1	3	1	1	1	1	1	1	1

Impact Assessment Criteria: A = disturbed surface stones; B = impressions of removed rocks; C = boot imprints; D = visibly disturbed area; E = surface colour difference; F = walking or vehicle tracks; G = litter; H = visible fuel spills; I = salt deposition; J = biological disturbance; K = cumulative impact; L = stratigraphic disturbance; M = textural change; N = rock cairns; O =% change in vegetation cover; P = evidence of exotic species. **Severity and Extent of Impacts**: rating of 1 is least disturbed/impacted, rating of 4 is severely disturbed/impacted.

Visual site assessment summary:

Abundant disturbed surface stones, < 5m^2 visibly disturbed area, visible salt deposition.

Site: SM10

Sampled on 16/01/19 at 1720

GPS: 166.7614 -77.848855

Wind: 5kt, Cloud: 30%, Temperature: -2℃

Site description:

Toe of hillslope approximately 30 m downhill of the soil climate station. Some patterned ground. Rocky, dry, reasonably flat area with small amounts of lichen in close proximity to the Hillary Trail bridge. Elevation = 32 m. Site of MWAC#2.

Soil characteristics:

Moisture content = 4.3% g/g

pH (0-2 cm) = 9.46

pH (2-5 cm) = 9.83

EC (0-2 cm) = 542.5 µS/cm

EC (2-5 cm) =227.8 µS/cm

Depth to ice-cement = 25 cm

Visual site assessment:

Site	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
SM10	3	1	1	2	1	1	1	1	2	1	1	1	1	1	1	1

Impact Assessment Criteria: A = disturbed surface stones; B = impressions of removed rocks; C = boot imprints; D = visibly disturbed area; E = surface colour difference; F = walking or vehicle tracks; G = litter; H = visible fuel spills; I = salt deposition; J = biological disturbance; K = cumulative impact; L = stratigraphic disturbance; M = textural change; N = rock cairns; O =% change in vegetation cover; P = evidence of exotic species. **Severity and Extent of Impacts**: rating of 1 is least disturbed/impacted, rating of 4 is severely disturbed/impacted.

Visual site assessment summary:

Many disturbed surface stones, 5-10 m^2 visibly disturbed area, faint salt deposition.

Site: SM11

Sampled on 17/01/19 at 1020

GPS: 166.7498 -77.84695

Wind: 5kt, Cloud: 5%, Temperature: -2℃

Site description:

Very rocky site on steep (15 degrees) slope, side of a block flow. Approximately 150 m from the SB to McM road. Limited vegetation present. Elevation = 70 m.

Soil characteristics:

Moisture content = 1.3% g/g

pH (0-2 cm) = 9.24

pH (2-5 cm) = 8.73

EC (0-2 cm) = 204.3 µS/cm

EC (2-5 cm) =36.0 µS/cm

Depth to ice-cement = too rocky to assess

Visual site assessment:

Site	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
SM11	2	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1

Impact Assessment Criteria: A = disturbed surface stones; B = impressions of removed rocks; C = boot imprints; D = visibly disturbed area; E = surface colour difference; F = walking or vehicle tracks; G = litter; H = visible fuel spills; I = salt deposition; J = biological disturbance; K = cumulative impact; L = stratigraphic disturbance; M = textural change; N = rock cairns; O =% change in vegetation cover; P = evidence of exotic species. **Severity and Extent of Impacts**: rating of 1 is least disturbed/impacted, rating of 4 is severely disturbed/impacted.

Visual site assessment summary:

Few disturbed surface stones, < 5 m^2 visibly disturbed area, faint salt deposition.

Site: SM12

Sampled on 19/01/19 at 0951

GPS: 166.7569 -77.84622

Wind: 4kt, Cloud: 50% (scattered), Temperature: -5℃

Site description:

Site located in a deep patterned ground cracks in a relatively undisturbed site near the road. Site appears to be periodically exposed to meltwater with some dried algal mat visible. Elevation = 58 m. Site of MWAC#8.

