# MATAKANUI

GOLD LIMITED

# Landscape and Ecological Rehabilitation Management Plan:

# Part B (Appendices)

**June 2026**

**Citation:** Habitat NZ Ltd. (2025). Bendigo-Ophir Gold Project: Landscape and Rehabilitation Management Plan: Part B (Appendices). Manaaki Whenua & Boffa Miskell., Auckland.

## DOCUMENT CONTROL

| Revision | Authors | Organisation | Date | Approved |
|---|---|---|---|---|
| 1 | Robyn Simcock, Keith Barber, Rhys Girvan | Manaaki Whenua, Habitat NZ, Boffa Miskell | 5 August 2025 | C Low |
| 2 | Robyn Simcock | New Zealand Institute for Bioeconomy Science | 21 June 2026 | |
| | | | | |

### Disclaimer

This report has been prepared by NZ Institute for Bioeconomy Science, Boffa Miskell and Habitat NZ Ltd. for Matakanui Gold Limited. If used by other parties, no warranty or representation is given as to its accuracy and no liability is accepted for loss or damage arising directly or indirectly from reliance on the information in it.

## APPENDIX A. LANDSCAPE MANAGEMENT UNIT ACTIONS

*Table A-1: Mine Site Management Units and Rehabilitation Approach*

| Management Units | | Description (landscape and ecology focus) and key risks | Rehabilitation and Closure Strategy |
|---|---|---|---|
| **Label** | **Name** | | |
| **Modified Areas** | | | |
| **TSF** | **TSF** | **Tailings Storage Facility (TSF)**<br>• **Facility specifications:** 75-hectare permanent in-valley landform storing 18 million cubic meters of tailings behind 108-meter-tall embankment. Tailings form relatively flat surface draining mostly northward.<br>• **Clean water diversion:** Channels constructed on valley walls above final TSF elevation in first year by excavating into rock/competent ground. Excavated material forms downslope bund.<br>• **Bund stabilisation:** Both sides vegetated using salvaged tussock sods placed during construction and seeding o erosion-control grasses. Enhanced with salvaged boulders, rocks, and biodegradable erosion control fabrics for maximum resilience and to enhance conditions for tussocks.<br>• **Access infrastructure:** Level gravelled driving surface on bund top forms permanent light vehicle track on northern side for long-term monitoring and maintenance access. Pre-closure enhancement includes replacing culverts with near-level, boulder-lined fords for improved resilience.<br>Key risks associated with the rehabilitation of this management area include the following:<br>• **Vegetation salvage failures:** Kowhai (for propagation), taramea, native broom etc. within TSF footprint not salvaged. Contingency | • **Rehabilitation timeline:** Occurs over 1-2 years at the end of mine life, beginning on southern and eastern beaches as tailings consolidate.<br>• **Embankment naturalisation:** Linear embankment form modified by adding brown rock (from ELF) to increase width in specific areas. Covered with soil, enhanced with lizard rock habitats and rubble pits. Dimpled surface profile creates plant establishment microsites and allows curved permanent access track.<br>• **Surface capping system:** Minimum 1m protective weathered rock capping acts as subsoil root zone layer, topped with minimum 0.2m soils from nearby stockpiles. Variable depths of brown rock and soil create topographic diversity.<br>• **Water management infrastructure:** Swales constructed to receive intermittent catchment run-on and transport water across TSF to large wetlands (including 0.5ha open water) near embankment and engineered outlet (Reference EGL Figures 1-9 BOGP Stage Plan).<br>• **Ecosystem mosaic design:** Swale/bund pattern with variable root zone depths, moisture supply and shelter creates heterogeneous vegetation covers. Swales provide enhanced moisture; adjacent low |

| Management Units | | Description (landscape and ecology focus) and key risks | Rehabilitation and Closure Strategy |
|---|---|---|---|
| Label | Name | | |
| | | zone kowhai and taramea not protected from accidental destruction during operations.<br>• **Material supply shortfalls:** Inadequate volume or quality of capping, root zone materials, and/or rock available to complete rehabilitation as designed.<br>• **Wetland sustainability:** Water depth or inundation duration insufficient to sustain planned 2ha and 4ha wetlands, requiring permeability reduction or increased water supply to reduce swale losses.<br>• **Access track erosion:** Erosion along permanent access track where stream flow crosses permanent/temporary diversions or enters TSF, including ephemeral watercourses requiring remedial work.<br>• **Surface flooding impacts:** Unplanned duration/depth of ponded water causing vegetation death in drier TSF surface areas, potentially due to outlet blockages.<br>• **Temporary cover failure:** Poor grass establishment leading to soil erosion and unstable surfaces unfavourable for native plant establishment.<br>• **Invasive tree establishment:** Large tree establishment (willows, poplars) on TSF surface compromising rehabilitation objectives.<br>• **Browsing animal access:** Pigs, cattle and deer accessing wetland areas causing vegetation damage and habitat degradation. | mounds/bunds (minimum 1.5m total rooting depth) with added rock support native shrubs (*Olearia lineata*, *O. bullata*).<br>• **Vegetation establishment:** Planting of nursery-raised seedlings concentrated on swales and bunds. Small patches of translocated short tussocks sourced from soil stockpiles or tussock propagation area. Majority sown with a low-density of sweet vernal or browntop grass to provide erosion suppression. Thin gravel layer and/or scattered rock (<50% cover) applied in areas where grass is ineffective at suppressing erosion.<br>• **Lizard habitat placement:** At least 50 rock stacks installed on bunds and areas with minimum 1.5m total root zone, positioned above 1-in-10-year inundation zone. No rubble pits.<br>• **Wetland design specifications:** TSF engineered outlet and permeability designed to support minimum 2ha swamp (year-round high water table above soil surface) and 4ha marsh (seasonal water table fluctuation supporting wetland species).<br>• **Open water features:** at least 500m² of open water in late spring (seasonal depth maxima) to enhance habitat diversity.<br>• **Wetland discharge management:** Wetland discharge joins diverted northern opening of ELF clean water diversion channel (naturalized permanent creek line), draining surface runoff from natural surfaces to south and rehabilitated surfaces to north and east. |

| Management Units | | Description (landscape and ecology focus) and key risks | Rehabilitation and Closure Strategy |
|---|---|---|---|
| Label | Name | | |
| | | • **Environmental hazards:** Fire risk and climate change resilience concerns threaten long-term rehabilitation success. | • **Long-term structural integrity:** Weathered rock and soil cap over tailings maintained in perpetuity. Tall tree species (willows, poplars) prevented from establishing to avoid blow-over exposure of underlying tailings. Removal required on 2-5 yearly basis depending on invasion rate from external sources.<br>• **Water supply enhancement:** At closure, gaps created in diversion channels allowing clean surface water flow onto TSF to supply wetlands. TSF and adjacent Mine Regeneration Zones permanently destocked with no stock access to TSF or disestablished northern diversion drain.<br>• **Headwater protection:** Northern headwater streams and seepages permanently protected from stock access, to maximize runoff volumes and enhance aquatic invertebrate sources which flow to TSF swales and wetlands.<br>• **Wetland establishment:** Planted with nursery-grown species and divisions from salvaged wetland sods. Marsh inoculated with *Carex kaloides* sourced from translocated plants salvaged at mine opening. Other threatened wetland species established using nursery-grown plants (Appendix 5). Species placement matched to designed inundation depths and duration.<br>• **Planting density:** Majority nursery-grown stock planted in unevenly spaced clusters at average 7,500 plants/ha. This high density helps compensate |

| Management Units | | Description (landscape and ecology focus) and key risks | Rehabilitation and Closure Strategy |
|---|---|---|---|
| Label | Name | | |
| | | | for limited natural establishment time at end of mine life. |
| ELF | Shepherd's ELF | • **Landform specifications:** Permanent landform built mainly from overburden and waste rock from Rise and Shine pit, partially filling Shepherds Creek and Jean Creek. At closure, comprises lower rolling slopes (15–22 degrees) and upper ridgeline (5–12 degrees) with specific slopes designed to support cushionfield and spring annual herbs.<br>• **Habitat enhancement:** Vegetation mosaic enhanced by placing boulders to form lizard rock stacks, rubble pits and additional loose rock. Broad fire buffer zone near ELF top established using thinner soils and higher rock cover to maintain strip of low plant biomass.<br>• **Water management infrastructure:** Permanent TSF northern clean water diversion channel extends along ELF, collecting surface runoff and directing through meandering low-flow channel with pool and riffle sequences designed to support aquatic invertebrates. Created at construction using salvaged weathered rock with flood zones established using riparian plants (mainly tussocks) salvaged from immediate area.<br>• **Operational water management:** During operations, water runoff from ELF collected in drainage channels draining to Shepherds Silt Pond before release into Shepherds Creek Services Corridor channel.<br>• **Closure transformation:** During mining, terraces on the ELF western face hosts mine infrastructure and ore stockpiles on terraces. At closure, this infrastructure is removed and terraces covered with overburden rock to create landform resembling broader landscape without obvious terracing or benching. Final slopes are filled and shaped to remove terracing, then scalloped to create heterogeneous aspects, slopes and micro-catchments supporting diverse vegetation mosaic. | • **Rehabilitation Timing and Water Management**<br>• **Rehabilitation schedule:** Occurs toward end of mining as surfaces become available. Slopes below the workshop terrace are finalised early in the schedule to enable early revegetation.<br>• **TSF diversion channel route:** Permanent sections wind around north side of ELF, collecting runoff from Shepherds Creek valley wall, continuing past ELF and ELF Silt Pond before dropping steeply to Shepherds Creek Services Corridor channel.<br>• **Channel design features:** Wider floodplain in permanent reaches accommodates overhanging riparian plants (tussocks and sedges placed during construction). Meandering low-flow channel includes defined pool and riffle sequences created with strategically-placed salvaged rocks.<br>• **Aquatic habitat enhancement:** Features designed to support aquatic invertebrates naturally seeding from intact upstream headwaters. Values enhanced through permanent stock exclusion.<br>• **Slope formation:** Overburden placed in 4-6m lifts with high-sulphur material kept >20m from edges. Slopes shaped to remove linear terracing and create naturalistic contours.<br>• **Surface preparation:** Intensive scalloping to minimum 50cm depth, followed by 100-200cm weathered brown rock fines. Surface variation |

| Management Units | | Description (landscape and ecology focus) and key risks | Rehabilitation and Closure Strategy |
|---|---|---|---|
| Label | Name | | |
| | | • **Long-term maintenance:** Integrity maintained by removing tall tree species (trees with potential to reach >10m height such as wilding conifers), repairing drainage channels if they erode, developing native shrubland density through pest plant management, and permanently excluding stock from headwaters and wetlands.<br>• Key risks associated with the rehabilitation of this management area include the following:<br>• **Vegetation salvage failures:** Kowhai within footprint not salvaged and contingency zone kowhai not protected. Inadequate amounts of short tussocks salvaged during ELF stripping despite large area of accessible and salvageable tussocks.<br>• **Landform contouring inadequacy:** Final landform contouring does not adequately cover large terraces installed in lower third of ELF to support infrastructure, failing to create sufficiently naturalistic landforms.<br>• **Erosion control failure:** Temporary rock and plant covers (non-native grasses) established on temporary landform before final slope contouring insufficient to prevent rill, gully and wind erosion, generating unexpectedly high sediment volumes.<br>• **Root zone inadequacy:** Root zones and micro-contouring of extensive west-facing slopes (highest drought stress) inadequate to provide sufficiently favourable conditions for native vegetation establishment and spread. Insufficient deep root zones created.<br>• **Environmental hazards:** Fire risk and climate change resilience concerns threaten rehabilitation success.<br>• **Water quality impacts:** Sediment discharge from drainage channels generates adverse downstream effects. | created using 10-50cm stripped soils containing incorporated rock and organic matter.<br>• **Root zone placement:** Deep zones (200cm depth) prioritized on south-to-east slopes covering >50% of landform, with minimum 25% coverage on exposed northeast-to-northwest slopes.<br>• **Habitat diversity:** Heterogeneous micro-environments enhanced by strategic boulder placement for lizard rock stacks, rubble pits and additional loose rock features.<br>• **Vegetation establishment:** Seeding with non-native grasses (primarily sweet vernal and/or browntop, avoiding bunch grasses) and c.1500 stems/ha clustered low-density planting of native nursery seedlings and translocated tussocks. Plantings concentrated around rock features and sheltered microsites with soil amendments and maintenance support. |
| **ELF-W** | **Western ELF** | • **Location and specifications:** Located within small unnamed catchment west of RAS pit. Permanent 18ha landform with maximum | • **Rehabilitation approach:** Overburden placement, root zones, surfaces and revegetation techniques follow Shepherds ELF methods. |

| Management Units | | Description (landscape and ecology focus) and key risks | Rehabilitation and Closure Strategy |
|---|---|---|---|
| Label | Name | | |
| | | elevation of 725m constructed within first 2 years of mine life using initial overburden/waste rock from RAS pit.<br>• **Final landform design:** Angular slopes replaced with contours mimicking adjacent landscape. Specific focus on creating landforms and root zones on aspects favouring cushionfield and spring annual herb establishment as developed in the ARP cushionfields. | • **Trial site function:** Location, aspect range and early rehabilitation timing (years 2-3) enables refinement of erosion control, cushionfield and spring annual herb, nursery-plant establishment, tussock transfer and nursery-raised tussock planting practices.<br>• **Habitat structure trials:** Rock stacks and rubble pits construction practices refined through trials of clustering at higher-than-average densities installed in year 2 to 3. Located on south to east facing slopes not in areas of potential cushionfield. |
| ELF-X | SRX-ELF | • **Landform specifications:** Permanent relatively small (up to 15.8 ha) and low landform with maximum 890m RL and 40m thickness. Constructed from overburden/waste rock from SRX Pit and SRX East pit.<br>• **Rehabilitation design:** Terraced landform bulldozed to variety of naturalised slopes up to maximum 1V:3H, contoured and scalloped to assist revegetation and visual blending with adjacent landscape.<br>• **Pit integration:** SRE Open Pit backfilled and covered with overburden to become part of SRX-ELF landform.<br>• Key risks associated with the rehabilitation of this management area include the following:<br>• **Vegetation salvage failures:** Taramea and kowhai in contingency zones immediately adjacent to pit and access haul road not protected or salvaged.<br>• **Landform contouring inadequacy:** Final landform contouring does not adequately soften batters and terraces, failing to create sufficiently naturalistic landforms. Haul road and benching remain as linear features. | • **Rehabilitation approach:** Overburden placement, root zones, surfaces and revegetation techniques follow Shepherds ELF methods, refined with performance data from Western ELF.<br>• **Root zone materials:** Created using soils from SRX soil stockpile containing elevated arsenic levels (Palich 2025), restricted to use in the valley only. Supplemented with weathered overburden from other stockpiles as needed to achieve required depths for root zones (Appendix Three).<br>• **Vegetation objectives:** Root zone addition designed to support mosaic of grey scrub with some tussock establishment.<br>• **Public access considerations:** Pit and ELF may include public cycle/walking trail (former Thompson's Gorge Road). Specific planting, bunds or safety structures required if trail constructed.<br>• **Pit transformation:** SRE Open Pit backfilled and covered with overburden to become SRX-ELF landform. |

| Management Units | | Description (landscape and ecology focus) and key risks | Rehabilitation and Closure Strategy |
|---|---|---|---|
| Label | Name | | |
| | | • **Erosion control failure:** Temporary rock and plant covers (non-native grasses, cereals) established on temporary landform before final slope contouring insufficient to prevent rilling, gully and wind erosion, generating unexpectedly high sediment volumes.<br>• **Water quality impacts:** Sediment discharge from drainage channels generates adverse downstream effects in Rise and Shine Creek. ELF lower slopes positioned close to creek with haul road culvert as particularly vulnerable point.<br>• **Root zone inadequacy:** Root zones and micro-contouring inadequate to mitigate severe drought stress preventing native vegetation establishment and spread. Insufficient deep root zones created.<br>• **Environmental hazards:** Fire risk and climate change resilience concerns threaten rehabilitation success.<br>• **Non-native tree establishment:** Establishment of non-native trees, particularly wilding conifers, compromising rehabilitation objectives.<br>• **Fire buffer vegetation issues:** Establishment of kanuka within fire buffer zone creating fire risk management concerns. | • **Permanent Diversion drains:** treated per those around Shepherd's ELF with rock and root zone materials placed at time of diversion drain construction and initial planting also completed as access may be difficult once pit is completed |
| PB | Pit Benching, Batters and Edges | • **Pit specifications:** RAS and SRX Pits largely retain unmodified pit benches and batters. Estimated 77.4ha and 14.6ha of highwall surface area in RAS and SRX pits respectively above lake level.<br>• **Natural revegetation expectations:** Surfaces generally unfavourable for plant establishment and growth until weathering creates frittered rock. Plant establishment very slow and sparse on north to west aspects. Southerly aspects with intermittent water flow may develop lichens, mosses, and herbaceous plants over decades, especially where rock frittering accumulates on benches. | • **RAS pit timeline:** Expands from year 1 to final depth in year 8. Final benches completed year 8 with upper batter rehabilitation treatments applied during final landform cuts.<br>• **Alternative seeding methods:** Hydro-mulching, hydroseeding, and aerial seeding feasibility explored for moist areas distant from natural seed sources (particularly SRX Pit). These treatments will have limited application due to expected minimal benefits. |

| Management Units | | Description (landscape and ecology focus) and key risks | Rehabilitation and Closure Strategy |
|---|---|---|---|
| Label | Name | | |
| | | • **Enhanced vegetation zones:** Dense vegetation expected on weathered root zones placed on narrow strip (minimum 20m width) where pits intersect natural ground. Vegetation abuts narrow 5-10m wide buffer wrapping around pits, enriched with rock habitat and native plants placed during pit construction using salvaged material. Buffer includes any required bunds.<br>• Key risks associated with the rehabilitation of this management area include the following:<br>○ **Pit edge definition failures:** Poor definition and stripping controls result in unplanned, unnecessary removal or degradation of adjacent high-value cushionfields and spring annual herbs due to imprecise pit edges.<br>○ **Buffer revegetation timing:** Final (outer) pit edges not revegetated before or during excavation, losing opportunity to enhance buffer areas with short tussocks and weathered rock that enrich grass skink habitat and native seed rain volume flowing onto pit benches, slowing revegetation.<br>○ **Security feature impacts:** Site security features such as earth bunds retrofitted late, resulting in damage to buffer area vegetation, especially cushionfields or spring annual herbs.<br>• **Root zone placement failures:** Scheduling or unsuitable equipment prevents wedges of root zones being applied as planned across bench width extending minimum 20m into pit. Reduces native vegetation volume and diversity and potential use of pit benches by native invertebrates and lizards.<br>• **Aquatic vegetation establishment:** Weathered brown rock and soils not placed to create variety of root zones in waters shallower than 1m depth, inhibiting establishment of native aquatic emergent vegetation pockets. | • **Upper bench treatment:** Root zone wedges placed along uppermost retained bench. Thes are weathered soil/rock wedges extending minimum 20m from pit-natural ground contact that provide habitat for lizards (although remain unsafe for human access). These form root zones (10-400cm deep), with greatest depth at batter toe, thinning toward bench crest (see Figures in Appendix B). Alternative option: lay-back uppermost batter (where adjacent vegetation of low value), roughen and surface with root zone and stockpile rocks.<br>• **Dense plant cover areas:** Specific benches and areas above upper bench of SRX and RAS pits receive Root zone wedges (as described above) (see Figures in Appendix B).<br>• **Lower bench root zones:** Minimum 30cm depth placed along lower benches and haul roads, extending 1m below pit lake water tables in SRX and RAS Pits. Support grey scrub and minor wetland on pit floor in low-moisture-stress environments.<br>• **Seed source enhancement:** Seed rain diversity/volume enriched by improving native species diversity and health in Mine Enhancement Zones while reducing weeds. Enhanced immediately adjacent to stripped areas using transplants into buffer zones and bunds.<br>• **Nursery planting:** Low-density nursery-grown seedlings planted in small, safe-access areas to initiate plant cover on root zone wedges.<br>• **Haul road rehabilitation:** Entry/exit near underground portal and linear infrastructure corridor |