Soil characteristics:

Moisture content = 4.3% g/g

pH (0-2 cm) = 9.04

pH (2-5 cm) = 9.73

EC (0-2 cm) = 947.5 µS/cm

EC (2-5 cm) =218.6 µS/cm

Depth to ice-cement = 24 cm (bottom of PG crack)

Visual site assessment:

Site	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
SM12	3	1	1	2	1	1	2	1	3	1	1	1	1	1	1	1

Impact Assessment Criteria: A = disturbed surface stones; B = impressions of removed rocks; C = boot imprints; D = visibly disturbed area; E = surface colour difference; F = walking or vehicle tracks; G = litter; H = visible fuel spills; I = salt deposition; J = biological disturbance; K = cumulative impact; L = stratigraphic disturbance; M = textural change; N = rock cairns; O =% change in vegetation cover; P = evidence of exotic species. **Severity and Extent of Impacts**: rating of 1 is least disturbed/impacted, rating of 4 is severely disturbed/impacted.

Visual site assessment summary:

Many disturbed surface stones (natural as patterned ground crack), < 5 m^2 visibly disturbed area, few litter, visible salt deposition.

Site: SM13

Sampled on 17/01/19 at 0900

GPS: 166.7537 -77.84803

Wind: 5kt, Cloud: -%, Temperature: -2℃

Site description:

Disturbed site in slight depression within a gentle (2 degree) slope, 4 m from the Hillary Trail. Small patches of lichen, moss and dried algae present. Elevation = 55 m.

Soil characteristics:

Moisture content = 4.7% g/g

pH (0-2 cm) = 9.76

pH (2-5 cm) = 9.71

EC (0-2 cm) = 285.0 µS/cm

EC (2-5 cm) =93.5 µS/cm

Depth to ice-cement = 18 cm

Visual site assessment:

Site	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
SM13	4	2	2	2	2	4	2	1	2	1	4	1	1	1	1	1

Impact Assessment Criteria: A = disturbed surface stones; B = impressions of removed rocks; C = boot imprints; D = visibly disturbed area; E = surface colour difference; F = walking or vehicle tracks; G = litter; H = visible fuel spills; I = salt deposition; J = biological disturbance; K = cumulative impact; L = stratigraphic disturbance; M = textural change; N = rock cairns; O =% change in vegetation cover; P = evidence of exotic species. **Severity and Extent of Impacts**: rating of 1 is least disturbed/impacted, rating of 4 is severely disturbed/impacted.

Visual site assessment summary:

Abundant disturbed surface stones, just visible impressions of removed rocks, just visible boot imprints, 5-10 m^2 visibly disturbed area, weak surface colour difference c.f. surrounding, faint salt deposition, disturbed and very obvious cumulative impact.

Site: SM14

Sampled on 17/01/19 at 1056

GPS: 166.7472 -77.84635

Wind: 5kt, Cloud: 5%, Temperature: -2℃

Site description:

Site located approximately 20 m from SB to McM road, 10 m from cable, on a 15 degree hillslope, with some evidence of colluvial/alluvial deposits from upslope. Site largely consisted of gravel and rocks with no visible vegetation. Site was also very salty. Elevation = 89 m.

Soil characteristics:

Moisture content = 4.1% g/g

pH (0-2 cm) = 9.16

pH (2-5 cm) = 9.85

EC (0-2 cm) = 1208.5 µS/cm

EC (2-5 cm) =208.3 µS/cm

Depth to ice-cement = 26 cm

Visual site assessment:

Site	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
SM14	2	1	1	2	1	1	1	1	4	1	1	1	1	1	1	1

Impact Assessment Criteria: A = disturbed surface stones; B = impressions of removed rocks; C = boot imprints; D = visibly disturbed area; E = surface colour difference; F = walking or vehicle tracks; G = litter; H = visible fuel spills; I = salt deposition; J = biological disturbance; K = cumulative impact; L = stratigraphic disturbance; M = textural change; N = rock cairns; O =% change in vegetation cover; P = evidence of exotic species. **Severity and Extent of Impacts**: rating of 1 is least disturbed/impacted, rating of 4 is severely disturbed/impacted.

Visual site assessment summary:

Few disturbed surface stones, 5-10 m^2 visibly disturbed area, abundant salt deposition.

Site: SM15

Sampled on 16/01/19 at 1545

GPS: 166.7585 -77.8485

Wind: 5kt, Cloud: 40%, Temperature: -2℃

Site description:

Disturbed site 4 m off the Hillary Trail, 40 m from cable, on a gentle (2 degree) slope. Site is covered with 65% moss and lichenised moss, all of which appeared inactive. No salt apparent. Elevation = 37 m. Site of MWAC#1.