| Management Units | | Description (landscape and ecology focus) and key risks | Rehabilitation and Closure Strategy |
|---|---|---|---|
| Label | Name | | |
| | | • **Surface preparation inadequacy:** Pit batters not horizontally scarified and pit benches not ripped, slowing revegetation processes.<br>• **Stream diversion failure:** Stream diversion across RAS pit bench fails, creating operational and environmental risks. | may require overburden fill to soften vertical cuts >2m height, facilitating ecological corridor linking Shepherds Valley sides while maintaining light vehicle access.<br>• **SRX pit enhancement:** Weathered overburden from SRX ELF supplements SRX soil stockpile for root zone wedges at highwall base and pit floor areas where pit lake water table <1m depth. Terrestrial areas receive minimum 2m deep root zones supporting tall grey scrub and kowhai, creating ecological connectivity pockets. |
| CT | CIT Pit | • **Pit specifications:** 13.8 ha pit conditional on results of spring annual survey 2026/2027 and/or Spring Annuals Applied Research programme.<br>• **Applied Research Programme requirements:** This programme includes surveys of existing populations, propagation and planting trials and development of methods to enhance cushionfields and threatened spring annual herbs currently within and adjacent to pit. It starts in year 1 with surveys of areas before stripping and will run for at least 7 years.<br>• **Edge effects management:** High ecological value and small stature of plant populations (most species less than 20mm tall) makes edge effects management critical, including dust management controls. | • **Backfill and contouring:** Backfilled with overburden/waste, scheduled to be sourced from RAS Open Pit with Shepherd's ELF being an alternative source. Rock shaped to integrate with surrounding terrain, blending seamlessly with adjacent land features.<br>• **Native herbfield establishment:** Contours and root zones cover a minimum of 4.5 ha within the CIT area that have with greatest potential to support spring annual herbs and cushionfields (collectively 'native herbfields').<br>• **Habitat feature placement:** At least 14 rock stacks and 2 rubble pits concentrated on margins and downwind of cushionfield/spring annual herb areas to reduce propagule pressure from native woody species.<br>• **Grazing-compatible design:** Surface and revegetation treatments modified from other ELFs to reduce palatable species susceptible to sheep |

| Management Units | | Description (landscape and ecology focus) and key risks | Rehabilitation and Closure Strategy |
|---|---|---|---|
| Label | Name | | |
| | | Key risks associated with the rehabilitation of this management area include the following:<br><br>• **Pit edge definition failures:** Poor definition and stripping controls result in unplanned, unnecessary removal or degradation of adjacent high-value cushionfields and spring annual herbs due to imprecise CIT pit edges.<br>• **Landform restoration inadequacy:** Final overburden volumes and/or landform shaping inadequate to reinstate pre-existing slopes and micro-topographies. Haul road and benching remain as linear features.<br>• **Soil composition issues:** Organic levels in soils used for cushionfield areas too high, favouring non-native pasture grasses and non-native weed species over target native vegetation.<br>• **Inappropriate erosion control:** High fertiliser rates and/or inappropriate erosion control seed mixes (containing legumes or large bunch grasses) inadvertently used for short-term erosion control, resulting in exclusion and smothering of native herbs. | grazing. Palatable species located in inaccessible parts of rock stacks. Stock water supply established for sheep grazing capability.<br>• **Protected species establishment:** Highly palatable species (Carmichaelia, kowhai) established and protected within at least 2 small rabbit and sheep-proof exclosures for protection from grazing. |
| PL | Pit Lakes | • **Lake formation:** Pit lakes will form at base of Rise and Shine Pit and part of SRX Pit. Lake values for aquatic and potential water supply depend on water chemistry, water-depth profiles of lake edges and depth of root zones in near-shore and riparian zones to support vegetation.<br>• **Lake specifications:** Rise and Shine Pit lake estimated at 14 hectares at 490m RL. SRX Pit lake estimated at 4.9 hectares. Both features designed with most areas having very steep cut rock faces entering deep water, creating limited potential for establishing marginal vegetation. | • **Emergent aquatic vegetation potential:** Very limited shallow areas suitable for lake-edge vegetation (likely <200m² at <1m depth) along haul roads entering both pits.<br>• **Vegetated shallows creation:** Minimum 30cm deep aquatic root zone created along minimum 50m of road where haul road intersects water table. Use gravel mulch to provide erosion protection against wave action and haul road runoff which will be |

| Management Units | | Description (landscape and ecology focus) and key risks | Rehabilitation and Closure Strategy |
|---|---|---|---|
| Label | Name | | |
| | | • **Access requirements:** Both lakes may require long-term light-vehicle access for monitoring and plant pest management.<br>Key risks associated with the rehabilitation of this management area include the following:<br>• **Root zone placement failures:** Weathered brown rock and soils not placed to create root zones in areas with less than 1m deep modelled water tables, inhibiting ability to establish small potential areas of aquatic vegetation.<br>• **Boulder placement inadequacy:** Boulders not placed to create emergent features in pit lakes and not positioned to prevent vehicle entry, reducing habitat diversity and safety controls.<br>• **Cold-air drainage impacts:** Cold air drainage is more severe than anticipated and kills planted species requiring enhanced 'hardening off' or replacement with alternative (hardier) species.<br>• **Security feature impacts:** Site security features such as earth bunds or vehicle exclusions retrofitted late, resulting in damage to established vegetation.<br>• **Water quality concerns:** Lake water quality inadequate to support healthy aquatic plants, invertebrates or birds, limiting ecological value and function. | moderated over time by emergent and terrestrial vegetation.<br>• **Stabilisation and habitat features:** Rock cover (10-25%) including large boulders (>1m diameter) deters vehicle access across waterline and provides resting sites for birds and invertebrates. No native wetland species planted due to decades-long lake filling timeframe.<br>• **Haul road enhancement:** Weathered waste rock and suitable soils installed across minimum 66% of haul roads to minimum 2m depth supporting tall grey scrub and kowhai. Low long-term fire risk areas, though outcomes depend on cold-air drainage.<br>• **SRX pit materials and water quality:** Root zones sourced from weathered overburden in SRX ELF and SRX soil stockpile. Modelling indicates SRX pit lake water suitable for direct release to Rise and Shine Creek.<br>• **Water treatment contingency: Reassess effects of attracting wildlife to pit lake. Potentially remove root zone to reduce plant uptake or change plant species to those that reduce food chain accumulation.**<br>If in-pit water treatment required, truck access maintained for disestablishment when water quality standards met. Adequate root zone volumes stockpiled within pit (along haul roads) and near treatment area for rehabilitation completion using small digger, creating wedges at highwall base and shallow water areas. |

<table>
<tr><th colspan="2">Management Units</th><th rowspan="2">Description (landscape and ecology focus) and key risks</th><th rowspan="2">Rehabilitation and Closure Strategy</th></tr>
<tr><th>Label</th><th>Name</th></tr>
<tr><td>S</td><td>Soil Stockpiles (Mine site)</td><td>• Strategic placement: Stockpiles strategically placed near stripping areas for rehabilitation. Typically located in valleys to maximise storage while minimising footprint and wind exposure, reducing dust. Size and elevation of some stockpiles creates visual intrusion while present.<br>• Soil handling methodology: Upper 20-30cm of soil with highest organic matter density and tussock/pasture roots stripped separately with minimal handling and placed on stockpile surfaces where possible.<br>• Material sources: Shepherds TSF Embankment root zones and soils stripped to schist bedrock with all materials stockpiled or used immediately for rehabilitation. Under ELFs, only soils and vegetation removed and stockpiled. Very small areas of live native plants (0.5-1.5ha) transplanted as sods before bulk stripping for immediate nearby rehabilitation.<br>• Sod utilisation: Sedge-dominated sods used to create wetlands. Short-tussock sods stored as living nursery to later inoculate rehabilitated areas.<br>• Soil segregation: Organic-rich fines from Shepherds Creek stockpiled in specific area on edge of Ardgour Terrace stockpile. SRX soils restricted to SRX catchment due to naturally elevated arsenic levels. Soils containing gorse, other long-lived pest plants, thyme or sedum segregated to prevent dispersal across natural ecosystems and placed in agricultural rehabilitation areas.<br>• Additional materials storage: Stockpiles store weathered boulders for lizard rock habitats alongside brown rock stored in larger stockpile footprints and accessible Shepherds ELF areas.<br>• End-of-life utilisation: Earth bunds, rock buttresses and final 50-100cm of soil used to rehabilitate stockpile footprints. All stockpiles expected to be fully utilised at mine closure with landforms returned to</td><td>• Resource planning: Soil volume and quality critical to rehabilitation success as no soil will be imported to site. Pre-stripping identification and mapping of plant species informs prioritisation and planning of boulder, soil and vegetation salvage depths, reuse and storage locations.<br>• Stockpile distribution: Rehabilitation resources (soil, weathered boulders, native plants) stockpiled throughout site adjacent to major project elements including pits, engineered landforms and tailings storage facility.<br>• Live plant salvage: Native plants with root zones removed before bulk soil stripping for immediate use in adjacent rehabilitation areas including disturbance edges, bunds, rock buttresses and sediment fences. Two larger areas conserved: Carex-dominated sods for wetlands below plant area, tussock-dominated sods for nursery and temporary storage to inoculate rock stacks and rubble pits (Appendix Two).<br>• Soil segregation: Organic-rich, fine textured Shepherds Creek soils (up to 1.5m depth) separately removed and stockpiled in Ardgour Terrace topsoil stockpile. Placed in discrete stockpile edges for preferential wetland use while preserving stockpile integrity. SRX soils restricted to SRX catchment due to elevated arsenic. Gorse-contaminated soils from small areas placed in designated separated area for reuse in accessible locations with low erosion risk, where gorse regrowth can be easily controlled.</td></tr>
</table>

| Management Units | | Description (landscape and ecology focus) and key risks | Rehabilitation and Closure Strategy |
|---|---|---|---|
| Label | Name | | |
| | | similar underlying contours but with thicker soil to facilitate vegetation establishment.<br>• Key risks associated with the rehabilitation of this management area include the following:<br>• **Stockpile edge definition failures:** Poor definition and stripping controls result in unplanned, unnecessary removal or degradation of adjacent intact native vegetation, especially high-value cushionfields, spring annual herbs, taramea and kowhai.<br>• **Sediment release impacts:** Stockpiles release sediment over adjacent undisturbed ground through wind erosion (most probable) or water erosion due to inadequate temporary surface stabilization.<br>• **Soil segregation failures:** Different soils (organic-enriched wetland soil, topsoil and 'other') not segregated and stored in defined stockpile areas, losing ability to differentially use them to enhance specific rehabilitation outcomes.<br>• **Insufficient salvage volumes:** Not enough soil, weathered boulders or tussocks salvaged to reinstate adequate deep root zones across engineered landforms.<br>• **Weed invasion:** Soil stockpiles invaded by weeds with long-lived seed banks and/or vegetative spread, requiring increased maintenance levels in rehabilitated areas.<br>• **Soil degradation during storage:** Soils degraded during stockpiling by heavy machinery compaction, soil erosion (wind and water), and absence of temporary living covers. | • **Stockpile management:** Brown rock and soil stockpiled up to 30m depth. Erosion control using minimally disturbed topsoil sods with attached plants and rock across tops and sides, or brown rock coating. Supplemented by hydromulch/wood waste and tackifiers with short-term irrigation. Rock gravels protect vulnerable areas. Non-native green-mulch (pasture grasses) used only where native growth is poor.<br>• **Stockpile maintenance:** Vegetation re-established or rock mulch applied on inactive stockpile areas (defined as more than 3 months before use or between extractions). Soil extraction in 1-2m cuts.<br>• **Boulder storage:** Weathered boulders for lizard rock stack habitat stored in soil stockpiles alongside mining-produced rock with suitable chemistry and structure. Weathered 'Brown' rock stored in larger soil stockpile footprints and main ELF.<br>• **Stockpile rehabilitation:** Earth bunds, rock buttresses and lower 0.5-1m of stockpiles used to rehabilitate stockpile footprint and adjacent roads. Process includes base ripping to minimum 30cm depth, lifting buried boulders to surface, and scalloping surface. Linear features removed by breaking bunds (preserving vegetation) and removing sediment fences. Original contours restored with rock-reinforced stormwater channels re-established at drainage points. Final treatments include soil replacement, construction of rock stacks and rubble pit habitats, and revegetation. Rock from buttresses placed in adjacent areas to a) soften and |

| Management Units | | Description (landscape and ecology focus) and key risks | Rehabilitation and Closure Strategy |
|---|---|---|---|
| **Label** | **Name** | | |
| | | • **Gorse contamination:** Soils containing gorse seeds spread throughout stockpiles, contaminating them and creating long-term maintenance liability.<br>• **Inadequate residual soil:** Insufficient residual soil left to allow adequate rehabilitation of stockpile footprint. | where possible remove linear features b) support lizards and c) create protected sites for vegetation (mixed tussock, grey shrubland). |
| **S-AT** | **Soil stockpile – Ardgour Terraces** | • **Formation and materials:** Soil and root zone stockpile formed in first year of operation, largely constructed from alluvial soils and deposits from lower Shepherds Valley. Materials generally more fertile, weedier and coarser than those stripped from loess-covered hillsides.<br>• **Salvage materials:** Soils may contain relic wood which will be salvaged for specific placement into rehabilitated areas. Expected to include organic-enriched material from wetlands, salvaged separately and placed in specific stockpile area with minimum dilution from other materials.<br>• **Organic material placement:** Organic-rich materials hold more water and are less stable than soils, placed in discrete areas near surface or stockpile edge. Positioning allows priority use for wetland rehabilitation.<br>• **Location characteristics:** Soil stockpile located within intensively farmed area with almost no native vegetation, having been ploughed, fertilised and irrigated to grow crops such as high-producing pasture and lucerne.<br><br>Key risks associated with the rehabilitation of this management area include the following:<br><br>**Note:** Key risks are similar to those of other soil stockpiles with the following exceptions: | • **Stockpile vegetation during construction:** As stockpile is constructed, exposed slopes and level surfaces not used for tussock or rock storage quickly vegetated with fast-growing cereals and grasses. Short-term species irrigated and fertilised with nitrogen to establish dense cover with deep rooting depths.<br>• **Tussock storage:** Part of level (upper) stockpile surface used to store tussocks salvaged from mine footprint.<br>• **Stockpile removal at closure:** Stockpile removed at closure (except soils used for its own rehabilitation). Materials will be required to create new root zones across the rehabilitated terrace (once infrastructure is removed). This will include riparian zones along the diverted Shepherds Creek, wetlands, grey scrub and forest patches in south-facing beds and deepest soils.<br>• **Agricultural restoration preparation:** Stockpile base deep ripped to minimum 0.5m depth at 0.8m centres. Bunds removed and mixed with residual soils to create homogenous stripped soil layer at even depth across gently-sloping landform. |

| Management Units | | Description (landscape and ecology focus) and key risks | Rehabilitation and Closure Strategy |
|---|---|---|---|
| Label | Name | | |
| | | • **Reduced weed risk:** Risk of weeds and pest plants lower as stockpile within farmland, not ecological areas. Therefore, it is suitable place to beneficially use soils with weed burdens.<br>• **Enhanced dust management requirements:** High exposure to dominant winds, location near temporary workers infrastructure and high visibility means dust management of higher importance than for other stockpiles.<br>• **Agricultural rehabilitation requirements:** Stockpile rehabilitated to productive farmland requiring contrasting soil management to ecological areas: homogeneous soils of even depth with few stones, high and even plant cover, and grazing or biomass management encouraging deep rooting and soil organic matter buildup. | • **Soil quality requirements:** Minimum plowable depth created with low stone content in upper 30cm. Area fertilised and limed as necessary to support productive pastures, with amendments mixed prior to lucerne or high-productivity pasture drilling.<br>• **Erosion management:** Interim cover crop established if wind erosion risk high, with pasture or lucerne later seeded using minimal surface disturbance techniques.<br>• **Productivity targets:** Minimum 90% of unirrigated farm average productivity (kg DM/ha) over 5 years with even growth. Target requires management by adjacent farmer and/or agricultural contractor. |
| HR | Haul Roads | • **Road specifications:** 17m wide (one-way) or 30m wide (two-way) with unsealed surfaces and stormwater runoff directed to sediment ponds. Some roads have constructed safety bunds, which are not required where roads are cut into surface to minimum depths specified by safety guidance.<br>• **Operational lifespan:** Most haul roads remain throughout mine life providing access between working areas and areas partially rehabilitated and/or closed. Some roads conditional and may not be formed (e.g., CIT haul road conditional on CIT ore body being mined).<br>• **Cut face management:** Steep cut faces along haul roads highly visible and may act as barriers to ground-based native fauna spread. Impacts moderated at construction by enhancing unimpacted vegetation above cut faces combined with horizontal scarification, and at closure by placing wedges of root zone minimum 1m deep against all cuts >2m height to support taller vegetation.<br>• **Post-closure configuration:** Many haul roads (excluding CIT haul road) retain 3-4m wide light vehicle running surface covered with | • **Road closure specifications:** Haul roads connecting Plant to pits, ELFs and soil stockpiles reduced to 3-4m wide light vehicle access tracks at closure. Culverts removed and replaced with fords to reduce maintenance needs.<br>• **Bund construction and treatment:** Windrows/bunds built from soils and weathered rock stripped ahead of road construction. Crown and outer slopes scalloped with tussock sods planted where possible and boulders placed to reinforce toes and provide microsites. Same treatment applied to fill slopes.<br>• **Cut treatment during construction:** Permanent cuts under 2m roughened horizontally to trap dust, retain water, and encourage colonisation of herbs, lichens and mosses. |

| Management Units | | Description (landscape and ecology focus) and key risks | Rehabilitation and Closure Strategy |
|---|---|---|---|
| Label | Name | | |
| | | rock/gravels and sparse grasses (sweet vernal and/or browntop and native grasses), herbs and mosses. Visual impact of permanent linear structures moderated by adopting meandering form and using boulders and vegetation to reinforce indirect routes.<br>• Key risks associated with the rehabilitation of this management area include the following:<br>• **Haul road edge definition failures:** Poor definition and stripping controls result in unplanned, unnecessary removal or degradation of adjacent intact native vegetation, especially high-value cushionfields, spring annual herbs, taramea or kowhai.<br>• **Fill slope sediment release:** Haul road fill slopes release sediment over adjacent undisturbed ground through wind or water erosion. Most likely if not treated at construction using salvaged weathered boulders and transplanted tussocks/sedges into suitable contoured bunds with rough surfaces.<br>• **Insufficient root zone materials:** Not enough soil or root zones available or placed to blend cut faces over 2m height or reinstate variable root zones across haul roads to support vegetation that breaks up linear forms and reconnects ecosystems cut by haul roads.<br>• **Cut face preparation inadequacy:** Cut faces not horizontally scarified, adequately roughened, or stable enough to support vegetation establishment.<br>• **Weed invasion:** Water tables and/or cut faces invaded by weed species that spread down water tables, along roadsides, and into adjacent earthworked areas. | • **Road surface disestablishment:** Water tables removed. Minimum one-third of road surface width deep ripped and/or spot mounded to minimum 0.5m depth, creating rough surface with water accumulation areas. Vegetated bunds broken up with plants and soil shifted in clumps to spot mounds, disrupting linear features and creating seed-inoculated sheltered microsites.<br>• **Root zone placement:** Residual soil and weathered brown rock from stockpiles placed on treated road surfaces to minimum 0.5m depth over minimum two-thirds of haul road width. RAS/ELF haul road zone may receive different treatment for cushionfield root zones requiring relatively smooth surfaces (based on ARP outcomes).<br>• **Cut rehabilitation:** Cuts over 2m high receive root zone and rock wedges at base (similar to pit benches) to minimise disturbance. Near grey scrub or tussock areas, batters may be collapsed to bring vegetation over ripped road base. Fill slopes remain undisturbed as already vegetated during construction.<br>• **Grey scrub establishment:** Combination of brown rock fill (cuts >2m), horizontal scarification (cuts <2m), 0.5m soil over 0.5m loosened road base/aggregate (60% of running surface) and bund disruption provides 100cm rooting depth supporting grey scrub over minimum 33% of haul road areas. Grey scrub enhances visual integration and |

| Management Units | | Description (landscape and ecology focus) and key risks | Rehabilitation and Closure Strategy |
|---|---|---|---|
| Label | Name | | |
| | | • **Inadequate decompaction:** Machinery used to decompact haul roads not large enough to break up compaction >0.5m deep and does not decompact minimum one-third of running surface, reducing capacity for tall shrub growth and limiting connectivity and visual integration.<br>• **Windrow disestablishment timing:** Windrow disestablishment undertaken at wrong time of year or with high vegetation disruption, resulting in low survival of native plants that have established into them. | ecological connectivity, particularly for lizards and non-flying invertebrates. |
| C | **Construction Camp and Ancillary Infrastructure** | • **Operational duration:** Site Workers Camp present for duration of start-up phase in year 1. Stripped topsoil (and where required, subsoils) used to create bunds sown with vigorous non-native grasses to provide short-term erosion and weed control.<br>• **Rehabilitation objective:** Site returned to non-native pasture or lucerne cover with temporary irrigation to ensure even, dense, high-biomass plants needed to rehabilitate soil quality for agriculture.<br>• **Ancillary buildings:** Similar approach used for ancillary buildings including explosives shed, emulsions plant and laydown areas.<br><br>Key risks associated with the rehabilitation of this management area include the following:<br>• **Foundation and gravel removal failures:** At decommissioning, foundations and compacted gravels not removed. Rocks remain in upper 30cm of soil profile preventing efficient cultivation, ploughing and/or seeding by direct drill.<br>• **Inadequate decompaction:** Machinery used to decompact ground prior to topsoil replacement not large enough to break up compaction >0.5m deep and does not decompact entire surface. | • **Camp disestablishment:** Foundations, imported gravels (hardstand) and impervious surfaces excavated and removed. Remaining surface deep-ripped to minimum 0.5m depth at maximum 0.8m centres. Stored topsoil from bunds replaced using same technique as Ardgour Terrace soil stockpile, providing opportunity to refine rehabilitation techniques and monitor outcomes over 5 years.<br>• **Ardgour Terrace Wetland location:** Created in Shepherds Creek on Ardgour Terrace west of haul road to Ardgour Terrace topsoil stack.<br>• **Wetland establishment timeline:** Created in year 1 using sedges including *Carex kaloides* removed during stripping for Shepherds Valley Services Corridor construction.<br>• **Wetland design:** Minimum 0.5ha wetland established using series of cells/swales prepared before transplanting to deliver low permeability and reduce water loss into underlying gravels. Water conservation includes use of organic-rich wetland soils stripped during Shepherds Valley Services |