Soil characteristics:

Moisture content = 2.4% g/g

pH (0-2 cm) = 9.64

pH (2-5 cm) = 9.38

EC (0-2 cm) = 152.0 µS/cm

EC (2-5 cm) = 114.3 µS/cm

Depth to ice-cement = 22 cm

Visual site assessment:

Site	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
SM15	4	1	1	2	1	4	1	1	2	1	4	2	1	1	1	1

Impact Assessment Criteria: A = disturbed surface stones; B = impressions of removed rocks; C = boot imprints; D = visibly disturbed area; E = surface colour difference; F = walking or vehicle tracks; G = litter; H = visible fuel spills; I = salt deposition; J = biological disturbance; K = cumulative impact; L = stratigraphic disturbance; M = textural change; N = rock cairns; O =% change in vegetation cover; P = evidence of exotic species. **Severity and Extent of Impacts**: rating of 1 is least disturbed/impacted, rating of 4 is severely disturbed/impacted.

Visual site assessment summary:

Abundant disturbed surface stones, 5-10 m^2 visibly disturbed area, strongly defined walking track, faint salt deposition, obvious cumulative impacts (margin of Hillary Trail), stratigraphic disturbance (within one unit).

Site: SM16

Sampled on 16/01/19 at 1645

GPS: 166.7617 -77.84805

Wind: 5kt, Cloud: wispy 40%, Temperature: -2℃

Site description:

Site located in a depression on a gentle 3 degrees slope, 20 m from the soil climate station, surrounding in patterned ground and some evidence of old bulldozed ground. 10% of the plot covered in salt. A small patch of moss present.

Soil characteristics:

Moisture content = 4.5% g/g

pH (0-2 cm) = 9.72

pH (2-5 cm) = 9.44

EC (0-2 cm) = 234.1 µS/cm

EC (2-5 cm) = 89.7 µS/cm

Depth to ice-cement = 21 cm

Visual site assessment:

Site	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
SM16	3	1	1	2	1	1	1	1	3	1	2	1	3	1	1	1

Impact Assessment Criteria: A = disturbed surface stones; B = impressions of removed rocks; C = boot imprints; D = visibly disturbed area; E = surface colour difference; F = walking or vehicle tracks; G = litter; H = visible fuel spills; I = salt deposition; J = biological disturbance; K = cumulative impact; L = stratigraphic disturbance; M = textural change; N = rock cairns; O =% change in vegetation cover; P = evidence of exotic species. **Severity and Extent of Impacts**: rating of 1 is least disturbed/impacted, rating of 4 is severely disturbed/impacted.

Visual site assessment summary:

Many disturbed surface stones, 5-10 m^2 visibly disturbed area, visible salt deposition, weakly evident cumulative impact, moderate surface texture change (fine material absent/bulldozed).

Site: SM17

Sampled on 17/01/19 at 1000

GPS: 166.7472 -77.84635

Wind: 5kt, Cloud: 10%, Temperature: -2°C

Site description:

Site located in a slight depression 20 m from the Hillary Trail and 100 m from the cable. A patterned ground crack runs through site. Overall vegetation covered approximately 16% of the plot with lichens found on soil crusts. Parts of moss patches also appeared to be partially active. Elevation = 69 m. Site of MWAC#4.

Soil characteristics:

Moisture content = 5.4% g/g

pH (0-2 cm) = 9.24

pH (2-5 cm) = 9.01

EC (0-2 cm) = 135.5 µS/cm

EC (2-5 cm) = 60.7 µS/cm

Depth to ice-cement = 23 cm

Visual site assessment:

Site	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
SM17	2	1	1	2	1	1	2	1	1	1	1	1	1	1	1	1

Impact Assessment Criteria: A = disturbed surface stones; B = impressions of removed rocks; C = boot imprints; D = visibly disturbed area; E = surface colour difference; F = walking or vehicle tracks; G = litter; H = visible fuel spills; I = salt deposition; J = biological disturbance; K = cumulative impact; L = stratigraphic disturbance; M = textural change; N = rock cairns; O =% change in vegetation cover; P = evidence of exotic species. **Severity and Extent of Impacts**: rating of 1 is least disturbed/impacted, rating of 4 is severely disturbed/impacted.

Visual site assessment summary:

Few disturbed surface stones, 5-10 m^2 visibly disturbed area, few litter (wire).