| Management Units | | Description (landscape and ecology focus) and key risks | Rehabilitation and Closure Strategy |
|---|---|---|---|
| Label | Name | | |
| | | • **Poor soil interface:** Interface between replaced soils and decompacted base not rough or loose enough to allow roots to pass into decompacted zone, making plants more vulnerable to drought with lower productivity. | Corridor establishment (such soils not readily compressible or competent).<br>• **Water supply requirements:** Wetland persistence requires adequate inflow from Shepherds Creek. Stopping stock water abstraction estimated to increase currents flows by ~50%.<br>• **Riparian enhancement:** Minimum 10m of valley slopes either side of wetland planted with grey shrubland including kowhai. Riparian zones and wetlands permanently fenced to exclude stock. |
| P | **Process Plant Mine Infrastructure** | **Infrastructure specifications:** Process Plant platforms and linear infrastructure corridor in Shepherds Valley built on compacted fill. Surface run-on from south-east managed by cut-off drains diverting clean water to Shepherds Valley Services Corridor diversion channel. Drains naturalised at closure to enhance plant growth.<br><br>**Facility components:** Process Plant includes maintenance workshops, storage facilities, mine offices, and security services, some built on terraces cut into Shepherds ELF.<br><br>Key risks associated with the rehabilitation of this management area include the following:<br>• **Flood plain vegetation inadequacy:** Realigned Shepherds Creek flood plain does not provide adequate rooting depth or bulk of native vegetation that provides aquatic ecological values and terrestrial connectivity across floodplain.<br>• **Foundation and gravel removal failures:** At decommissioning, foundations and compacted gravels not removed, creating ongoing rehabilitation constraints. | • **Shepherds Creek realignment:** Permanent realignment against northern valley wall during construction creates vegetated earth and rock bund defining flood channel. Information cross-sections and extent of flood plain supporting bulky plants (flax, toetoe, tussocks), additional rock habitat/substrates, and form of low-flow channel provided in Growplan concept design, August 2025.<br>• **Lower Shepherd's wetland establishment:** Minimum 0.40ha wetland created downstream of process plant infrastructure using wetland sods transplanted from plant and ELF footprint in years 1 or 2. Includes *Carex kaloides* forming second population for seed and propagule collection, likely to benefit invertebrates reliant on sedges as a host.<br>• **Plant area wetland establishment:** Minimum 0.5 ha created at end of mining when process plant is removed<br>• **Infrastructure removal staging:** Two-stage process with majority of buildings not required for post mining |

| Management Units | | Description (landscape and ecology focus) and key risks | Rehabilitation and Closure Strategy |
|---|---|---|---|
| Label | Name | | |
| | | • **Inadequate decompaction:** Machinery used to decompact ground prior to root zone replacement not large enough to break up compaction >0.5m deep and does not decompact entire surface. Interface between replaced soils and decompacted base not rough enough to allow roots to pass into decompacted zone.<br>• **Root zone material shortfalls:** Inadequate volume or quality of root zone materials brought from Ardgour Rise soil stockpile available to complete rehabilitation as designed.<br>• **Wetland water supply inadequacy:** Inadequate water levels or natural flows available to sustain planned wetlands, requiring minimum depths and duration of water for viability.<br>• **Stock access failures:** Area not maintained free of stock. Wetlands, stream beds and banks vulnerable to damage from cattle. Both cattle and sheep will graze rehabilitated vegetation that is palatable. | use removed first. Water treatment plant, treatment wetlands (not included in the rehabilitation) and associated hardstand/storage/turnaround areas retained.<br>• **Area rehabilitation:** Rehabilitated areas deep ripped with root zones and rock from Ardgour Terrace soil stockpile using similar methods to haul roads.<br>• **Native tree establishment:** Small patches of native trees (totara, kowhai) totalling minimum 0.5ha created on frost-drained valley floor areas. Located in fire-protected areas with deep root zones (>3m) created by deeper ripping and/or deeper brown rock and/or deeper soils. May integrate with diverted Ardgour stream bunds but positioned outside flood zone.<br>• **Access control:** All stock permanently excluded to protect ecological and aquatic values. Boundary gates and stock-exclusion grates installed at gorge entrance. Dedicated narrow entry (single person/single horse) provided for horses and cyclists. |
| **AR** | **Ardgour Rise Alignment** | • **Road closure and replacement:** Western part of Thomson Gorge Road from Thomson Saddle to Ardgour Terrace replaced with Alternative Ardgour Rise Alignment early in mine life for public safety. Ensures continuous vehicle access to Thomson Saddle.<br>• Combination of new and upgraded roads are not included in mine rehabilitation but abuts Mine Regeneration Zone in Ardgour Station (MRZ-A), generally minimum 50m below road.<br>• **Setback requirements:** 50m setback designed to maintain stock grazing along boundary forming important fire buffer to protect long- | • **Road specifications:** Creates narrow 12km long gravel road similar to existing Thomson Gorge Road standard. Maintains 4m carriageway with 1m swales either side during mine operation.<br>• **Disturbance minimization:** Road footprint formed to minimise disturbance to adjacent vegetation including extensive taramea swathes in upper section and some cushionfields in lower section. |

<table>
<tr><th colspan="2">Management Units</th><th rowspan="2">Description (landscape and ecology focus) and key risks</th><th rowspan="2">Rehabilitation and Closure Strategy</th></tr>
<tr><th>Label</th><th>Name</th></tr>
<tr><td></td><td></td><td>term ecological investment. Setback also reduces disturbance to stock from road users, helping ensure grazing extends to boundary of ungrazed area. Minimum 250m setback established between MRZ-A and airstrip to ensure grazing continues across airstrip vicinity.<br><br>Key risks associated with the rehabilitation of this management area include the following:<br><ul><li>Road edge definition failures: Poor definition and stripping controls result in unplanned, unnecessary removal or degradation of adjacent intact native vegetation, especially high-value cushionfields, spring annual herbs and taramea.</li><li>Fill slope sediment release: Fill slopes release sediment over adjacent undisturbed ground through wind or water erosion. Most likely if fill slopes not treated at construction using salvaged weathered boulders.</li><li>Cut face preparation inadequacy: Cut faces not horizontally scarified, adequately roughened, or stable enough to support vegetation establishment.</li><li>Weed invasion: Water tables and/or cut faces invaded by weed species that spread down water tables and along roadsides into adjacent areas.</li></ul></td><td><ul><li>Fill batter treatment: Fill batters formed to support revegetation and seeded with mixed native and exotic vegetation. Salvaged rock placed in suitable locations and salvaged vegetation placed in fill slope hollows to reflect surroundings.</li><li>Fill slope management: Rock used to constrain fill slopes. Some fill overhauled for placement on low-value non-native pasture areas to minimise footprint in high ecological value areas (taramea and cushionfields).</li><li>Contamination prevention: Gravels, earth-moving machinery and erosion control products used in construction must be clean and free of pest plant species.</li></ul></td></tr>
<tr><td>TGT</td><td>Thomson Gorge Road Recreation Track</td><td>Route re-establishment: At closure, Thomson Gorge Road re-opened as recreation route broadly following original alignment of existing road for walking. Parts may be required to function as stock mustering track and light vehicle farm track.</td><td>Route planning: At closure, indicative recreation routes through site remain subject to detailed design supporting wayfinding and safe access re-establishing a route over the saddle.<br><br>Experience opportunities: Routes facilitate lookout opportunities and signage where interaction with, and experience of, new mining elements are enabled,</td></tr>
</table>

| Management Units | | Description (landscape and ecology focus) and key risks | Rehabilitation and Closure Strategy |
|---|---|---|---|
| **Label** | **Name** | | |
| | | **Additional recreation opportunities:** Mountain biking and equestrian opportunities may be facilitated on 4WD maintenance tracks maintained within site.<br><br>**Rehabilitation objectives:** Track rehabilitation specifically reduces fire risk and manages risk to users in proximity to RAS and SRX highwalls, spring annual herb areas, and facilitates potential stock management in Mine Regeneration Zones B1 and B2.<br><br>**Note:** Key risks are similar to those for the Ardgour Rise realignment although this road does not need widening, and new areas are part of mined areas so impacts on existing ecosystems are much lower.<br><br>The use of the site by horses introduces risks of weed-seed introduction and spread (in horse excrement, notably brier) and browsing of palatable plants. | alongside measures managing ongoing separation from hazards including operational plant.<br><br>If horses are provided for, change location of palatable plants or physically protect them with boulders and prickly plants or vines. Strategically locate horse rest spots where weed establishment risks are low and any weeds are easily identified and managed. |
| **QU** | **Quarries, Magazine and Emulsion** | **Infrastructure specifications:** Small 1-3ha areas on Ardgour Terrace within agricultural land include two gravel pits, a magazine, and an emulsion facility.<br><br>**Magazine and emulsion facility rehabilitation:** Rehabilitated to restore land covers and contours matching surrounding agricultural areas, remaining plowable with similar agricultural productivity.<br><br>**Gravel pit rehabilitation:** Two gravel pits become hollows in landscape with even slopes of less than 18 degrees down to relatively level floor. May be developed as sites for agricultural or horticultural infrastructure or re-established with pasture, however areas will not be plowable as gravels likely near surface.<br><br>Key risks associated with the rehabilitation of this management area include the following: | **Soil stockpile management:** Topsoils and subsoils removed from sites stockpiled in bunds within footprint. Bunds seeded and grassed to maintain soil health, minimise weed establishment, and maintain effective dust-suppressing cover until rehabilitation. Existing soil piles by gravel pit contoured with dense pasture cover established.<br><br>**Magazine and emulsion facility:** Rehabilitated using methods similar to Site Workers Camp, to provide plowable land with similar agricultural productivity.<br><br>**Gravel pit rehabilitation:** Walls contoured and/or backfilled to create machine-trafficable slopes to pit floor. Pit floors contoured to form gentle slopes removing holes and hazards. Plant establishment areas ripped with bund |

<table>
<tr><th colspan="2">Management Units</th><th rowspan="2">Description (landscape and ecology focus) and key risks</th><th rowspan="2">Rehabilitation and Closure Strategy</th></tr>
<tr><th>Label</th><th>Name</th></tr>
<tr><td></td><td></td><td><ul><li>Building material coverage failures: At decommissioning, concrete or other building materials not sufficiently covered by soil, preventing efficient cultivation, ploughing and/or seeding by direct drill.</li><li>Inadequate decompaction: Machinery used to decompact ground prior to topsoil replacement not large enough to break up compaction >0.5m deep and does not decompact entire surface.</li><li>Poor soil interface: Interface between replaced soils and decompacted base not rough or loose enough to allow roots to pass into decompacted zone, making plants more vulnerable to drought with lower productivity.</li><li>Pit wall safety hazards: Pit walls not adequately battered back, creating safety hazard and accentuating visibility of excavated pits.</li><li>Drainage inadequacy: Base of gravel pits not free draining with water ponding for extended periods, creating operational and safety concerns.</li></ul></td><td>materials used to create root zone suitable for pasture support.<br><br>Agricultural infrastructure areas: Contoured to create free-draining, level surfaces with gravel cover positioned higher than and draining to pasture areas.<br><br>Water management: Where water ponds in pit base, opportunity assessed to convert areas for stock water supply or small wetland development.</td></tr>
<tr><td>W</td><td>Wetlands</td><td>Ardgour Terrace Wetland: Created in Shepherds Creek on Ardgour Terrace, west of haul road. Established in year 1 using sedges, including Carex kaloides. May be expanded downstream during mine life depending on water flow and retention. Minimum 0.5ha wetland consists of engineered cells/swales bordered by planted riparian strip of grey shrubland, including kowhai. Area fenced to exclude stock.  THIS MAY BE SUBSTITUTED FOR by enlarging the Lower Shepherd’s wetland to at least 1 ha<br><br>Lower Shepherds Wetland: Minimum 0.5ha wetland established within Shepherds Gully, downstream of plant and adjacent to Shepherds Stream and intact shrubland (part of MRZ-A management unit). Boundaries and extent determined through detailed design and constructed within 3 years of mine opening. Initially may serve as stockpile area for wetland plants and</td><td>Ardgour Terrace Wetland establishment: Created in year 1 using tightly -packed sods of intact wetland sedges with attached root zones, including Carex kaloides, removed from Shepherds Valley Services Corridor and/or plant area construction footprint. Sods placed in herring-bone pattern into engineered cells/swales with base designed to reduce permeability and water loss into underlying gravels.<br><br>Lower Shepherd’s wetland establishment: Minimum 0.5ha wetland established within Shepherds Gully downstream of plant, adjacent to Shepherds Stream and intact shrubland within 3 years of mine opening. Initially</td></tr>
</table>

| Management Units | | Description (landscape and ecology focus) and key risks | Rehabilitation and Closure Strategy |
|---|---|---|---|
| Label | Name | | |
| | | organic-rich soils before incorporation into MRZ A1. Areas may be at least 1 ha if Ardgour Terrace wetland is not established.<br><br>**Plant wetland**: Minimum 0.5 ha established when plant is removed at end of mining.<br><br>**TSF wetlands:** Cover minimum 6ha, including 2ha of permanent water (>0.5m depth) and 4ha of ephemeral wetland, and include 0.5ha area of free water (see TSF for description).<br><br>Key risks associated with the rehabilitation of this management area include the following:<br><br>• **Water supply inadequacy:** Inadequate water levels or natural flows available to sustain minimum depths and duration of water ponding for various wetlands.<br>• **Root zone material shortfalls:** Inadequate volume, depth or quality of wetland root zone materials available. Organic-rich soils not separately stripped and stored in accessible areas.<br>• **Salvage timing failures:** Scheduling does not facilitate salvage of adequate wetland area at suitable time of year (spring to early summer) to deliver required area of wetland sods. Sufficient area of sods containing *Carex kaloides* not salvaged.<br>• **Translocation quality issues:** Salvaging and translocation of wetland sods insufficient quality and wetland species do not exceed 66% vegetation cover required.<br>• **Species composition changes:** *Carex kaloides, Carex buchananii, Carex diandra, Juncus distegus* density in transferred sods reduces | serves as stockpile area for wetland plants and organic-rich soils before revegetation using wetland/seepage sods and nursery-raised seedlings. Expected to flood in high-flow events and integrate completely with adjacent grey shrubland hill slope. If Ardgour Terrace wetland is not established, Lower Shepherd's wetland will need to contain >0.5 ha of tightly-packed sods per Ardgour Terrace wetland.<br><br>**Wetland construction specifications:** Organic-rich wetland soils from corridor construction may supplement construction. Wetland vegetation covers minimum 66% of surface assessed at end of growing season following construction. Grey shrubland planted on valley slopes forming minimum 10m wide riparian vegetation strip either side of wetland. Area permanently fenced to exclude stock with grove of kowhai established within riparian area (at least 30 individual trees established additional to the kowhai nodes).<br><br>**Ongoing management:** All rehabilitated wetlands and riparian margins require ongoing management to remove invasive willows establishing from wind-blown seed, and permanent exclusion of cattle and horses.<br><br>**Propagule supply:** Ardgour Terrace and Lower Shepherd Valley wetlands provide propagules (seeds/divisions) for nursery production used to vegetate TSF wetland and Plant wetland revegetation at closure with the 'donor' wetlands maintaining a minimum 75% native sedge and wetland species cover. Ardgour Terrace wetland may have potential to expand downstream during mine life depending |

| Management Units | | Description (landscape and ecology focus) and key risks | Rehabilitation and Closure Strategy |
|---|---|---|---|
| Label | Name | | |
| | | over time as other species become more competitive. The other threatened species planted as nursery seedlings do not spread.<br>• **Stock access failures:** Areas not maintained free of stock. Wetlands extremely vulnerable to damage from cattle, and both cattle and sheep will graze rehabilitated vegetation.<br>• **Weather event impacts:** Unusual weather events (floods or severe drought) impact success of vegetation establishment and growth. | on water supply (flows, retention, losses). Establishment and growth of riparian vegetation helps reduce evapotranspiration losses from Ardgour Terrace wetland. Location of Ardgour Terrace wetland enables short-term irrigation during establishment if needed. |
| D | **Clean Water Diversion channels** | **Purpose and design:** Narrow, linear features established at beginning of mine opening to minimise entry of clean water into mined areas, designed to keep clean water clean.<br><br>**Channel specifications:** Temporary Diversion Channels sized for 1 in 10 year ARI (see TSF description). Permanent Diversion channels sized for much larger rainfall events (see ELF description).<br><br>**Access infrastructure:** Top of specific diversion channel bunds has level, gravelled driving surface forming permanent light vehicle track for long-term access. Where tracks are permanent and diversion drains disestablished, culverts replaced with fords to reduce scour risk from streams and overland surface flows crossing diversion drain.<br><br>Key risks associated with the rehabilitation of this management area include the following:<br>• **Diversion drain edge definition failures:** Diversion drain edges rough, resulting in unnecessary removal or degradation of adjacent intact native vegetation, especially high-value cushionfields, spring annual herbs and taramea.<br>• **Fill slope sediment release:** Fill slopes release sediment over adjacent undisturbed ground through wind or water erosion. Most | **Bund construction:** All diversion drain bunds in natural ground constructed at mine opening to support native vegetation while minimising fill-slope footprint, focusing on high-value ecosystems including taramea and cushionfield. Salvaged boulders used to constrain fill over high-value plant root zones, brought to surface as valuable rehabilitation materials rather than buried.<br><br>**Fill slope treatment:** Fill batters formed to support revegetation with salvaged rock placed on slopes for habitat and salvaged vegetation (tussocks, sedges, taramea) placed in hollows for protected microsites and enhanced revegetation speed. Bunds generally seeded with clean sweet vernal or browntop grass at 3kg/ha without legumes or bunch grasses. Slash from cleared shrubland placed over fill slopes as erosion cover.<br><br>**Channel design specifications:** Temporary diversion channels not designed for plants or aquatic ecology. Permanent clean water diversion channels sized for tussock and riparian vegetation establishment in variable root zones (nil to 50cm depth) with boulders and |