Site: SM18

Sampled on 16/01/19 at 1545

GPS: 166.7587 -77.84795

Wind: 5kt, Cloud: 40%, Temperature: -2℃

Site description:

Site is 5 m from cable on a slight depression on a 5 degree slope. Patterned ground. Highly vegetated site with a lot of moss (some of which appeared active) and biological (algal) soil crusts. Site positioned in a slightly lower drainage area (depression), although at time of sampling site was still quite dry and salty. Elevation = 40 m. Site of MWAC#3.

Soil characteristics:

Moisture content = 7.4% g/g

pH (0-2 cm) = 8.51

pH (2-5 cm) = 9.15

EC (0-2 cm) = 2489.5 µS/cm

EC (2-5 cm) = 215.4 µS/cm

Depth to ice-cement = 24 cm

Visual site assessment:

Site	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
SM18	2	1	1	2	1	2	2	1	3	1	2	1	1	1	1	1

Impact Assessment Criteria: A = disturbed surface stones; B = impressions of removed rocks; C = boot imprints; D = visibly disturbed area; E = surface colour difference; F = walking or vehicle tracks; G = litter; H = visible fuel spills; I = salt deposition; J = biological disturbance; K = cumulative impact; L = stratigraphic disturbance; M = textural change; N = rock cairns; O =% change in vegetation cover; P = evidence of exotic species. **Severity and Extent of Impacts**: rating of 1 is least disturbed/impacted, rating of 4 is severely disturbed/impacted.

Visual site assessment summary:

Few disturbed surface stones, 5-10 m2 visibly disturbed area, weakly defined walking track (along cable), few litter, visible salt deposition, weakly evident cumulative impact (along cable).

Site: SM19

Sampled on 17/01/19 at 1138

GPS: 166.7464 -77.84672

Wind: 5kt, Cloud: 15%, Temperature: -2℃

Site description:

Site located on a very gentle slope (<2 degrees) 3 m from Hillary Trail, and 3 m from bulldozer track. Vegetation along patterned ground crack, very dry/dead moss patches covered in lichen. Overall, vegetation covered an estimated 5% of the plot. Elevation = 76 m.

Soil characteristics:

Moisture content (%g/g) = 2.1

pH (0-2 cm) = 9.73

pH (2-5 cm) = 9.54

EC (0-2 cm) = 255.2 µS/cm

EC (2-5 cm) = 222.7 µS/cm

Depth to ice-cement = 20 cm

Visual site assessment:

Site	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
SM19	4	2	2	2	3	4	1	1	2	1	4	3	3	1	1	1

Impact Assessment Criteria: A = disturbed surface stones; B = impressions of removed rocks; C = boot imprints; D = visibly disturbed area; E = surface colour difference; F = walking or vehicle tracks; G = litter; H = visible fuel spills; I = salt deposition; J = biological disturbance; K = cumulative impact; L = stratigraphic disturbance; M = textural change; N = rock cairns; O =% change in vegetation cover; P = evidence of exotic species. **Severity and Extent of Impacts**: rating of 1 is least disturbed/impacted, rating of 4 is severely disturbed/impacted.

Visual site assessment summary:

Abundant disturbed surface stones (track and patterned ground crack/natural), just visible impressions of removed rocks, just visible boot imprints, 5-10 m^2 visibly disturbed area, moderate contrast in surface colour c.f. surrounds, strongly defined walking and bulldozer tracks, faint salt deposition, disturbed and very obvious cumulative impact, stratigraphic disturbance within two units, moderate change in surface texture.

Site: SM20

Sampled on 17/01/19 at 1542

GPS: 166.7513 -77.8458

Wind: 10kt, Cloud: 40%, Temperature: -13℃

Site description:

Site located 20 m from SB to McM road and 100 m from cable, on a gentle 3 degree hillslope. Site below snow patch in a wider drainage area with running water flowing approximately 1 m from plot. An estimated 8% of the plot was covered in moss. Elevation = 76 m. Site of MWAC#6.