<table>
<tr><th colspan="2">Management Units</th><th rowspan="2">Description (landscape and ecology focus) and key risks</th><th rowspan="2">Rehabilitation and Closure Strategy</th></tr>
<tr><th>Label</th><th>Name</th></tr>
<tr><td></td><td></td><td>likely if fill slopes not treated at construction using salvaged vegetation, slash and weathered boulders.<br>• Cut face preparation inadequacy: Cut faces not horizontally scarified, adequately roughened, or stable enough to support vegetation establishment.<br>• Fill face habitat failures: Fill faces do not establish with adequate native plant cover and not provided with adequate rock cover to provide equivalent or better habitat for lizards (because rocks are buried within bunds during construction rather than being brought to the surface).<br>• Willow establishment: Willows establish in diversion drains. In permanent drains this can reduce flood capacity and risk integrity of bunds.<br>• Culvert replacement erosion: Replacement of culverts and disestablishment of temporary diversion drains results in unacceptable erosion levels.</td><td>weathered rock placed for microhabitats. Higher erosion risk surfaces reinforced with salvaged boulders and rocks.<br><br>Disestablishment process: Linear vegetated diversion bunds disrupted by digger moving up to 25% of upper fill bunds with plants and root zones into channel, avoiding boulders. Up to 75% of channels may remain intact for habitat enrichment through higher water retention. Lower half of bunds remains intact to minimise risk to adjacent undisturbed areas.<br><br>Infrastructure modifications: All culverts removed and replaced with wide fords having high and low water flow edges reinforced against erosion with rock.<br><br>Ongoing maintenance: Both permanent and temporary diversion drains require ongoing maintenance removing establishing willows and remediating erosion areas to maintain safe vehicle access.</td></tr>
<tr><td colspan="4">Enhanced Areas <u>Mine Regeneration Zones</u></td></tr>
<tr><td>MRZ-B1</td><td>Mine Regeneration Zone B1</td><td>Management objectives: Protect and enhance cushionfield, native spring annual herbs, and associated invertebrates as dominant components of vegetation mosaic. Secondary objective to provide increased flow and diversity of native propagules across and into Western ELF.<br><br>Zone boundaries: Centred on CIT pit, covering north-east to north-west facing slopes. Bounded by main haul road and plant at base and Thomson</td><td>Weed management: Ongoing management controls or removes non-native woody weeds and herbaceous weeds threatening cushionfield and spring annual herb habitat. Management techniques and successful interventions refined in ARP applied across zone.<br><br>Fire buffer function: Cushionfield vegetation's low biomass enables MRZ-B1 to serve as fire buffer zone</td></tr>
</table>

| Management Units | | Description (landscape and ecology focus) and key risks | Rehabilitation and Closure Strategy |
|---|---|---|---|
| Label | Name | | |
| | | Gorge Road near top, extending to gorge mouth and Pest Exclusion Fence adjacent to Bendigo Historic Reserve.<br><br>**Access and grazing management:** Thomson Gorge Road provides sheep access and post-mining recreational use, but cattle excluded from grazing. Reticulated stock water (troughs) and new fencing required, with water likely sourced from new bore as Shepherds Creek extraction will cease.<br><br>**Boundary refinement:** Spring annual herb surveys in 2025 refine boundary locations with MRZ-B2, trough locations and access track locations. Priority to maximise areas where spring annuals maintained by grazing if necessary. Surveys inform edge management for haul roads and pits, focusing on sediment/runoff control, dust control, and weed management (targeting brier and cushionfield threats plus eradicable weed species). Final fencing sites consider specific management interventions and practicality of stock/rabbit control.<br><br>Key risks associated with the rehabilitation of this management area include the following:<br><br>• **Grazing management failures:** Sheep and rabbits used to graze cushionfields do not deliver targeted control of non-native grasses and herbs as intended.<br>• **Road user impacts:** Users of Thomson Gorge Road including farm staff result in physical damage to adjacent or rehabilitating vegetation from uncontrolled vehicles.<br>• **Weed control challenges:** Some weeds threatening cushionfields or spring annual herbs prove harder to control, more intractable or more expensive than anticipated. Enhancement techniques unsuccessful. | extending to RAS pit high walls. May require targeted plant biomass removal or reduction.<br><br>**Small enclosure establishment:** Small rabbit-fenced enclosures (up to 20 m ²) located to promote natural seedling establishment of high-value native woody plants at cushionfield margins, targeting *Pimelea*, *Melicytus*, and *Carmichaelea*.<br><br>**Large enclosure establishment:** Large rabbit-fenced enclosures (up to 1000m²) established on lower slopes and incised gullies separating cushionfield spur ridges. Located in higher moisture areas currently in non-native pasture and/or brier. Kowhai trees and highly palatable species established taking advantage of fire buffer protection with limited spread potential due to ongoing grazing.<br><br>Ongoing management will control or remove non-native woody weeds and herbaceous weeds that threaten cushionfield and spring annual herb habitat. The Applied Research Plan will develop and refine this management, with successful management interventions applied across this zone.<br><br>Since cushionfield vegetation has low biomass, MRZ-B1 will serve as a fire buffer zone extending to the RAS pit high walls. This fire buffer zone may require targeted removal or reduction in plant biomass.<br><br>Small rabbit-fenced enclosures will be located to promote natural seedling establishment of high-value native woody |

| Management Units | | Description (landscape and ecology focus) and key risks | Rehabilitation and Closure Strategy |
|---|---|---|---|
| Label | Name | | |
| | | • **Exclosure breaches:** Rogue snowfalls or erosion allows rabbits to access fenced exclosures and consume palatable plants, compromising protection objectives.<br>• **Mining-related damage:** Significant areas damaged by dust or spill from adjacent mined areas during operations. | plants at the margins of cushionfields, targeting *Pimelea, Melicytus*, and *Carmichaelea.*<br><br>Large rabbit-fenced enclosures will be established on lower slopes and in some incised gullies that separate the cushionfield spurs ridges in areas with higher moisture and currently in non-native pasture and/or brier. In these areas (up to 1000 m2) kowhai trees and highly palatable species will be established, taking advantage of the long-term protection provided by the surrounding fire buffer, and with limited potential to spread due to ongoing grazing (see Appendix 5). |
| **MRZ-B2** | **Mine Regeneration Zone B2** | **Zone boundaries:** Borders Zone B1 and Rise and Shine pit slopes, extending to Battery Hill ONL. Excludes certain slopes with low potential for spring annual herbs but includes dense tussock areas. Boundaries with MRZ-B1 and B3 determined based on cushionfield research, with potential adjustments to permanently exclude stock from grey shrubland areas.<br><br>**Kowhai protection:** remnant kowhai trees present within mine site contingency areas will be retained and enhanced using exclosure fencing and additional planting where possible.<br><br>**Management objectives:** Primary objective to protect (buffer) MRZ B1 (cushionfield) and secondly to enhance ecological values of currently degraded ecosystem and provide increased flow and diversity of native propagules across and into RAS pit and Shepherds ELF. Area currently consists of grey shrubland, tussockland, cushionfield, pasture grasses and brier with locally abundant lizard populations.<br><br>Key risks associated with the rehabilitation of this management area include the following: | **Grazing management:** Ecological values delivered by restricting time, duration and intensity of sheep-only grazing to deliver native cover that protects adjacent MRZ B1 cushionfields. This will promote regeneration of tussock and Olearia shrublands, riparian and seepage areas, and lizard habitat.<br><br>**Enhancement planting:** Minor enhancement planting over 5-10% of area establishes clusters of native, nursery-grown woody and vine species in favourable microsites. Target areas have existing cover and higher moisture where competition from non-native pasture grasses can be efficiently controlled until establishment. Areas predominantly in non-native pasture grasses or tussock. Rock outcrops and seepages targeted to introduce low-density species.<br><br>**Vegetation and soil management:** Targeted control of non-native vegetation (including brier) reduces competition |

| Management Units | | Description (landscape and ecology focus) and key risks | Rehabilitation and Closure Strategy |
|---|---|---|---|
| Label | Name | | |
| | | 1) **Tussock regeneration delays:** Short tussocks respond more slowly than expected to grazing release. Tussock mast season does not align with stock pressure release, reducing establishment of tussock seedlings.<br>2) **Weed response acceleration:** Weeds respond more strongly than expected with grazing removal and prove difficult or expensive to control to levels allowing native dominance.<br>3) **Native plant enrichment failures:** Native plant species enrichment using nursery-grown plantings less successful than anticipated (higher mortality or greater competition with non-native grasses).<br>• **Fire risk:** Fire events threaten rehabilitation success and long-term ecological objectives.<br>4) **Sheep grazing ineffectiveness:** Grazing by sheep does not deliver targeted control of non-native grasses and herbs and instead impacts regeneration of tussock and native shrubs.<br>5) **Cattle exclusion failures:** Cattle not excluded in perpetuity, with consequent degradation of seepages and riparian areas.<br>6) **Exclosure breaches:** Rogue snowfalls or erosion allows rabbits or stock to access fenced exclosures and consume palatable plants.<br>7) **New weed establishment:** New weeds establish and compete with native plants (wilding pine and fir species, and bird-dispersed woody weeds). | with native plants. Scarification and/or mulching trailed to remediate soil compaction in stock camp areas and stimulate native regeneration.<br><br>**Infrastructure requirements:** New public and stock access track around RAS required, potentially needing specific planting and/or boulder placement for safety enhancement. Reticulated water not needed.<br><br>**Boundary refinement:** Boundary with MRZ-B1 refined based on ARP survey and management results for cushionfields and spring annuals research. Boundary with B3 will include grey shrubland and rock outcrop areas delivering high values under permanent stock exclusion.<br><br>**Kowhai protection strategy:** Remnant kowhai trees within mine site buffers protected and maintained throughout mining. All retained trees fenced within rabbit-proof exclosures up to 1000m² in size. Exclosures planted with kowhai sourced from on-site (using cuttings taken before removing trees) and seed/seedlings from fertile off-site stands to enhance fertility and genetic resilience.<br><br>**Enhanced species establishment:** Highly palatable species planted within fenced areas with capacity to grow above rabbit browse height within 20 years. Additional kowhai seedlings added where defendable in low fire risk areas. |
| **MRZ-B3** | **Mine Regeneration Zone B3** | **Zone function and boundaries:** Connects high-elevation Ardgour Conservation Reserve to lower-elevation native ecosystems in Bendigo Historic Reserve, forming ecologically enriched halo around Shepherds ELF and TSF. Southern boundary yet to be finalized, but if placed along Jean | **Browse control strategy:** Long-term destocking and mammalian pest browser control (deer, goats, pigs, rabbit |

| Management Units | | Description (landscape and ecology focus) and key risks | Rehabilitation and Closure Strategy |
|---|---|---|---|
| Label | Name | | |
| | Taramea and Olearia | Creek near SRX landforms, cattle could degrade seepages serving as water supplies, reducing benefits to Jean Creek headwaters.<br><br>**Existing vegetation:** Area contains remnant kowhai and areas of taramea amid grey shrubland, short tussock, brier and pasture grasses.<br><br>**Management priorities:** Primary priorities to enhance ecological values of currently degraded ecosystem and provide increased flow and diversity of native propagules across and into SRX pit and SRX ELF, soil stockpiles, Shepherds ELF and TSF. Also protects and enhances Jean Creek's riparian zones and seepages, and ephemeral streams and seepages that will flow onto southern side of TSF at closure.<br><br>**Aquatic connectivity:** Watercourses serve as sources of aquatic invertebrates that inoculate permanent diversion channels, swales and rehabilitated wetlands.<br><br>Key risks associated with the rehabilitation of this management area include the following:<br><br>**Note:** Key risks are the same as for MRZ-B2 with the following additions:<br><br>8) **Cattle access impacts:** Area not maintained free of cattle. Riparian areas, seepages and wetlands degraded, impacting water quality and ecological function.<br><br>9) **Mammalian pest browser impacts:** Pest browsers (deer, goats, possums, pigs and hares) reach high enough densities or frequencies to impact regenerating vegetation with highly palatable seedlings (specifically re-introduced) and plants within browse height. | and hare, and possums) to levels allowing palatable species to regenerate and grow above browse height.<br><br>**Species diversity enhancement:** Plant species diversity enriched using enhancement planting over 10-20% of area with diverse range of palatable native species. Nursery-grown seedlings include high proportion of species now absent from site and species at very low densities (restricted to refugia).<br><br>**Taramea patch management:** Large taramea patches interplanted with low densities of Olearia species.<br><br>**Kowhai tree treatment:** Remnant kowhai trees treated per MRZ-B2 methods but initially without rabbit fencing as most of MRZ-B3 is at higher elevation with stock exclusion so likely to develop a denser and taller ground cover that is less favourable for rabbits; however, may require initial hare protection as individual plant guards. |

<table>
<tr><th colspan="2">Management Units</th><th rowspan="2">Description (landscape and ecology focus) and key risks</th><th rowspan="2">Rehabilitation and Closure Strategy</th></tr>
<tr><th>Label</th><th>Name</th></tr>
<tr><td></td><td></td><td>10) Taramea regeneration failures: Taramea seedlings do not regenerate as quickly as expected or are consumed by hares. Mature plants continue to be damaged by pigs, compromising population recovery.</td><td></td></tr>
<tr><td>MRZ-A</td><td>Mine Regeneration Zone A</td><td>Zone connectivity: Connects high-elevation Ardgour Conservation Reserve to low-elevation Ardgour Sanctuary, creating biodiversity halo that benefits both areas and extends into mined zones.<br><br>Buffer requirements: Unit set back minimum 50m below Ardgour Rise road to maintain low-biomass fire buffer and 250m below airstrip to allow continued grazing and airstrip use, which supports important moth species in area.<br><br>Management priorities: Focus on maximizing native regeneration on northern side of main ELF and TSF while protecting Shepherds Creek headwaters, seepages, and riparian zones.<br><br>Vegetation characteristics: Area contains dense taramea and is suitable for re-establishing snow tussock.<br><br>Key risks associated with the rehabilitation of this management area include the following:<br><br>Note: Key risks are similar to MRZ B-3 with the following additions:<br><br>• Snow tussock establishment failures: Snow tussock does not establish as quickly or successfully as expected, limiting vegetation diversity and ecological function.<br><br>• Fire buffer inadequacy: Fire buffer zone above MRZ-A not as effective as required, creating risk to ecological investments and infrastructure.</td><td>Regeneration support: Long-term destocking and pest browser control implemented to support palatable species regeneration alongside targeted weed control.<br><br>Enhancement planting coverage: Enhancement planting covers 10-20% of area, focusing on sheltered, high-moisture sites.<br><br>Snow tussock establishment: Snow tussock planted at higher densities (0.8-1.2m spacing, minimum 5,000 plants over 10 years) in favourable locations within about 10 ha.<br><br>Management technique refinement: Techniques refined based on adaptive management, and are likely to include soil decompaction, scarification, mulching, basal fertilisation, and plant-release methods focusing on rock outcrops and stock camp areas.</td></tr>
</table>

# APPENDIX B. VEGETATION SUCCESSIONS AT SANTANA PROJECT MINE AND MINE ADJACENT REGENERATION ZONES.

## B.1. Summary

The rehabilitation approach for the Santana project plans to deliver four main vegetation associations that will be rehabilitated (in mined areas) and enhanced overall (in the wider area covered by Mine Regeneration Zones[1]). These vegetation associations form a mosaic that currently favours plants that tolerate pastoral farming practices but will be enhanced with components of historic ('pre-degradation') ecosystems that can be sustained by new management that prioritises ecological outcomes (Santana), and considers future risks of fire, drought and browse. There is no single 'pre-degradation state' to return to that would be resilient under current, or future climate or management. Instead, a range of vegetation associations is needed.

This document summarises the evidence on which the four 'rehabilitation' vegetation associations are based. Evidence is presented in three sections: the range of historic ecosystems (at three time-periods), likely vegetation successions and current ecosystems. Stresses that drive the current vegetation mosaic are described. Rehabilitation management is designed to accentuate differences in drought stress and grazing/browse pressure to sustain a mosaic, and favour persistence/expansion of the highest-value components. These components are cushionfield (characterised by Raoulia) and spring annual herbs which generally occur within cushionfield.

The key findings are summarised in the following aspects.

**Ecosystems present before current state (part 2)**. Aerial photos show a marked increase in woody vegetation (kanuka and grey shrubland) and non-native grasslands/vineyards/orchards and decrease in cushionfield since 2003 on Ardgour and ~1975 in lower Bendigo slopes[2]. Large areas have no pre-human vegetation associations present today (McGlone 2001). There is general agreement that the current kānuka or Olearia scrub/treeland (T12 in Singers and Rogers classification) was present 50 to 100 years ago and that kanuka (*Kunzea serotina*), although present before burning, did not form the extensive cover present today. Kanuka has increased because

---

[1] Note 'overall', as the scale at which management is applied favours specific vegetation in each management unit – e.g. cushion herbfields in MRZ B1 (browsed) and grey shrubland in MRZ B3 (removal of browsers) which means highly palatable plant species will remain in low abundance in most of MRZB1 and abundance of plant species vulnerable to shading will gradually reduce in MRZ B3

2 Rocky Point aerial photo assessment (the report also considers accelerated woody thickening in the last 6 years with stock removal). RMA Ecology draft ''Aerial analysis for veg cover Argour&dry Creek 2003-20020.wpd' shows similar patterns since 2003.

it is tolerant of fire and grazing. However, there are divergent opinions on what was present ~800 years ago, before more frequent fires were initiated by early Māori.

ORC maps (ArcGIS Enterprise - Otago Ecosystems and Habitats) show kanuka/olearia scrub/treeland present with significant areas of a second vegetation type – totara - (*Podocarpus hallii*), celery pine (*Phyllocladus alpinus*) and broadleaf (*Griselinea lucida*) forest. However, all three species have higher moisture-demand and lower fire tolerance than the dominant shrubland, and Wood and Walker (2008) show these species do not occur in macrofossils. Pole (2022) also found no evidence of species of 'wetter' forest such as broadleaf. Pole's work, based on 115 rock shelters and coprolites suggests large areas had a canopy dominated by kowhai and pittosporums with lower proportions of Malvaceae (ribbon wood or lacebark, Plagianthus or Hoheria, in 5% of shelters) and lancewood (*Psuedopanax ferox,* in 4% of shelters). It is therefore considered unlikely the 'wetter' species in the ORC maps would have been widely present in the Bendigo study area because the area is so dry, although they may have occurred in fire sheltered pockets along SE-facing stream banks (and proposed to be established in such areas).

**The vegetation mosaic today**, described in part 3, has been induced and maintained by five types of disturbance:

- **Fires** have stunted tussocks and restricted vulnerable species to refuges (rocky outcrops and raoulia slopes with low fuel loads); for example Pole (2022) found *Hebe cupressoides* in 32% of shelters, but none/few are now present
- **Mammalian grazing and browsing** has stunted/removed tussocks (notably snow tussock from higher elevations, toetoe from wetlands), removed palatable plant species to inaccessible refuges, supressed regeneration and/or removed foliage within browse height, e.g. kowhai, larger-leafed hebes (Veronica species) and native brooms (Carmichaelia)
- Stock (merino, cattle) **trampling**, rabbit **burrowing and scratching**, and probably farm vehicle **tracking** has limited vegetation cover on shallow soils and exposed soils to greater frost-heave and wind erosion, while leading to net soil deposition in gullies and leeward (south-easterly) slopes
- **Over-sowing** with non-native pasture species combined with **topdressing** with phosphate and sulphur fertilisers has excluded native species (and allowed establishment of non-native plant competitors
- **Physical clearance** by cattle trampling and browse, and mechanical damage by machinery combined with herbicides (aerial and ground-based) has constrained expansion of grey shrubland and kanuka in some areas.

These disturbances have favoured fire-resistant, unpalatable species and development of areas mapped as 'depleted herbfields' by RMA Ecology that are dominated by cushions and mats of *Raoulia* (scabweed) species in areas where pasture is not competitive. These herbfields have high conservation values due to a rapid decline in their area and presence of both threatened plant and invertebrate species; they also support skinks and geckos. The flora has been mapped in the Direct Development Footprint (DDF)and wider landscape in various complementary ways, as: plant-associations; locations of taramea near the DDF and of remnant kowhai trees (Fig X); heat maps showing probability of spring annual herbs presence (Fig  X) and cushionfields (Fig X); and comprehensive lizard and invertebrate data including locations of an important weevil linked to taramea and an important moth linked to herb field (Fig X). These figures are based on RMA Ecology and Habitat NZ surveys from late 2023 to early 2025.

*Figure 2: Left. Grey shrubland on Ardgour southern upper slopes. Browse has removed lower branches and leaves. Right: a site with hollows where sheep have 'camped' and extremely heavily grazed sheltered (photos Sept 2024 before the spring flush of growth).*

## B.2. Native vegetation types previously present

It is probable the Bendigo landscape has always comprised a mosaic of vegetation types differentiated by stress and disturbance. The succession pathways follow in reverse to a limited extent if native seed sources are present and if the conditions that maintained the 'before' species are present, hence diversity is higher in areas inaccessible to browsing mammals. Even in these areas, woody seedlings may only be able to establish in unusually wet summers, and/or specific sequences of La Nina/El Nino (and/or other global patterns) when extended periods of lower stress that give time for seedlings to develop roots deep into soils (roots systems extending more than 2 m depth have been observed for Olearia and matagouri on site), and in suitable microsites 'primed' by facultative vegetation (including brier), disturbance and reduced moisture stress (e.g. rock stacks, swales). The vegetation types that were previously present are described below as three phases: before Māori settlement, before European pastoralism, and in the pastoral intensification era.

### B.2.1. Prior to Māori settlement (>700 years ago)

The best evidence on prehuman vegetation is documented by Pole (2022) who studied macrofossils and coprolites from 112 rock shelters at lower elevations in gorges adjacent to the river Clutha, in the same dry, high-stress Land Environments NZ (LENZ) Level IV environments as the Bendigo site (mainly N4.1e, N4.1d, and N4.2c)[3].

Pole analysed samples of mid-late Holocene dried leaf material from 115 rock shelters, identifying the taxa using epidermal details of the leaf cuticle. He writes "Based on it being the only large tree in the area now, and the nearly ubiquitous presence of its leaves in the shelters, the most important plant in the area is considered to have been *Sophora microphylla*. Based on the size of old, relict trees that remain, kowhai likely formed a forest with a continuous, but low (perhaps 14 m) and open canopy over the study area. Other trees which were present and are entirely absent (or almost so) from the area now include *Pittosporum tenuifolium* and *Pseudopanax ferox*. They suggest more closed canopy forest, perhaps in more localized areas, but were subordinate to *Sophora*. However, other common plants included *Carmichaelia*, *Rubus*, and *Hebe cupressoides* that are more suggestive of lower, open vegetation". Importantly, Pole found that there was "no indication of a conifer component or of 'wetter' forest trees such as *Nothofagus* and *Griselinia*".

Pole's analysis of moa coprolites supports this conclusion, He writes "Cuticle within the largest associated coprolites indicate that moa (Aves, Dinornithiformes) was ingesting a similar range of plants as the shelter material. Of particular interest is that moa clearly ate *Sophora microphylla*, the first evidence for this. Together these data suggest a Central Otago ecosystem where a low *Sophora microphylla* forest predominated and was utilized and perhaps maintained by moa."