Soil characteristics:

Moisture content = 10.3% g/g

pH (0-2 cm) = 8.67

pH (2-5 cm) = 9.03

EC (0-2 cm) = 678.0 µS/cm

EC (2-5 cm) = 137.5 µS/cm

Depth to ice-cement = 31 cm

Visual site assessment:

Site	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
SM20	2	1	1	1	1	1	1	1	3	1	1	1	1	1	1	1

Impact Assessment Criteria: A = disturbed surface stones; B = impressions of removed rocks; C = boot imprints; D = visibly disturbed area; E = surface colour difference; F = walking or vehicle tracks; G = litter; H = visible fuel spills; I = salt deposition; J = biological disturbance; K = cumulative impact; L = stratigraphic disturbance; M = textural change; N = rock cairns; O =% change in vegetation cover; P = evidence of exotic species. **Severity and Extent of Impacts**: rating of 1 is least disturbed/impacted, rating of 4 is severely disturbed/impacted.

Visual site assessment summary:

Few disturbed surface stones, < 5 m^2 visibly disturbed area, visible salt deposition.

Site: SM21

Sampled on 19/01/19 at 1044

GPS: 166.7558 -77.84701

Wind: 4kt, Cloud: wispy 20%, Temperature: -5℃

Site description:

Disturbed site located on a gently sloping hillslope (3 degrees) in a patterned ground crack within an old bulldozer track, approximately 150 m downhill of the SB to McM road and 50 m from the storage containers. Highly vegetated site (overall 65%) comprised mostly of moss and dried algal mats. Elevation = 65 m.

Soil characteristics:

Moisture content = 5.0% g/g

pH (0-2 cm) = 9.66

pH (2-5 cm) = 9.81

EC (0-2 cm) = 675.5 µS/cm

EC (2-5 cm) = 158.4 µS/cm

Depth to ice-cement = 20 cm

Visual site assessment:

Site	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
SM21	3	1	1	2	2	3	2	1	3	1	3	3	3	1	1	1

Impact Assessment Criteria: A = disturbed surface stones; B = impressions of removed rocks; C = boot imprints; D = visibly disturbed area; E = surface colour difference; F = walking or vehicle tracks; G = litter; H = visible fuel spills; I = salt deposition; J = biological disturbance; K = cumulative impact; L = stratigraphic disturbance; M = textural change; N = rock cairns; O =% change in vegetation cover; P = evidence of exotic species. **Severity and Extent of Impacts**: rating of 1 is least disturbed/impacted, rating of 4 is severely disturbed/impacted.

Visual site assessment summary:

Abundant disturbed surface stones, 5-10 m^2 visibly disturbed area, weak surface colour contrast c.f. surrounds, moderately defined bulldozer track, few litter, visible salt deposition, clearly visible cumulative impact, stratigraphic disturbance within two units, moderate surface textural change.

Site: SM22

Sampled on 16/01/19 at 1615

GPS: 166.7595 -77.84784

Wind: 5kt, Cloud: wispy 25%, Temperature: -2℃

Site description:

Site is on a flat plateau 100 m uphill of the Scott Base soil climate station and 20 m from cable. 50% of the surface of plot is covered in salt, with a small patch of moss and sparse lichen. Elevation = 40 m.

Soil characteristics:

Moisture content = 3.1% g/g

pH (0-2 cm) = 9.53

pH (2-5 cm) = 9.48

EC (0-2 cm) = 1657.5 µS/cm

EC (2-5 cm) = 200.3 µS/cm

Depth to ice-cement = 26 cm

Visual site assessment:

Site	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
SM22	3	1	1	2	1	1	1	1	4	1	1	1	1	1	1	1

Impact Assessment Criteria: A = disturbed surface stones; B = impressions of removed rocks; C = boot imprints; D = visibly disturbed area; E = surface colour difference; F = walking or vehicle tracks; G = litter; H = visible fuel spills; I = salt deposition; J = biological disturbance; K = cumulative impact; L = stratigraphic disturbance; M = textural change; N = rock cairns; O =% change in vegetation cover; P = evidence of exotic species. **Severity and Extent of Impacts**: rating of 1 is least disturbed/impacted, rating of 4 is severely disturbed/impacted.

Visual site assessment summary:

Many disturbed surface stones, 5-10 m^2 visibly disturbed area, abundant salt deposition.

Site: SM23

Sampled on 19/01/19 at 0930

GPS: 166.7533 -77.84548

Wind: 4kt, Cloud: wispy 40%, Temperature: -5℃

Site description:

Disturbed site located 20 m downhill of the SB to McM road on a 15 degree slope. Monitoring plot is in the middle of a bulldozer track with no visible vegetation. Elevation = 72 m. Site of MWAC#7.

Soil characteristics:

Moisture content = 1.4% g/g

pH (0-2 cm) = 9.78

pH (2-5 cm) = 9.49

EC (0-2 cm) = 206.4 µS/cm

EC (2-5 cm) = 230.5 µS/cm

Depth to ice-cement = 32 cm

Visual site assessment:

Site	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
SM23	4	1	1	2	1	3	2	1	2	1	3	3	4	1	1	1

Impact Assessment Criteria: A = disturbed surface stones; B = impressions of removed rocks; C = boot imprints; D = visibly disturbed area; E = surface colour difference; F = walking or vehicle tracks; G = litter; H = visible fuel spills; I = salt deposition; J = biological disturbance; K = cumulative impact; L = stratigraphic disturbance; M = textural change; N = rock cairns; O =% change in vegetation cover; P = evidence of exotic species. **Severity and Extent of Impacts**: rating of 1 is least disturbed/impacted, rating of 4 is severely disturbed/impacted.

Visual site assessment summary:

Abundant disturbed surface stones, 5-10 m^2 visibly disturbed area, moderately defined bulldozer track, few litter, faint salt deposition, clearly visible cumulative impact, stratigraphic disturbance within two units, very obvious surface textural change.

Site: SM24

Sampled on 17/01/19 at 1409

GPS: 166.7586 -77.84805

Wind: 10kt, Cloud: wispy 20%, Temperature: -8°C

Site description:

Site is located within the antenna farm restricted area at the edge of a running stream fed by a melting snowpack. Site was the wettest and most highly vegetated with active algal mats. Scott Base science tech would likely visit this site infrequently when maintaining science equipment. Elevation = 20 m.

Soil characteristics:

Moisture content = 17.6% g/g

pH (0-2 cm) = 9.38

pH (2-5 cm) = 9.19

EC (0-2 cm) = 255.3 µS/cm

EC (2-5 cm) = 185.5 µS/cm

Depth to ice-cement = unable to get measurement in streambed but likely >40 cm

Visual site assessment:

Site	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
SM24	2	1	1	1	1	1	1	1	4	1	1	1	1	1	1	1

Impact Assessment Criteria: A = disturbed surface stones; B = impressions of removed rocks; C = boot imprints; D = visibly disturbed area; E = surface colour difference; F = walking or vehicle tracks; G = litter; H = visible fuel spills; I = salt deposition; J = biological disturbance; K = cumulative impact; L = stratigraphic disturbance; M = textural change; N = rock cairns; O =% change in vegetation cover; P = evidence of exotic species. **Severity and Extent of Impacts**: rating of 1 is least disturbed/impacted, rating of 4 is severely disturbed/impacted.

Visual site assessment summary:

Few disturbed surface stones (likely science tech visits infrequently to maintain science equipment), abundant salt deposition.

Site: SM25

Sampled on 17/01/19 at 1409

GPS: 166.7589 -77.84913

Wind: 10kt, Cloud: 30%, Temperature: -8℃

Site description:

Site is located in the antenna farm restricted area up on the 5 degree slope of a depression which appears to periodically fill with snow before melting and running into site SM24. Located approximately 100 m from Scott Base, the site borders the edge of a patterned ground crack and is highly vegetated site (moss). Elevation = 28 m. Site of MWAC#11.

Soil characteristics:

Moisture content = 7.6% g/g

pH (0-2 cm) = 9.42

pH (2-5 cm) = 9.11

EC (0-2 cm) = 238.6 µS/cm

EC (2-5 cm) = 43.0 µS/cm

Depth to ice-cement = 36 cm

Visual site assessment:

Site	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
SM25	3	1	2	2	1	2	2	1	2	1	2	1	1	1	1	1

Impact Assessment Criteria: A = disturbed surface stones; B = impressions of removed rocks; C = boot imprints; D = visibly disturbed area; E = surface colour difference; F = walking or vehicle tracks; G = litter; H = visible fuel spills; I = salt deposition; J = biological disturbance; K = cumulative impact; L = stratigraphic disturbance; M = textural change; N = rock cairns; O =% change in vegetation cover; P = evidence of exotic species. **Severity and Extent of Impacts**: rating of 1 is least disturbed/impacted, rating of 4 is severely disturbed/impacted.

Visual site assessment summary:

Many disturbed surface stones, just visible boot imprints (likely science tech infrequently walks past), 5-10 m^2 visibly disturbed area, weakly defined walking track, few litter, faint salt deposition, weakly evident cumulative impact.

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