Pole's (2022) study found the 'whip-cord' *Hebe cupressoides* present in 31 (37%) of shelters in the Cromwell Gorge. This fire-sensitive species is now found only very sparsely on the fringes of Central Otago, with the closest known specimens near Luggate and a streamside in Dunstan Creek 20-30km away. Bathgate (1922) referred to *Hebe cupressoides* as an element of "scrub in the riverbed" in Central Otago and its common shelter remains suggest it was common in pre-human shrublands. *Olearia* (which could not be attributed to species) was in about 10% of rock shelters in Pole's study.

Pole's analysis is convincing and is backed up by more geographically limited studies. Wood & Walker (2008) found *Pittosporum tenuifolium* leaves along with a range of

---

[3] Land Environments of New Zealand LENZ » Manaaki Whenua

lianes (including *Scandia*). Two Podocarpus seeds but no leaf macrofossils were found in any of the 115 rockshelters. As Pole (2022) points it is very unlikely that there was Hall's totara growing in the vicinity and more likely that the two seeds were transported from elsewhere, especially upslope where snow totara is still common and was probably more so in pre-human times. Wood (2008) identified moa nesting material from the gorges was *Muehlenbeckia*, *Malvaceae* (either *Hoheria* or *Plagianthus*), *Plagianthus regius*, *Coprosma* sp., *Olearia* sp. and (a non-whipcord) '*Hebe* sp. cf *odora*'.

Conifers were absent in Pole's samples. Kānuka (*Kunzea serotina*) occurred as a macrofossil only very rarely in Pole's sample (only two fragments of *Kunzea ericoides* leaf were found). Kānuka is currently rare within the catchments of the proposed mine site, although it is common on rockier ground in Bendigo Scenic Reserve to the southwest. Aerial photographs from the 1950s sourced from Retrolens show only sparse shrubland in the Scenic Reserve, so the kānuka has only recently consolidated there recent decades. There is no evidence that it occurred previously, and Pole's conclusion that *Kunzea* (and similarly *Leptospermum*) are anthropogenic is well founded.

Environments on the eastern slopes of the Dunstan and Pisa ranges are moister and are not analogous to those at Bendigo. Unlike the northwest-facing slopes of the Dunstan Mountains, the eastern and southeast facing range slopes will have supported less drought-tolerant tree species such as beech, Hall's tōtara (*Podocarpus laetus*), broadleaf and toatoa. For example, in the Waikerikeri Gorge on the eastern flanks of the Dunstan Mountains, several old, clearly relictual *Griselinia* trees, a single *Pseudopanax* and many *Podocarpus* are growing at about 700 m above sea level (Pole 2022). There is no empirical evidence that any of these 'wetter forest' tree species were ever present at the much drier proposed mine site. If they were present (and Ardgour's owner reports seeing totara stumps in gullies decades ago) the empirical evidence suggests they were only ever a minor and localised component of the vegetation.

### B.2.2. Before European pastoralism (about 175 years ago)

We have no accounts of the vegetation on the eve of European settlement, but the charcoal record tells of unprecedented and repeated burning throughout the period of Māori occupation and hunting (Rogers et al. 2007). Since fires were rare until Māori settlement, the woody vegetation was probably very rapidly and then progressively further depleted, with periods of regeneration interspersed with further clearance and retraction to fire-refugia. In this period, tall tussock grassland expanded greatly downslope from probably very localised range-top environments, and repeated burning ensured that woody components were relatively few.  Short tussocks and a range of other herbaceous species would have greatly expanded their ranges in lower, drier environments cleared of fire-sensitive woody species in the absence of browsing and grazing mammals and birds. Increases in large-grained and small-grained Poaceae (grass) pollen track this transition (Rogers et al. 2007).

### B.2.3. Era of early European mining and pastoralism (about 175 to ~75 years ago)

During the 1850s gold miners removed remaining wood for fuel and structures, and then a rapid "cleaning out" of palatable species occurred alongside further retraction of fire-sensitive species as European sheep farming began. Mather (1983) describes the changes based on early botanical accounts, "The combination of frequent burning of the vegetation and overgrazing soon resulted in a perceptible decrease in vegetation cover, such that land deterioration accelerated in the 1870s and 1880s when a rabbit pest irrupted. No effective action was taken to deal with the problem of land deterioration, and by the early part of the twentieth century parts of Central Otago were described as man-made desert. The tussock grassland had given way to almost bare soil interspersed with patches of Scabweed (*Raoulia lutescens*[4]), and accelerated soil erosion resulted in slope-wash and gullying."

Mather's synthesis and accounts by O'Connor show stocking rates and stock carrying capacity dropped rapidly as vegetation was stripped. Because the taller elements of the indigenous vegetation had little resilience, and rabbits and sheep were still present, plant stature recovered only slowly if at all, protracting desertification. Bendigo and stations to its north were among the most denuded pastoral leases, comparable to Earnscleugh and Galloway in the Alexandra basin, because they have extensive areas of north-west-facing, drought-prone slopes. Repeated rabbit plagues and cushionfields were widespread below about 700m through much of the 20th century. There was also widespread soil erosion, redistribution and loss which Hewitt describes from the climatically similar Conroy land system (Hewitt 1996). At higher elevations, snow tussock and its shrub elements were depleted, and snow tussock could be eliminated when fire was followed by grazing (this is probably what happened west of Thompsons saddle).

### B.2.4. Pastoral intensification era

Widespread oversowing and topdressing commenced after WW2, along with more fencing and associated differentiation of land use by blocks. It is likely that cover of exotic grasses, clovers and (inadvertently) also shrubs were able to be increased on darker (moister) faces, creating vegetation less suitable for rabbits. However, on sunny, NW-facing drought-prone slopes the replacement of cushionfield with sward grasses

---

[4] Now *Raoulia australis*

was slower and less certain, probably dictated by year-to-year variations in weather, rabbits, merino stocking rates, and the farm budget available for oversowing, topdressing and rabbit control. Accordingly, cushionfields have probably waxed and waned with over the last 50 years. Concurrently waves of annual and herbaceous weeds (including Echium, sheep's sorrell, St John's wort, and thistles) have boomed at times and then settled back again.

More recently, introduction of cattle have severely damaged the wetlands and streambeds they prefer, collapsing stream banks and opening shrublands, especially on gentler relief. However, cattle have probably not spent long on dry spurs where cushionfields which afford little forage, and the main mechanical disturbance there is probably by merino trails and camps and rabbits.

### B.3. Present vegetation and remnants

Present vegetation associations (ecosystems) in the Direct Development Footprint and wider landscape are provided as mapped plant-associations, locations of taramea near DDF edges, locations of remnant kowhai trees, a heat map showing probability of spring annual herbs presence, and heat map for herbfields (cushionfields). Lizard and invertebrate data include locations of notable species linked to taramea and to herb field. Figures are based on RMA Ecology surveys from late 2023 to early 2025 for Santana. The vegetation forms a mosaic defined by slope, aspect, elevation and moisture:

- high-stress sunny spurs and faces: low to mid-elevation cushionfield (*Raoulia* dominant) with spring annual herbs and *Pimelea aridula*
- gullies within sunny spurs and gentle slopes: sparse short tussock grasslands of species of *Poa*, *Festuca*, *Deyeuxia* and *Rytidosperma*, with inter-tussock prostrate herbfield species with occasional taller shrubs including brier, *Coprosma*, *Olearia*, matagouri, *Carmichaelia* and *Melicytus*.
- 'dark', shaded faces at low elevations (<600m) and favourable sites above 600-700m: Sparse to dense *Olearia* scrub/treeland with the occasional relict kōwhai. The thickest shrubland is on south-facing slopes and most diverse shrubland around tors/rocky outcrops. Contains *Olearia*, *Carmichaelia* and *Melicytus* species, with korokia, matagouri, mountain tauhinu, lianes (*Muehlenbeckia, Rubus*) and perhaps locally in fire-sheltered sites *Myrsine divaricata* (still present in the vicinity today) and possibly (but not found yet) *Leonohebe cupressiodes*.
- high elevation herbfield – now dominated by short-tussocks (*Festuca* and *Poa*) and with sparse or local *Chionochloa* and taramea and *Ozothamnus* but would have included toatoa, snow totara and snow tussocks.
- seepages, riparian areas of ephemeral and permanent streams and wetlands. Scattered across slopes and valley floors, generally impacted by cattle.

Taller ecosystems in the project area are generally in poor ecological condition with severely depleted plant diversity, limited regeneration, and simplified tier structure (few lianes, few emergent trees, depleted groundcover) (e.g., Fig. 2 shows an extreme outcome). However, woody cover has thickened over at least the last 3 decades in deeper gullies and shaded or protected aspects. In the project area this recovery mainly consists of browse-resistant or tolerant species such as *Coprosma propinqua*, *Olearia odorata,* and matagouri, along with brier, and probably reflects many decades with lower frequencies of fire, a general decrease in rabbit numbers since the 1990s and the introduction of RCD, and possibly replenishment of nutrients by oversowing and topdressing. It differs markedly from thickening in Bendigo DOC Reserves, where kānuka has dominated.

*Figure 3: In the Santana project area landform, elevation, and aspect combine to create a mosaic of more-sheltered, less-stressed areas with higher cover of woody plants (predominantly grey shrubland). The left photo shows mid to higher-elevation areas where cushionfields are sparse to absent (photo April 2024). The right photo shows cushionfields with Raoulia australis mats in the foreground and on the higher slopes above a band of sparse short tussock and shrubland (photo September 2024 before the browning-off of exotic herbs and pasture species).*

The BOGP site area also contains scattered kowhai trees (Fig. 4), some of which occur in patches likely to have regenerated from single remnant individuals. These are generally on lower-biomass slopes that could be fire refuges; rarely on rock outcrops or area with high rock cover.

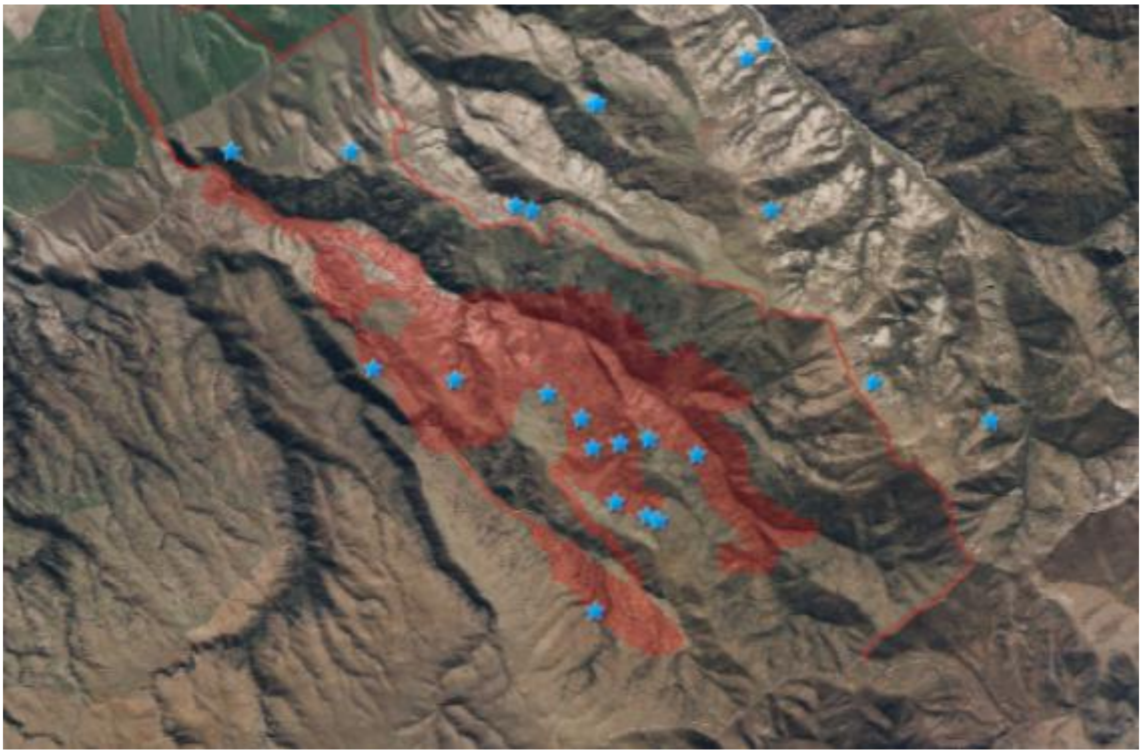


*Figure 4. Map showing confirmed locations of individual and small groups of kowhai, February 2025. RMA Ecology April 2025*

Woody non-native plants have also been ecosystem transformers in the wider landscape. At the site only brier is widespread. Brier may be transitory and may facilitate establishment of native species in drier sites. However, other smothering non-native plants that could degrade grey shrubland are present in low densities and in the wider area. An undated DOC report reports wilding pines and *Clematis tangutica* as primary weeds of concern for Bendigo Reserves. Adjacent farms have a range of woody weeds that present risks in the medium-term including willows and bird-dispersed woody shrubs (which may include elderberry, hawthorn, boxthorn, maybe rowan). A range of Nitrogen-fixing and drought tolerant non-native species were established in historic trials below Welsh town. Surveys associated with the Rocky Point subdivision recorded *Pinus radiata* and *Pinus contorta* in kanuka, *Buddleja davidii* in cushionfields, flowering currant (*Ribes sanguineum*) and cotoneaster (*Cotoneaster franchetti*) becoming well established amongst brier shrubland, and wild plum (*Prunus sp.*), flowering currant and stinking iris (*Iris foetidissima*) along the lower northeastern slopes of the site (ref). In areas nearer to Alexandra, raoulia and annual herb habitats are being smothered by thyme, stonecrop (*Sedum acre*), pasture grasses (especially taller bunch grasses) and other herbaceous weeds with stonecrop a particular threat to depleted herbfields[5].

[5] Succulent leaf and stem fragments root, giving it a creeping habit. Quick maturing; produces very many, relatively long-lived and well-dispersed seeds. Tolerates wind, salt, very hot to hard frost, drought, poorest soils. Seed, stem and leaf fragments spread by soil, wind, water, road graders, traffic and gravity. Forms mats that can exclude almost all other species

MATAKANUI GOLD LIMITED

## B.4. References


Brown and Company Planning Group. 2024. Application for Resource consent for a comprehensive residential development at Rocky Point, Cromwell. Updated 26 July 2024. (contains additional investigations) including Beale S, Wells A. 2024.Rocky Point Ecological Assessment (Attachment H)

Ewans E 2024. Evidence of Richard Andrew Ewans (Technical Advisor - Ecology) on behalf of the Director-General of Conservation Tumuaki Ahurei Dated 11th November 2024. TKO Holdings Ltd for a residential development and subdivision at Rocky Point, Bendigo. (ORC case 230179)

Gosden 2023. An observation of *Aciphylla aurea* recovery following the exclusion of lagomorphs in the Canterbury High Country. Pp 37-45

Harding M. 2024. Application by TKO Properties Limited for a residential development and subdivision at Rocky Point, Bendigo Supplementary Statement Mike Harding Terrestrial Ecology, 20 November 2024

Harding M 2024. Application by TKO Properties limited for a residential development and subdivision at Rocky Point, Bendigo (RC230179). Supplementary statement. Terrestrial ecology. 20 Nov 2024.

Heenan PB, Shepherd LD, Teele B, Wood JR 2025. Identification of late Holocene kōwhai (Sophora, Leguminosae) seeds from Central Otago dry rock shelters using nuclear DNA markers. New Zealand Journal of Botany 63:133–141.

McGlone 2001 The origin of the indigenous grasslands of southeastern South Island in relation to pre-human woody ecosystems

McGlone MS, Wood JR 2019. Early Holocene plant remains from the Cromwell Gorge, Central Otago, New Zealand. New Zealand Journal of Ecology. Jan 1;43(1):1-8.

Mather AS. 1982. The desertification of Central Otago, New Zealand. Environmental Conservation. 9:209–216. doi: 10.1017/S0376892900020415

Pole M. 2022. A vanished ecosystem- *Sophora microphylla* (kōwhai) dominated forest recorded in mid-late Holocene rock shelters in Central Otago, New Zealand. Palaeontologia Electronica Vanished Ecosystem

Nicholls R 2024. Rocky Point evidence Nov2024

Rogers G, Overton JM. 2007. Land use effects on 'spring annual' herbs in rare non-forest ecosystems of New Zealand, NZ Journal of Botany 45:2 317-327 https://www.tandfonline.com/doi/pdf/10.1080/00288250709509720

Rogers GM, Walker S, Basher LM, Lee WG 2007. Frequency and impact of Holocene fire in eastern South Island, New Zealand. New Zealand Journal of Ecology 31:129-42.

RMA Ecology (unpublished) ‘Aerial analysis for veg cover_Ardgour&dry Creek 2003-20020.wpd’

Wells A, Beale S, Lloyd K. 2024. Vegetation succession and climax communities at Rocky Point. WC Contract report 7080a. Prepared for TKO Properties Ltd. 44p (Appendix 6 in AEE)

Wood JR 2008. Moa (Aves: Dinornithiformes) nesting material from rock shelters in the semi-arid interior of South Island, New Zealand. Journal of the Royal Society of New Zealand 38:115–129.

Wood JR, Walker S 2008. Macrofossil evidence for pre-settlement vegetation of Central Otago's basin floors and gorges. New Zealand Journal of Botany 46:239–255.

# APPENDIX C. POST-MINING REHABILITATION METHODS FOR LIZARD HABITAT AT THE BENDIGO-OPHIR PROJECT

This appendix describes the lizard species in the Bendigo-Ophir project footprint, their habitat requirements, and methods for salvage and rehabilitation of lizard habitats within mined areas and adjacent edges of Mine Regeneration Zones. Lizards are locally abundant in suitable habitat across the site. Rehabilitation of lizard habitat requires establishment of shelter (suitable rocks and structural plants such as tussocks), food (invertebrates and plants) and suitable temperature and moisture regimes over interconnected territories[6]. **The density of suitable rock refugia is a fundamental control on lizard density (particularly gecko density).** Although smaller rocks will be stripped with soil (so respread on area to be rehabilitated) and some scree will form as pit highwalls weather, the high-value, stable, long-lasting (centuries) rock outcrops/stacks must be added to mined areas (Fig. 1) as they will not otherwise be present. These rock outcrops/stacks also provide lower-stress microclimates and refugia that can support a wide diversity of plants if grazing is controlled. **Rock refuges are also plant refuges as they create and sustain plant diversity and invertebrates**, especially through fires and climatic extremes. The rock stacks created for lizards are a visible part of the rehabilitated landscape, so their placement on rehabilitated landforms should complement natural patterns and avoid creating obviously artificial constructed patterns. T**he salvage and reintroduction of larger tussocks is a second fundamental component of rehabilitation of mined/stripped areas.** These are likely to re-introduce microbes and invertebrates concentrated in the protected plant and root bases of tussocks and may reintroduce tussock leaf mining invertebrates. Concentrating these tussocks in clumps and adding to them with nursery-raised (or seeded) tussocks is more likely to be effective at enhancing locations for invertebrates and lizards than spacing tussocks widely. Many mammalian predators of lizards are present (mustelids, cats, hedgehogs, pigs, mice). Although predator control is proposed for the duration of the project, the rehabilitated tussock and rock features are designed to provide long-term habitat refuges that secure lizard populations irrespective of the level of predator control delivered in the future.

This section describes success criteria and methods used to develop rehabilitated habitat on mined land for lizards: dense tussock areas, individual rocks and rock refugia created as rock stacks and rubble pits with suitable native plant species and

[6] Herbert et al (2025) note '*With high initial and ongoing resources required for effective predator control, creation of self-sustaining, high-quality habitats is an attractive complementary strategy for conserving New Zealand's endemic lizard fauna (Norbury et al. 2014). Habitat enhancement is encouraged for lizard conservation in New Zealand and has been used to attempt to mitigate adverse effects of land use change or development on lizards.*

initial densities that will naturally spread into adjacent areas. Photographs and figures are used to illustrate key points. Photos include examples of higher quality (acceptable) and low quality (unacceptable) rehabilitation outcomes. The benefits of rehabilitation will be quantified by monitoring lizard colonisation and population abundance as described in the Lizard Management Plan or Biodiversity Effects Management Monitoring Plan.

### C.1. Lizard species and habitat needs

Although three lizard species are present, rehabilitation of lizard habitat on mined land focuses on the two threatened species: Kawerau gecko and southern grass skink. The **Kawerau gecko** is a nocturnal species requiring refuges of deep, clean cracks 5 to 20 mm wide[7] between, and under, rocks and boulders. These rocks and boulders range from A4 paper-size to house-size. Trees such as old kowhai with fissures probably also provide suitable habitat, however these are sparse (12 individual trees or small groups are mapped within or near the mine footprint). The Kawerau gecko lives in communal, multi-generational 'harems' with single males and groups of females and young together in one refuge. Lizard habitat currently probably covers 60 – 100 % of the project site in the various habitat types, even across very sparsely vegetated areas such as cushionfield (mapped as depleted herb-fields by RMA Ecology) where small rocks are present. However, lizard densities are highest within relatively open areas that have suitable individual rocks and rock outcrops or stacks. Up to 20 geckos were recorded under single artificial habitats (ACOs) that were deployed for 10 months, indicating such artificial retreats can also provide temporary replacement or additional habitat if needed. **Southern grass skinks** are in higher densities in areas with moderate to high sedge (or tussock) cover, particularly in moister areas such as ephemeral wetlands and in combination with rocks or divaricating plants/vines which provide cover. **McCann's skink** is also present across the site. This species is much more abundant, is not threatened and appears to occupy habitats used by both Kawerau gecko and southern grass skink. This indicates it is likely to benefit from the rehabilitation practices focused on the two threatened species.

All three species:

- These lizards have varied diets that include berries, nectar, and invertebrates. The habitat restoration strategy incorporates several approaches to support this dietary diversity. Transplanting salvaged tussocks serves as biological "seeding"

[7] It would be useful to include measurements during lizard salvage to determine the lower range, e.g. crack height (may be less than 5 mm) and depth. Optimum crack depth is probably 10 to 50 cm, narrowing towards the back as this provides greater thermal protection from cold and predator protection. Smaller geckos can use smaller rocks/cracks.

- these grass clumps harbour invertebrate communities that live within their root systems and the deep, moist organic matter that is concentrated at their base

- Benefit from habitat enhancement that involves adding organic mulches such as wood chips and potentially wool, along with placing large-diameter logs from salvaged trees like kowhai, willow, poplar, or pine. Creating small wetland areas within rock piles and excavated depressions further enriches the environment for soil-dwelling and leaf litter invertebrates that form a crucial part of the lizards' diet
- Benefit from the inclusion of native plant species that produce berries and nectar (referenced in Table 1), which directly provides food sources for the lizards while simultaneously attracting insects that serve as additional prey. This multi-layered approach aims to create a self-sustaining ecosystem that supports the lizards' complex nutritional needs
- Are vulnerable to predation, particularly larger individuals and when temperatures drop below ~1.5C (when they cannot move away from threats)[8]. Skink eDNA was found in guts of ferrets and one of five cats captured across the Bendigo-Ophir site by Habitat NZ. Rock stacks are designed to include crevices with narrow openings that allow lizards to hide in inaccessible areas and/or defend themselves against most predators. Design can also reduce the accessibility of bare rock basking areas to mammalian predators by including basking areas located at least 1 m above the ground and establishing ground or rock-hugging vegetation that is densely divaricating (porcupine shrub), thickly tangled (some vines), spikey (taramea), or thorny (bush lawyers). Rehabilitation establishes dense stands of tussocks and aids natural thickening of existing tussocks by removing browse and reducing weed competition (primarily with non-native pasture grasses)
- May be vulnerable to freezing temperatures in unusually cold years. Providing refuges that include rock sunk at least 1m[9] below ground, stacks with cracks >200 mm depth and dense adjacent vegetation aims to maintain warmer refugia in winter
- Are in lowest densities in the Project Area within dense *Olearia* or matagouri/ brier rose. These typically have depleted/absent ground cover, and in areas with

---

[8] Bogisch and Monks 2016 state *'habitat was created by ecosanctuary staff and volunteers using schist and other rock slabs to mimic rock tors used by Otago skinks in the wild elsewhere in Otago'* . They report *'Monitoring during the previous winter showed that temperatures of potential retreat sites at 200–650 mm depth within the rock piles remained above 1.5 °C, enabling skinks to avoid freezing (Sophie Penniket and Alison Cree, pers. obs.)'*

[9] to be confirmed with measurement of temperature within the refuges constructed in year 1 using the first rocks and boulders stripped during opening works per Turner et al 2024

non-native pasture grasses may be closely grazed or bare ground with few rocks e.g., the air strip surface or earthy bunds along the side of the roads and drill tracks (Fig. 3). Removing grazing from most areas of grey scrub will allow thickening of groundcovers, including tussock when combined with selective control of competition from non-native pasture.

- Are in highest densities in the Project Area within outcrops, tussock, sedge and cushionfield (particularly where rocks are present) and taramea (Fig. 4). Establishing rock habitats in rehabilitated areas and enhancing rock and tussock density along edges of stripped areas is designed to enhance lizard densities in areas from which they can spread throughout most rehabilitated areas.

### C.1.1. Rehabilitation objective for lizard habitat

Establish habitats suitable for Kawerau gecko over 20% of the rehabilitation area within 5 years of initial rehabilitation treatment by applying the specified soil and root zone reinstatement, rock placement and planting and other treatments prescribed in this section. Establish habitats suitable for Kawerau gecko and McCann's skink over 40% of the rehabilitated areas by closure (20 years post initial rehabilitation treatment) and at least X ha of sedge-enriched habitat for southern grass skink. These habitats will be representative of the types used by lizards across the site pre-mining, and under suitable pest plant and animal management are anticipated to gradually expand as vegetation and leaf litter develops and highwalls weather to create a mosaic of ecosystems that support expansion of the three lizard species in rehabilitated areas in the medium to long term[10]. This expansion and development will be supported by weed, mammalian browser and predator management with weed management and stock grazing varying by Mine Management Zones.

### C.1.2. Rehabilitation Methods

Enhance depleted lizard habitat along suitable edges of all excavated areas bordering undisturbed ground. Edges are nominally 5 m width (up to 8 m width being the reach of a digger arm depending on machine configuration). Salvage resources (rock, boulders, live tussock, dead taramea and porcupine shrub), and establish new lizard habitat on TSF, ELFs, soil stockpiles, haul roads and outer edges of highwall benches (Fig 2) to provide lizard access to highwall benches. Enhance overall[11] lizard habitat in Mine Regeneration Zones by increasing plant diversity and encouraging thickening. These rehabilitation methods include the following actions:

[10] Short term ~ 10 years, medium term ~XX years being the term of the resource consent, long term >50 years.
[11] Some shrubland thickening may reduce habitat for lizards, particularly if tussock density or cover is reduced; predator management will also influence lizard densities

- Strip, salvage and stockpile rehabilitation resources
- Salvage all weathered boulders during stripping. Either place boulders into 'suitable edges' of excavated areas or stockpile. Suitable edges are windrows/bunds and natural, undisturbed ground immediately adjacent to stripped areas (nominally 5 m width up to 8 m width depending on machine configuration, i.e. the maximum reach of an excavator to avoid trafficking undisturbed ground) where the undisturbed ground has >25% non-native pasture cover and <25% boulders/rock cover (on a nominal assessment unit of 100 $m^2$)[12]. Place salvaged rocks onto non-native grass or clovers to achieve up to 50% rock coverage – this includes covering pasture or non-native herbs that are under grey scrub. Do not add rock to areas supporting spring annual herbs or cushionfield. Some rock may be used off-site in Predator Proof Zones. High value boulders for lizard habitat have deep (>200 mm) horizontal cracks 5 to 20 mm wide with no soil, but all weathered boulders must be salvaged as boulders are a scarce and valuable rehabilitation resource that even without cracks provide shelter and pockets of higher soil moisture
- Provide adequate stockpile areas and volumes for weathered boulders >500 mm diameter that are separate from soil and root zones (rocks <500 mm will be stripped together with soil and whole plants). Note: the cutoff diameter for separate salvage may be smaller, as it depends on the machinery used to strip soils and may be as small as 300 mm. Large boulders will need to be broken into transportable sizes
- Salvage live tussocks either by placing/planting into suitable edges or windrows (if suitable, e.g. not spring annual herb habitat) or to rehabilitation areas. Salvage at least 25,000 live tussocks, equating to 1.25 ha at 1m spacing (natural spacing in denser areas is often 0.4 to 0.6 m so if tussock 'bucket loads' are removed rather than individual plants, less space will be required). Once more than 25,000 tussocks have been successfully translocated[13], tussock may be placed in soil stockpiles, i.e. mixed with soil in full truck loads which will kill tussocks that are buried. The final outer surfaces of soil stockpiles are potentially valuable

[12] Grazing will be removed from most buffer areas other than those adjacent to Mine Regeneration Zone B1 where raoulia and spring annual herbs are prioritised. Combined with weed control, reduced browse is expected to allow natural expansion of individual plants in most areas and regeneration between plants in areas with ?>30% initial cover (by providing shelter and seed). Limiting rock placement to areas with ~<30% native cover allows space for this natural recovery.

[13] A suggested success criterion is 150 tussock habitat nodes, each with >50 tussocks surviving (i.e. a minimum 7500 tussocks) and each rock stack with at least 10 transplanted tussocks (e.g. if there were 500 rock stacks at least 5000 tussocks surviving). Success is maintenance of live tussock over 3 years following transplanting, although some dieback is likely following translocation, healthy regrowth should be present by year 3 with leaf lengths similar to those present before shifting. Target tussock species are identified as * in Table 1. Tussocks will have basal diameters >100 mm and full root depth (nominally 300 mm depth as larger plants are generally more resilient to shifting). Resilience to shifting may be increased by avoiding grazing by cattle in the growing season prior to stripping to allow tussock to build up carbohydrate supplies.

areas in which mixed tussock and soil may survive and regenerate, or into which individually stripped tussocks could be stored. Mine schedules and stripping methods need to be prioritised this for it to happen and be successful (spring and early summer is likely to be most successful and summer the least successful time). However, even a stockpile surface of salvaged live or dead tussocks will help reduce dust erosion from the soil stockpiles and rehabilitated areas (irrigation may have the dual benefit of supressing dust and enhancing tussock survival)

- Salvage all taramea (including at least the upper 300 mm of root systems) and at least 50% of porcupine shrubs (above-ground parts) from stripped areas. Place these along suitable edges and into rehabilitated rock stacks when and where scheduling permits. Suitable rock stacks for taramea will be at higher elevations and relatively near to undisturbed populations. Both taramea and porcupine plants provide long-lived cover even though they are unlikely to survive shifting. Shifting taramea may also inoculate soils and leaf litter with a range of invertebrates[14], while porcupine shrub seed or root regeneration might occur within protected microsites within rehabilitated rock stacks
- Construct lizard habitats in rehabilitated areas (Fig. 1). Each lizard habitat includes a rock stack and surrounding sparse rocks with clusters of planted tussock and shrubs at an average density of 1 per ha,. These rock features will not be built on pit walls, lakes or wetlands. Clusters of rock stacks will form 'habitat nodes' designed to cover 20% of the site, excluding highwalls, by 5 years post-construction. Construction methods will be refined within 3 years of mine opening and include monitored rock stacks on the Western ELF. Individual truck loads may be unloaded over trenches at least 1 m depth that are excavated into final landforms within rehabilitated areas that have been covered with root zone, including soil. An excavator with grapple may be used to stack rocks to create clean, horizontal crevices, and place or throw less suitable rocks (smaller or rounder) from the pile into adjacent areas. At least >100 rocks/ha will be exposed on rehabilitated surfaces by either 'throwing' rocks from the piles or 'rock picking' from spread soils where they contain adequate rock or adding additional rock
- Create 'Rubble pits' at a minimum density of 1 per 5 ha. These do not need to be associated with rock outcrops/stacks (Fig. 1)

[14] Taramea may also host specific high-value invertebrates. These are subject to specific requirements.

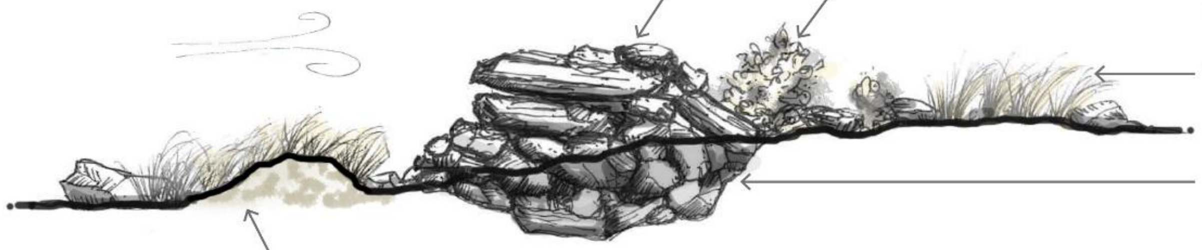
- Establish ROM rock volumes and suitability for lizard habitat, i.e. platey/shale forms, probably TZ4 geology (Rufaut et al 2020; Aitken et al 2025) as fresh rocks are unlikely to have crevices
- Establish vegetation at 'habitat nodes' by planting tussocks, shrubs, taramea and vines within and adjacent to rock stacks (generally concentrated in areas with greater shelter and where runoff concentrates), and as groups of > 50 tussocks with interplanted olearia away from the rock outcrops/stacks in more sheltered, higher-moisture areas (i.e. shallow bowls, changes from steep to gentle slope, and swales where runoff concentrates)
- Inoculate habitat nodes using salvaged live tussock and taramea and invertebrate-supporting materials (dead porcupine shrub, mulch, compost, wood chips and/or possibly wool. Low-value fleeces may contain plant seeds, so will need to be screened using germination trials and information on farm location, taking care to avoid farms containing thyme or stonecrop
- Treat benches where highwall intersections with natural ground to enhance access to benches for lizards (and their use of shale/loose or frittering rock). Treatment will include placement of a rootzone of weathered brown rock and soil to create wedges at the points where benches intersect natural ground extending at least 20 m along each bench. These wedges will cover 75% of the width of the bench >300 mm depth and target a 4 m depth at the inside base of each bench. These wedges underpin natural establishment of a dense plant cover from propagules sourced from adjacent buffers (which are enriched) (Fig. 2) and invertebrate and lizard movement onto benches. Other methods to enhance vegetation establishment into these small areas may also be used, depending on accessibility and likely outcomes (e.g. hydro mulching, seed bombing)
- Create lizard habitat on outer faces of long-term bunds and stream diversions by placing loose, clean rocks and translocated tussocks within a roughened (dimpled) surface. Such bunds will be treated to deliver outer slopes with at least10% cover of rocks >300 mm diameter and at least 20% cover of tussock, sedge or native shrubs within 3 years of establishment (area nominally including the base + 1 m to natural ground). When adjacent areas are rehabilitated at mine closure, parts of these bunds may be partly deconstructed and plants with their attached root zones gently moved to break up these otherwise linear features.
- Identify areas within MRZ that have high pasture cover and are seasonally wet or within 5 to 10 m of seasonally-wet vegetation. Establish native sedges that are facultative wetland plants (e.g. *Carex coriacae, C. demissa, C. geminata, C. secta, C. kaloides*) in these areas at ~1 m spacing over at least 5000 m$^2$ that achieves >75% sedge or tussock cover with mean top height greater than 30 cm height within 5 years.

### C.1.3. Notes

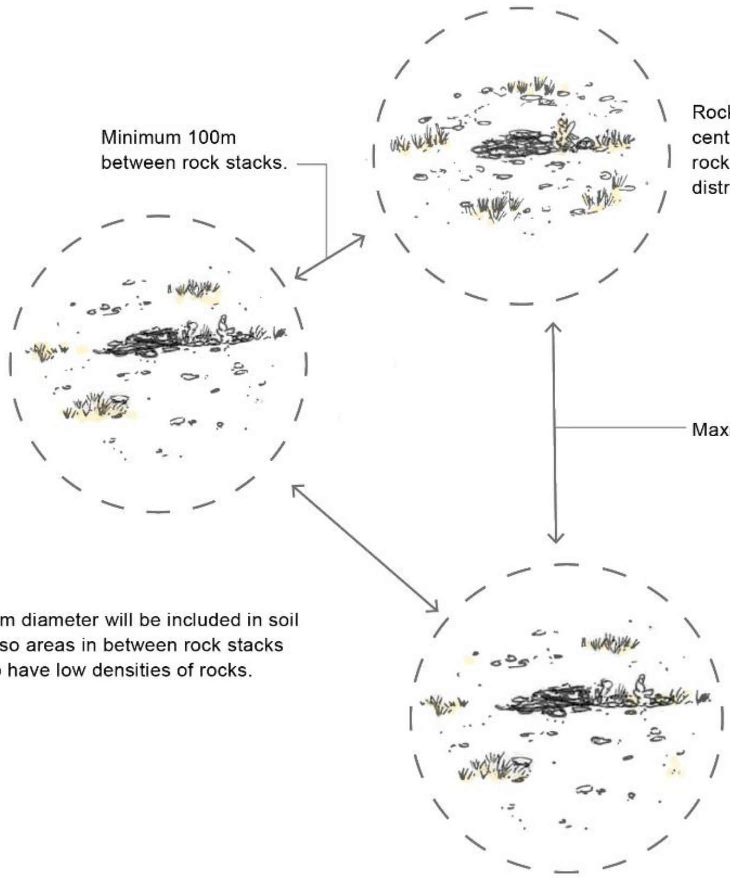
- Rock stacks and rubble pits will be placed on specific areas of the tailings, concentrating on the embankment and adjacent areas that are above the 10-year inundation zone. Both rock stacks and rubble pits will be generally placed on the higher ground and deeper root zones created by discontinuous bunds along swale edges. This allows trenches to be excavated without disrupting tailings as the root zone and capping layer is 1 to 1.5 m depth (the minim depth of capping layer is ≥0.5 m depth). No rock outcrops/stacks will be placed in the planned wetland areas or below the 1 in 10-year inundation zone. Tussocks and sedges will be preferentially clustered along swales where soils are expected to be moist for longer periods.
- No rock outcrops/stacks will be placed on high walls as the highwalls rocks will weather to form shale, large rocks could be a safety hazard and access is unsafe.
- No rock outcrops will be placed along the Shepherd Creek Valley floor within areas impacted by the plant area given the short-term light, noise and vibration and medium-term disruption that may be associated with water treatment infrastructure.

# ROCK STACKS

## TYPICAL FORM




## DISTRIBUTION

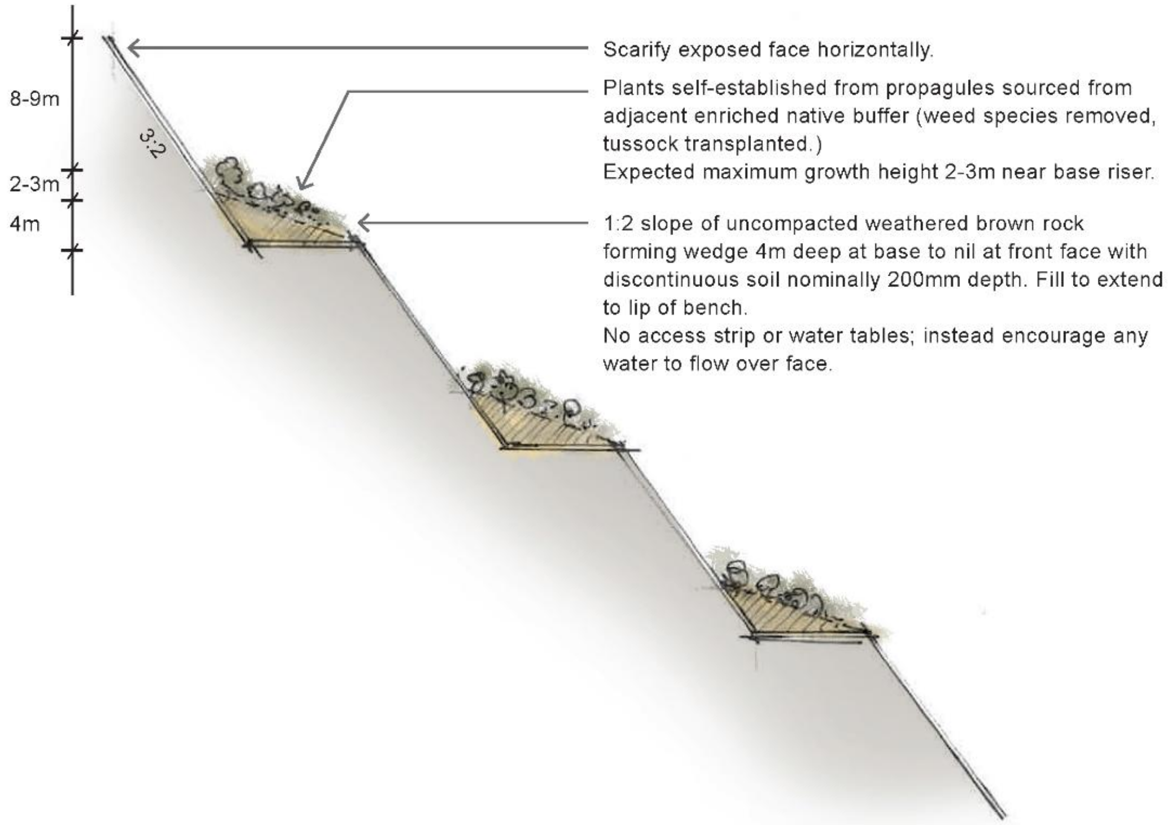



*Example of natural rock distribution within site.*

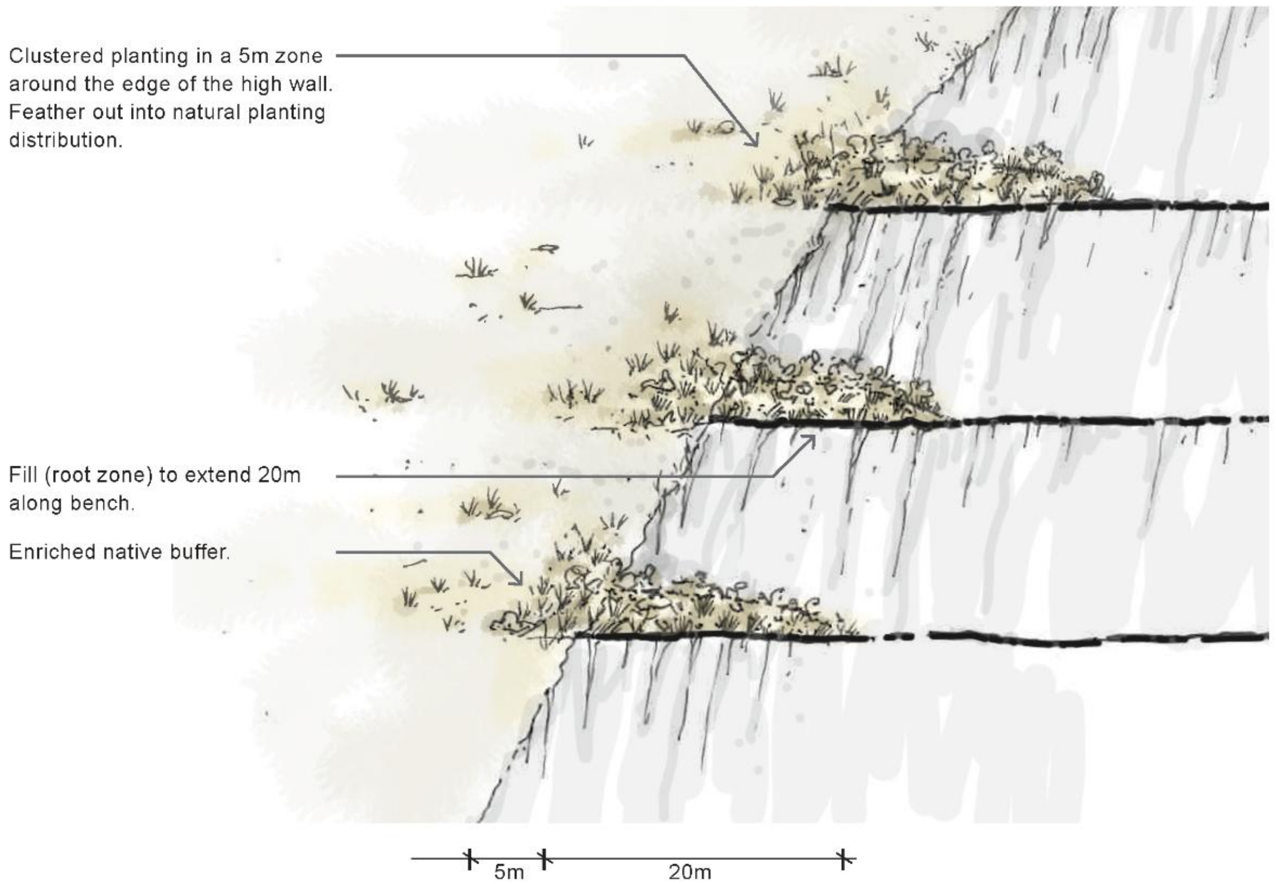
# HIGH WALL

## TYPICAL BENCHING MITIGATION

**Typical cross section where benches intersect with natural ground.**




**Elevation of benching fill.**



#### C.1.4. Success criteria

- Proof of concept: Rehabilitated rock stacks are occupied by skinks and geckos in trial areas over several years. These trial areas shall comprise at least 12 rock stacks completed within 2 years of mine development and be located in the Western-ELF and parts of Mine Regeneration Zones B1 or B2 that have low native plant and rock cover and are at least 100 m from natural tors/rock outcrops. Construction of these first rock stacks will identify the number, depth and width of interstitial gaps in constructed rock stacks and in an equivalent number of lizard-occupied tors, and the temperature in cracks ≥10 mm width and >200 mm depth in winter. Lizards will be released into new rock stacks no sooner than 1 growing season following their construction despite this providing limited time for invertebrate establishment for stacks established in the Western-ELF. Rock pile use by lizards will be monitored to quantify which relocated lizards use which features of rehabilitated rock stacks in areas with no initial lizards (i.e. Western-ELF) and rates of natural colonisation in areas containing resident lizards (i.e. MRZ).
- Rock volume. Adequate rock volume and type will be salvaged and stockpiled (and reported annually) or demonstrated to be capable of production from TZ4 or favourable geology as Run Of Mine rock. A minimum of 20% of rock outcrops/stacks will include salvaged weathered rocks.
- Number of rock stacks. At least 1 per mine rehabilitation ha, on average[15]. Each rock stack is made from at least 10, ≥0.5 m diameter rocks.
- Crevice size. Rocks must be stacked close together in at least 2 layers to create 5-20 mm interstitial gaps[16]. Target creating at least 20 discrete crevices of these dimensions (not a strict requirement), and clarify target based on proof-of-concept fieldwork to determine what a realistic design abundance of lizard-capable crevices is for the tor sizes proposed in this rehabilitation plan. Surface stripping and rehabilitation uses 40 to 50 T articulated trucks which carry 20 to 25 m3 material, so probably one truckload would be used for each rock stack with adjacent individual scattered rocks. Because a truckload is generally >10

[15] No rock stacks or rubble pits will be placed in pits or areas modelled to flood at a frequency of more than 1 in 10 years (e.g. pit lakes, wetlands including TSF, ponds).
[16] Some literature suggests skinks & geckos also use 10 to 30 mm gaps, hence the value of monitoring to refine the values for these species at this site.

rocks, rough dumping may deliver some suitable crevices. However, trials are needed to optimise the equipment and methods used to achieve the design.

- Spacing and location. Rock stacks and rubble pits are clustered along higher areas of rehabilitated landforms but avoiding potential to breach the skyline or creating legible patterns seen beyond the site, requiring (landscape architect approval that a) locations are consistent with a natural landscape and b) that the stacks and rubble pit forms are consistent with a natural landscape features.). Each cluster should be within a 100 m radius and each cluster no further than 300 m apart (Fig 1 shows a rock stack plus individual rocks within 100m radius with 2 other stacks <300m away).
- At least 20% of rock outcrops/stacks shall be centred on a pre-excavated trench that contains >2 m2 area at least 1 m deep to provide winter refuges
- Individual rock. More than 100 pieces of individual rock per ha, excluding wetlands and highwalls or at least 5% rock cover measured within a year of construction (i.e. before plant growth)
- Clean rock. Rock outcrops/stacks shall not contain soil of fines in any area higher than 30 cm above the ground because soil fills crevices. This can be achieved by using a digger to lift and place the upper layers of rocks ensuring the ROM is clean; rock and soil stockpiles are kept separate
- Rubble pits. Create at least 1 'rubble pit' per 5 ha. These are shallow excavated pits (at least 0.5 m deep x >10 m x 4-6 m wide filled with clean rock approximately 20-40 mm diameter. Lennon et al. (2021) developed a model to optimise design of rock piles to enhance habitat for small skinks; 20–40 mm crushed greywacke piles formed interstitial spaces able to be entered by *O. polychro*ma and *O. aeneum* but which excluded larger mice and larger mammalian predators.
- Each pit should be placed across the contour to enhance interception of runoff. Soils/root zone excavated from the pit shall be only placed along the lower margin and in low mounds to create a rough surface (not a linear feature) creating shelter into which plants are established in low points.
- Vegetation: each rock stack and rubble pit has ≥ 10 salvaged tussocks ≥10 cm basal diameter. In addition, four of the following interventions will be applied immediately adjacent to and within each rock stack and rubble pit:
  - ≥ 20 nursery-grown tussock species with ≥2 cm basal diameter (* in Table 1)
  - ≥ 5 lianes (M*uehlenbeckia* or native *Rubus* species)
  - ≥ 5 speargrass seedlings (A*ciphylla aure*a)
  - ≥ 10 nursery-grown shrub seedlings (** in Table 1)

  - ≥ 40 litres organic compost or wood chip placed to >10 cm depth (initial) on southern, sheltered and wetter areas of rock stacks
  - 2 relocated (living or dead) porcupine shrub or taramea wedged into sheltered edges between rocks over soil (rock stacks only).
- Plant nodes: At least 20 nodes/ha of tussocks* and shrubs** (from Table 1). Each node is >30 shrub* seedlings and >10 tussocks* at 0.5 to 1 m spacing (refer to * species list providing outcomes with flexibility). Success is plant numbers maintained and planted seedlings showing an active increase in area measured over 5 years. Nodes are likely to be added to over 5 years to take advantage of sheltering by initial planting, e.g. tussock shelter will shelter Olearia (i.e. 50 plants * 20 nodes = 1000 plants/ha).

The above criteria enable quantitative monitoring and auditing. Rock stack and 'rubble pit' 'trenches' must be signed off as conforming before rock placement as they are probably unable to be checked after construction without destructive sampling.

Table 1. Plant species for lizard habitat to be established with rock stacks and rubble pits. Conservation status is coded NT (Not Threatened), At Risk D (Declining), Threatened RE (Regionally Endangered), RV (Regionally Vulnerable), RNU (Regionally Naturally Uncommon). N indicates nitrogen fixing plant. All pant species except *Myrsine divaricata* and *Pentachondra pumila* are confirmed as present on the site by RMA Ecology vegetation surveys. The provision associated with each plant species is assessed for geckos and skinks is either – (nil), + (present) or ++ (abundant/important).

| **Species** | **Common name** | **Conservation Status** | **Provision for geckos and skinks** | | | **Invertebrates** |
|---|---|---|---|---|---|---|
| | | | **Shelter** | **Fruit** | **Pollen/ nectar** | |
| Tussocks* (grasses) | | | | | | |
| *Anthosachne apica* | Blue wheat grass | AR-NU, T-RV | ++ | - | - | + |
| *Chionochloa spp.* | Slim Snow Tussock | | ++ | - | - | ++ |
| *Festuca matthewsii* | Tussock | NT, R DD | ++ | - | - | ++ |
| *Festuca novae-zelandiae* | Fescue tussock, hard tussock | NT | ++ | - | - | ++ |
| *Poa cita* | Silver tussock | NT | ++ | - | - | ++ |
| *Poa colensoi* | Blue tussock | NT | + | - | - | ++ |
| Herbs and Ferns | | | | | | |

| Species | Common name | Conservation Status | Provision for geckos and skinks | | | Invertebrates |
|---|---|---|---|---|---|---|
| | | | Shelter | Fruit | Pollen/ nectar | |
| *Aceana buchanani* | Bidibid / piripiri | NT, AR-D | - | - | - | + |
| *Acaena inermis* | Spineless acaena | NT, AR RD | - | - | - | + |
| *Aciphylla aurea* | Golden Spaniard | NT | ++ | - | ++ | ++ |
| *Cheilanthes sieberi* | Rock fern | NT, AR-NU | - | - | - | + |
| Lianes | | | | | | |
| *Muehlenbeckia axillaris* | Creeping wire vine | NT | ++ | ++ | - | ++ |
| *Muehlenbeckia complexa var. complexa* | Small-leaved pōhuehue | NT | ++ | ++ | - | ++ |
| *Rubus schmidelioides var. subpauperatus* | White-leaved lawyer | NT | + | ++ | - | + |
| Shrubs** | | | | | | |
| *Acrothamnus colensoi* | Colenso's mingimingi | NT | ++ | ++ | - | + |
| *Carmaechaelia sp (N)* | Native brooms incl. Coral broom | Various | - | - | - | ++ |
| *Coprosma brunnea* | | At Risk D, Threatened RE | ++ | ++ | - | - |
| *Coprosma cheesemanii* | | NT | ++ | ++ | - | - |
| *Coprosma dumosa* | | NT | ++ | ++ | - | - |
| *Coprosma petriei* | Turfy coprosma | NT | - | ++ | - | - |

| Species | Common name | Conservation Status | Provision for geckos and skinks | | | Invertebrates |
|---|---|---|---|---|---|---|
| | | | Shelter | Fruit | Pollen/ nectar | |
| *Coprosma propinqua var. propinqua* | Miki | NT | ++ | ++ | - | - |
| *Coprosma rugosa* | Needle-leaved mtn. Coprosma | NT | ++ | ++ | - | - |
| *Coprosma virescens* | Mikimiki | At Risk D, Threatened RV | ++ | ++ | - | - |
| *Corokia cotoneaster* | Korokio, wire-nettting bush | NT | + | ++ | - | + |
| *Discaria toumatou (N)* | Matagouri, tāmatakuru | NT | + | - | - | + |
| *Melicytus alpinus* | Porcupine shrub | NT | ++ | ++ | - | + |
| *Myrsine divaricata* | Weeping matipo | NT | ++ | ++ | - | + |
| *Myrsine nummularia* | Creeping mapou | NT | - | ++ | - | + |
| *Olearia lineata* | Tree daisy | AR-D, AR-RD | - | - | - | + |
| *Olearia odorata* | Scented tree daisy | At Risk D, NT | | - | - | ++ |
| *Pentachondra pumila* | Carpet heath | NT | - | ++ | - | + |
| *Pimelea aridula aridula* | | At Risk D, Threatened RV | - | ++ | - | + |
| *Pimelea oreophila lepta* | | NT | - | ++ | - | + |
| *Pimelea notia* | | NT, At Risk RNU | - | ++ | - | + |
| *Pimelea prostrata subsp. prostrata* | | NT, R data deficient | - | ++ | - | + |

| Species | Common name | Conservation Status | Provision for geckos and skinks | | | Invertebrates |
|---|---|---|---|---|---|---|
| | | | Shelter | Fruit | Pollen/ nectar | |
| *Styphelia nana* | | At Risk – D | - | ++ | - | + |
| *Styphelia nesophila* | Dwarf mingimingi | NT | - | ++ | - | + |

*Figure 3. Poor quality lizard habitats to avoid and/or to enhance with management interventions, Ardgour and Bendigo Stations, 2024.*

*Left. Sparse tussock, sparse shrubs, no visible rock and evidence of stock compaction along trails. Centre: Shrubs (mainly matagouri) with no dense understorey near the ground, no tussock and no rock. Right: Temporary track and batter/windrow (also temporary) have smooth surfaces where rock is mixed with soil removing refuge gaps for lizards. No lizards were found in these areas, however some skinks and geckos were downslope where clean rocks rested on existing ground, either as single slabs or small jumbles. If the road was a permanent feature, tussocks would be transplanted to scallops on the batter, rocks added, and shrubs planted at the base of the batter where stress is lowest (receiving runoff).*

*Figure 4. High quality rock stacks and tussock habitat contrasting with lower-quality tussock habitat for lizards.*

*Left: High quality habitat for gecko due to stacked rocks with horizontal cracks and divaricating fruiting native plants (here, heavily browsed). These rocks would be a high priority to salvage but probably need to be broken up into 1 to 3 m long pieces for transport. When replaced, the cracks need to remain horizontal. Bendigo 2024.*

*Centre: High quality skink habitat has a density of about 2 mature tussock/m$^2$ with sparse Olearia or shrubs. Shrubs provide pollen, nectar and fruit for lizards and support invertebrates. Both tussock and shrubs are expected to thicken over time with removal of stock. Buffer areas with low tussock densities would be supplemented with transferred tussock and rock taken from adjacent areas. Lightly grazed area near Battery Hill, Bendigo 2024.*

*Right: patchy habitat for McCanns skink on heavily grazed area. The tussocks are refuges – if this was the edge of a mined area, drain diversion or road, this area would be enriched with salvaged tussock from within the adjacent excavated footprint. Grazing would be stopped to allow tussock to recover shoot and root biomass, and to flower and set seed that promotes natural regeneration. Ardgour 2024.*

### C.1.5. Risk reduction, Hold Points and Remedial works

- 'Stack certification', training and sign-off will be developed by the environmental team. These will be refined following results of construction of the first twelve rock stacks and rubble pits, may need to be revisited when ROM rock is used and will need to be formally revisited following results of lizard use monitoring.
- Use contracts and training that support delivery of high-quality rock stacks, e.g. hourly rates not volume rates
- If an inadequate number or dimensions of crevices is present at construction, move and replace rocks, reduce fines by lifting rocks (using digger). It is likely a combination of rock selection, dumping method (e.g. a running spread vs end tip) and grapple head/machine configuration may be required
- Amendments to plants and inoculation materials are straightforward at construction and during establishment period; methods are likely to be refined to increase survival of transplanted tussock and of nursery plants – these will include micro-site selection, and may include micro-site preparation (e.g. amendments to increase moisture supply) and plant preparation (hardening off, pre-plant soaking, slow-release fertilisation etc)
- If criteria are not met at closure, add artificial habitats (ACO 3-tier or concrete shelters) could be used to deliver a minimum 100 lizard refuges/ha. These artificial habitats are small so support fewer lizards than the larger (and permanent) rock stacks and rubble pits should with the right gaps/crevices support many more lizards.

### C.1.6. Changes from other projects

- Shorter, smaller, more natural rock stacks than the 20 m long, 3 m high overtly engineered stacks tested by Herbert et al (2025)
- Excavating into the ground (advice from Mokomoko Sanctury and Banks Peninsular research to provide refuge against severe cold, maybe also fire)
- Largely created using diggers, not hand placed given the number of interventions (contrasting with Orokanui Sanctury below).

*Figure 5. Left photo: High quality reconstructed habitat for large skinks at Orakanui Predator Proof Sanctuary, Dunedin.*

*Right: Earth bunds surfaced with rock (to provide erosion resistance) within broad swales to slow and detain water, creating areas with higher moisture availability and lower drought stress. Could use to slow water but modify to use earth bunds with rocks generally above the 1 in 10 year water level and tussocks and sedges established in the base of the swale to physically protect and bind the surface with native shrubs on the sides extending roots into the swale to create or enhance habitat for southern grass skink(South America).*


**Figure 1.** Concrete artificial refuge attached to a rock using rebar, with crevice and basking platform showing.

*Figure 6. Left photo: closeup of reconstructed habitat for large skinks at Orokanui Predator Proof Sanctuary with skinks basking close to cracks. 'Habitat was created by ecosanctuary staff and volunteers using schist and other rock slabs to mimic rock tors used by Otago skinks in the wild elsewhere in Otago' and initial outcomes reported by Bogisch and Monks (2016)*

*Right photo: Artificial habitat designed by Marie Lettink, Matt Charteris and Anthony Black, tested by Turner et al (2024) to provide habitat for (nocturnal) Waitaha gecko relocated from nearby rock outcrops. Each concrete habitat is 120 mm high, 320 mm long with 50 mm wide basking ledge in front of crevice 5-10 mm high and 250 mm deep. Habitats had 31-55% occupancy by geckos through year. Data indicated these refuges may provide adequate buffering against winter frosts (being above the 1 C required for lizard locomotion). There was little use of these artificial habitats by McCann's skink and Tussock skink.* ***From Turner et al 2024,*** *Figure 1. Original title 'Concrete artificial refuge attached to a rock using rebar, with crevice and basking platform showing.*

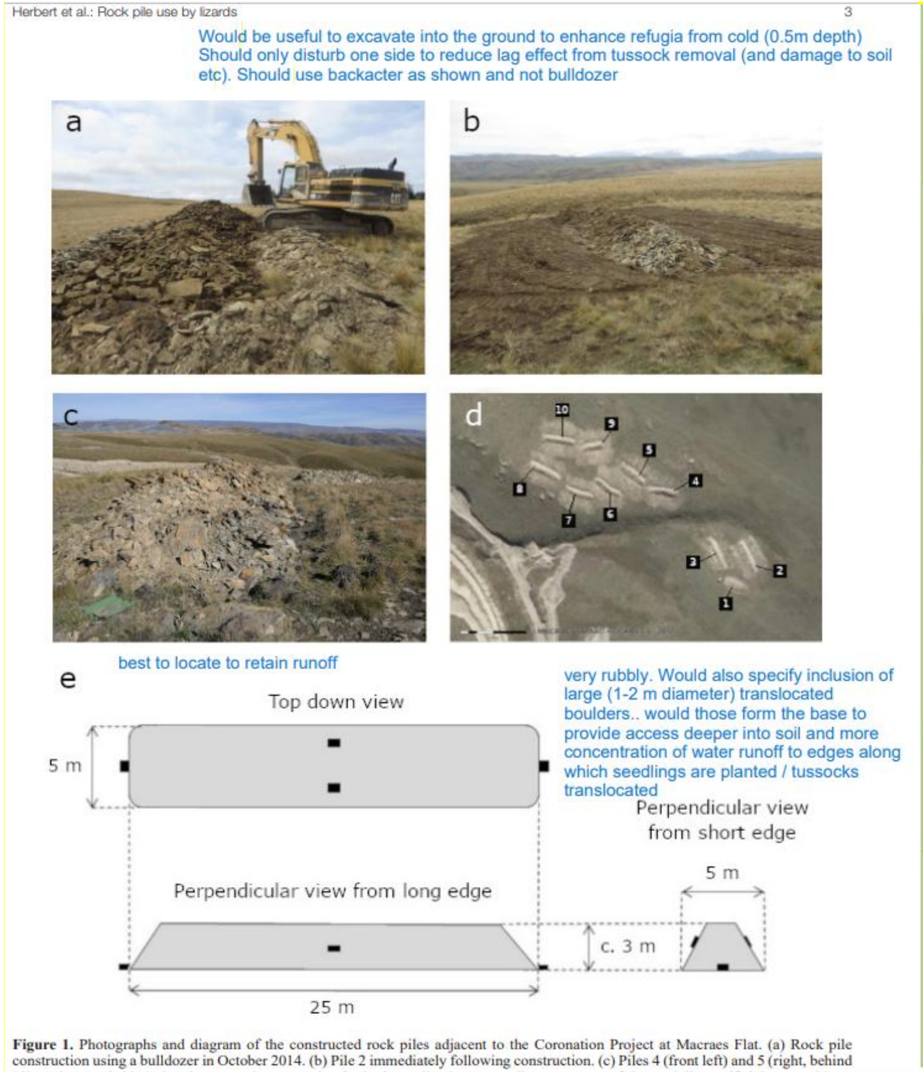
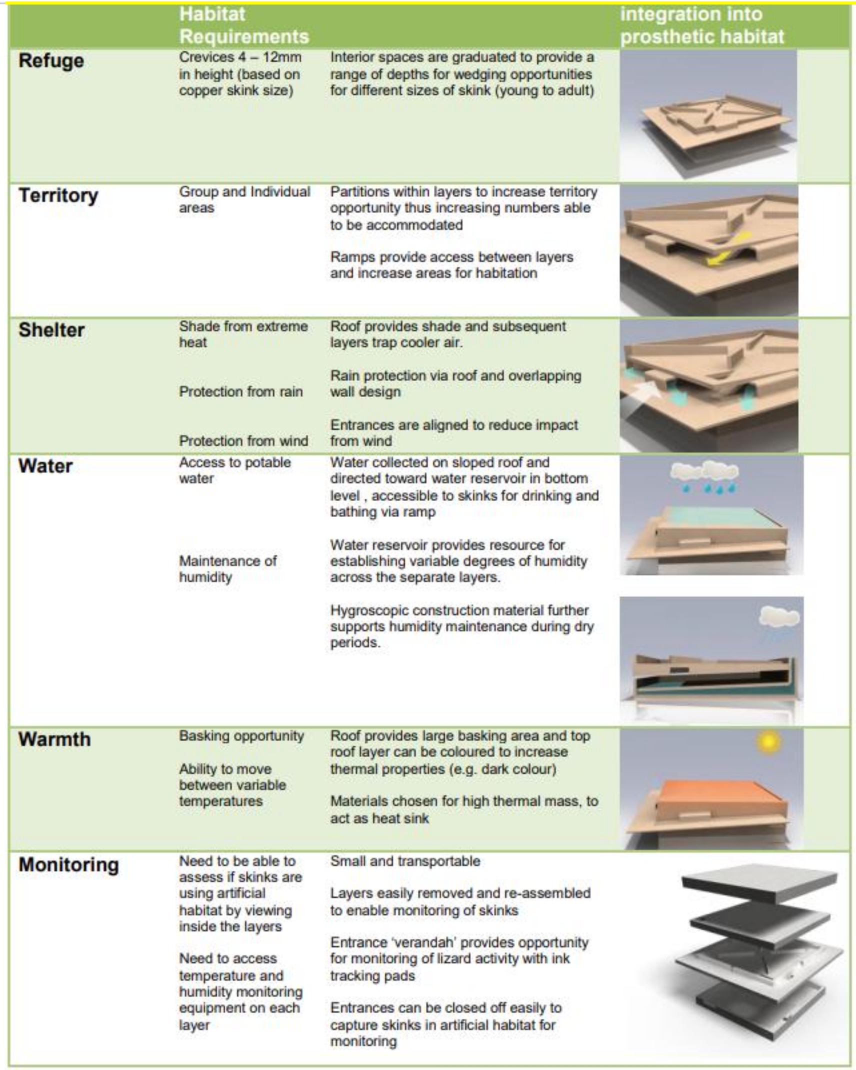

Herbert et al.: Rock pile use by lizards 3



**Figure 1.** Photographs and diagram of the constructed rock piles adjacent to the Coronation Project at Macraes Flat. (a) Rock pile construction using a bulldozer in October 2014. (b) Pile 2 immediately following construction. (c) Piles 4 (front left) and 5 (right, behind



| | Habitat Requirements | | integration into prosthetic habitat |
|---|---|---|---|
| **Refuge** | Crevices 4 – 12mm in height (based on copper skink size) | Interior spaces are graduated to provide a range of depths for wedging opportunities for different sizes of skink (young to adult) | |
| **Territory** | Group and Individual areas | Partitions within layers to increase territory opportunity thus increasing numbers able to be accommodated<br><br>Ramps provide access between layers and increase areas for habitation | |
| **Shelter** | Shade from extreme heat<br><br>Protection from rain<br><br>Protection from wind | Roof provides shade and subsequent layers trap cooler air.<br><br>Rain protection via roof and overlapping wall design<br><br>Entrances are aligned to reduce impact from wind | |
| **Water** | Access to potable water<br><br>Maintenance of humidity | Water collected on sloped roof and directed toward water reservoir in bottom level , accessible to skinks for drinking and bathing via ramp<br><br>Water reservoir provides resource for establishing variable degrees of humidity across the separate layers.<br><br>Hygroscopic construction material further supports humidity maintenance during dry periods. | |
| **Warmth** | Basking opportunity<br><br>Ability to move between variable temperatures | Roof provides large basking area and top roof layer can be coloured to increase thermal properties (e.g. dark colour)<br><br>Materials chosen for high thermal mass, to act as heat sink | |
| **Monitoring** | Need to be able to assess if skinks are using artificial habitat by viewing inside the layers<br><br>Need to access temperature and humidity monitoring equipment on each layer | Small and transportable<br><br>Layers easily removed and re-assembled to enable monitoring of skinks<br><br>Entrance 'verandah' provides opportunity for monitoring of lizard activity with ink tracking pads<br><br>Entrances can be closed off easily to capture skinks in artificial habitat for monitoring | |

*Figure 7. Left: Lizard rock piles at Macraes Mine.* ***From Herbert et al 2025 (Figure 1.)*** *with added blue annotations by R Simcock 2024.*

*Right: Features of artificial skink habitats designed to provide refuges for Auckland mammal-free greenroofs highly vulnerable to drought (a water source was included).* ***From Davies et al 2011***.

### 3. Schist Slabs & Blocks Structure Lizard Refuge Sites

Outcrops are not uniform at the mine. They are made up of different rock end members that produce schist slabs and schist blocks.

Micaceous (pelitic) schist slabs develop multiple, narrow horizontal crevices 1-3cm wide from coarse micas preferentially weathering.

*Figure 8. Left photo: TZ4 Schist near Macraes Project. Right photo shows preferred rock fractures for lizards. Both photos from* ***Rufaut, Pillai, Craw, Mossman 2020****. 'Constructing and extending lizard habitat: not all rocks are equal. High quality refuges are associated with outcrops that contain partially oxidised, micaceous schist, with narrow horizontal partings along foliation. Partings may be complete to form 'pancake' slabs or partial to variable depths. 'Lizard quarters' are supported by quartzofeldspathic schist bases, less resistant to weathering, that elevate refuge sites to the top 1/3 of a commonly occurring 2m x 2m outcrop.*

## C.2. References

Aitken E, Rufaut C, Scott J, Read S, Craw D and Pillai D. 2025. *Otago schist for lithology controls on lizard habitats, East Otago, New Zealand*. New Zealand Journal of Geology and Geophysics 68(5):1176-1189. Otago Schist tor lithology controls on lizard habitats, East Otago, New Zealand - Aitken - 2025 - New Zealand Journal of Geology and Geophysics - Wiley Online Library

Bogisch M and Monks JM. 2016. *Short-term success of a translocation of Otago skinks (Oligosoma otagense) to Orokonui Ecosanctuary*. New Zealand Journal of Zoology 43(2).
'

Davies R, Simcock R, Toft R, Ussher G, de Groot C, Boult M. 2011. *Elevated islands – urban conservation potential on living roofs*. 25th International Congress for Conservation Biology, Auckland, 5–9 December 2011.

Herbert SM, Knox C, Clarke D, Bell T. 2023. *Use of constructed rock piles by lizards in a grassland habitat in Otago, New Zealand.* New Zealand Journal of Ecology 47(1) 3543.pdf

Herbert SM, Kelly FB, Panteleeva E, Dean SM, Hartley S, Nelson NJ. 2025. *Short-term responses of terrestrial skinks to habitat enhancement in a pest-invaded landscape on mainland New Zealand*. New Zealand Journal of Zoology. Full article: Short-term responses of terrestrial skinks to habitat enhancement in a pest-invaded landscape on mainland New Zealand

Lennon O. 2019. *Mitigation translocation for conservation of New Zealand skinks*. Unpublished PhD thesis. Victoria University of Wellington. Mitigation translocation for conservation of New Zealand skinks

Rufaut C, Pillai D, Craw D, Mossman G. 2020 *Constructing and extending lizard habitat, Mine rehabilitation, Department of Geology | University of Otago*

Turner MK, Kelly D, Lettink M. 2024. *Concrete refuges and the influence of temperature on artificial refuge occupation by terrestrial izards*. New Zealand Journal of Zoology 43(2) *Full article: Concrete refuges and the influence of temperature on artificial refuge occupation by terrestrial lizards*.

Turner MK. 2021. *Improving the management of Canterbury's lizards*. Unpublished MSc thesis. University of Canterbury *Improving the management of Canterbury's lizards*

Norbury G. Reardon J, Mckinley B. (undated @2007) *DoC Grand and Otago skink management plan* Standard Format for Species Recovery Plan.

'*In the mid-1990s rock-count surveys focused on the occurrence of grand skinks over approximately 300 rocks on Redbank Ridge (Whitaker 1996). Rock count surveys were* *also reviewed in 2004 and integrated with more accurate methods for assessing 'rock occupancy', based on standardised methodologies and analytical procedures. These account for relative detectability of skinks (MacKenzie & Bailey 2004, Roughton 2005). Rock patch occupancy is also recorded at all experimental populations*.

Full article: Current challenges and future directions in lizard conservation in New Zealand identifies control of mice, and pest control that benefits native birds may change the predator guilds enough to have worse outcomes for lizards and suggests (lower cost) low fences might be useful

The risks and rewards of using artificial habitat structures for wildlife conservation - Watchorn - 2023 - Austral Ecology - Wiley Online Library summarises requirements to show effectiveness including monitoring of the response of lizards (e.g., survival, fecundity, and population size) to the structures across relevant ecological spatial and temporal scales, and their effects compared with appropriate controls

# APPENDIX D. ROOT ZONES AND SOIL REQUIREMENTS FOR MINE MANAGEMENT UNITS

Table 1. Areas requiring rehabilitation by management unit, the source of soils and root zones and general approach to root zone placement. Notes [1-] Some areas below differ from the 'plan' footprint, with largest differences for RAS and SRX pits. [2-] All stockpiles will contain soils. Some may also contain brown rock which is the main component of lower root zones. [3-] Deep root zones are a minimum 2.2 m deep (this includes 20 cm soil) [4-] Areas with higher erosion vulnerability and soils with low rock or gravel content are likely to be sheeted with thin layer of weathered gravels. [5-] The areas of individual management units do not generally include the contingency areas (or 'buffers') as some of these areas may not be stripped. An exception is the area between RAS pit and Shepherd's ELF as in this zone hauls roads will be moved across the area as the pit and ELF are constructed to minimise changes in elevation during haulage and accommodate dust suppression infrastructure.

| **Management Unit** | | **Area needing rehabilitation (ha)[1, 5]** | **Source of soils[2]** | **Explanatory notes and 'root zone type'** |
|---|---|---|---|---|
| ***Label*** | ***Name*** | | | |
| *Modified Areas* | | | | |
| *TSF* | *TSF* | 56.7<br>(52.6 ha tailings + 4.1 ha embankment, 75 ha including contingency areas)<br>Includes 6 ha wetlands and 0.5 ha open water | TSF and ELF stockpiles<br>(18.3 ha) | These stockpiled soils will be the last to be used at scale and will have been stored for ~10 years.<br>TSF-specific root zone includes capping layer (> 1 m brown rock) and variable soil depth from shallow root zones (at least 0.2 m depth covering <20%) supporting swales and wetlands) to deep root zones (at least1.5 m depth) covering >20% of surface, supporting woody shrubs and at least 50 rock stacks with associated plantings (no rubble pits). All rock stacks will be above the 1 in 10-year inundation zone. Areas with higher erosion pressure and soils with low gravel content are likely to be sheeted with weathered gravels[4]. |
| *ELF* | *Shepherd's ELF* | 115.5 ha | ELF stockpiles<br>(14.4 ha) | ELF root zone. Variable 1.2 m to 2.2 m depth with 'deep root zones[3]' over at least 50% of S-SE slopes and 25% of NE to NW slopes. Shallower root zones with higher rock cover underpin a fire buffer with low plant biomass (no woody species |

| Management Unit | | Area needing rehabilitation (ha)[1, 5] | Source of soils[2] | Explanatory notes and 'root zone type' |
|---|---|---|---|---|
| *Label* | *Name* | | | |
| | | | | or tussock established in this zone). At least 115 rock stacks and 25 rubble pits (with plantings) are constructed on this landform. |
| *ELF-W* | *Western ELF* | 18.0 ha | Run of Mine (not from stockpiles) | ELF root zone. Landform and root zones completed by end of year 2 using soils from RAS pit. Main rehabilitation trial site. At least 20 rock stacks and 10 rubble pits allow refinement of techniques and measurement of efficacy given proximity of lizard populations. Up to 2 ha of rehabilitation on NE to NW facing slopes delayed allowing direct use of materials from CIT depending on ARP cushionfield and spring annuals. |
| *ELF-X* | *SRX-ELF* | 15.8 ha | SRX-Soil stockpile (2.1 ha) | ELF root zone. |
| *PB* | *Pit Benching, Batters and Edges above lake level* | 77.4 ha (RAS walls)<br>14.6 (SRX walls)<br>(total SRX pit footprint 13.0 ha) | ELF stockpiles<br>(14.4 ha) | Only the first 20m (minimum) of benches intersecting with natural ground and upper bench will be provided with Pit wall root zone which has depths from 10 cm near lip to 4 m depth at base of benches. Haul roads into pit will be at least 60% covered with root zone at least 2 m deep to support grey scrub and kowhai, taking advantage of low fire risk and reduced stress. |
| *CT* | *CIT Pit (backfilled)* | 13.8 ha | ELF stockpiles<br>(14.4 ha) | ELF root zone, at least 4.5 ha of soils and contours with potential to support cushionfield. Location and % of deep soils based on Western ELF trials and aspects, but 'deep root zones[3]' over at least 50% of S-SE slopes. |
| *PL* | *Pit Lakes* | 14 ha (RAS lake)<br>4.1 ha (SRX lake) | Negligible<br>Negligible | Pit lake root zone of minimum 0.3 m depth in areas < 1.0 m water depth to support emergent plants (this is a narrow riparian strip where water intersects internal pit haul roads bench with haul road 17 to 30 m wide) and along at least 50 linear m of haul road that intersects with water table, with stabilising rock cover including 10-25% including boulders >1 m to provide barriers and perching sites. |

| Management Unit | | Area needing rehabilitation (ha)[1, 5] | Source of soils[2] | Explanatory notes and 'root zone type' |
|---|---|---|---|---|
| *Label* | *Name* | | | |
| *S* | *Soil Stockpiles (Mine site)* | Total: 24.0 ha<br>RAS 3.6 ha, ELF 10.4 ha & 4.0 ha; TSF 3.9 ha, SRX 2.1 ha | Soil stockpiles (lower 50 cm) and adjacent bunds. | ELF root zone, with minimum 33% of deep soils (where not limited by rock). Base deep ripped >0.5 m depth with scalloping or spot mounding to at least 0.5 m depth. Rocks and boulders pulled to surface. Spot mounds to 1.5 m deliver deep soils. |
| *S-AT* | *Soil stockpile – Ardgour Terraces* | 6.8 ha | Soil stockpile, at least the lower 1 m | Agricultural production root zone, able to be cultivated. Base of stockpile deep ripped to at least 0.5 m depth at 0.8 m centres and homogenous stripped soils replaced evenly to create a ploughable depth >30 cm that has low stone content. May require stone picking. |
| *HR* | *Haul Roads* | Entrance to Plant 6.1 ha<br>Shepherd's Creek fill 11.4 ha<br>CIT haul road 4.1 ha<br>SRX haul road 8.6 ha<br>RAS/ELF zone 19.8 ha | Shepherd's Creek fill uses Ardgour Terrace soil stockpile. Others use nearest stockpile and windrows/bunds | Haul road root zone, avoiding 3-4 m wide light vehicle track (which remains compacted basecourse and gravel surface), importation of root zone minimised by deep ripping >0.5 m depth (where not limited by rock) with scalloping or spot mounding to at least 0.5 m depth. Root zone placed to at least 50 cm depth (brown rock or soil) over two-thirds of the haul road surface. Wedges of root zone at least 1 m depth placed against all cuts > 2m<br>RAS/ELF haul road zone may include cushionfield root zone depending on success of ARP |
| *C* | *Construction Camp and Ancillary Infrastructure* | 1.2 ha | Earth bunds stripped at construction | Treated per Agricultural production root zone |
| *P* | *Process Plant Mine Infrastructure* | 4.3 ha | *Ardgour Terraces soil stockpile* | Terrestrial areas treated per haul road root zone, with separate treatment for wetland area (see wetlands). Specific addition: at least 0.5 ha of root zones >3 m depth to support tall trees. |

| Management Unit | | Area needing rehabilitation (ha)[1, 5] | Source of soils[2] | Explanatory notes and 'root zone type' |
|---|---|---|---|---|
| ***Label*** | ***Name*** | | | |
| *AR* | *Ardgour Rise Alignment* | *TBC* | *Existing alignment* | *No specified root zones on cut; fill batters restricted using boulders at toe in sensitive areas; fill batters mildly scalloped with transplanted sods put in scallops; boulders and rock used to minimise erosion* |
| *TGT* | *Thomson Gorge Road Recreation Track* | *TBC* | *Existing track where not on SRX ELF* | *Soils from excavated areas (fill slopes) with rocks taken to surface from existing windrows* |
| *QU* | *Aggregate Pits, Magazine and Emulsion* | *Magazine 0.64 (80x80m)*<br>*Emulsion Plant 1.20 (110x110m)*<br>*Access road 1.60*<br>*Aggregate pit 3.2 ha Ardgour Rise pit 1 ha* | *Bunds around Plant and Magazine and along access road, and Ardgour Rise aggregate pits*<br>*Ardgour Rise soil stockpile* | *Magazine, Emulsion Plant and Access Road treated per Agricultural Production Zone*<br>*Aggregate pit/s may be treated as above or to enable rural infrastructure: floor levelled and compacted to retain high bearing strength suiting vehicles with drainage (no planting). Potential water supply/wetlands if drainage is impeded.* |
| *W* | *Wetlands* | *TSF – 6 ha (includes 0.5 ha open water)*<br>*Ardgour Terrace (0.5 ha) if constructed*<br>*Lower Shepherds wetland (0.5 ha)*<br>*Process Plant wetland* | *TSF soil stockpile*<br>*Fresh organic-rich wetland soils*<br>*As above*<br>*Ardgour Terrace soil stockpile, organic soils* | *TSF 'swale' Rooting medium (>0.3 m) from soils and/or Brown Rock over engineered low-permeability layer*<br>*Ardgour Terrace (if constructed) and Lower Shepherds wetlands are created by intact soil/plant sods from wetlands (VDT) placed on engineered low-permeability surface. This surface may include 30 cm to 50 cm of organic rich soils.*<br>*Process Plant wetland is planted into >0.3 m of organic rich soils or wetland sods stripped in year 1 from Shepherd's Valley* |

| Management Unit | | Area needing rehabilitation (ha)[1, 5] | Source of soils[2] | Explanatory notes and 'root zone type' |
|---|---|---|---|---|
| ***Label*** | ***Name*** | | | |
| *D* | *Clean Water Diversion channels* | *Not determined, lies within contingency zone* | *Adjacent bunds (no imported soil)* | *Permanent access retained along Shepherd diversion from ELF to top of TSF (~6.3 km rock/gravel)* |

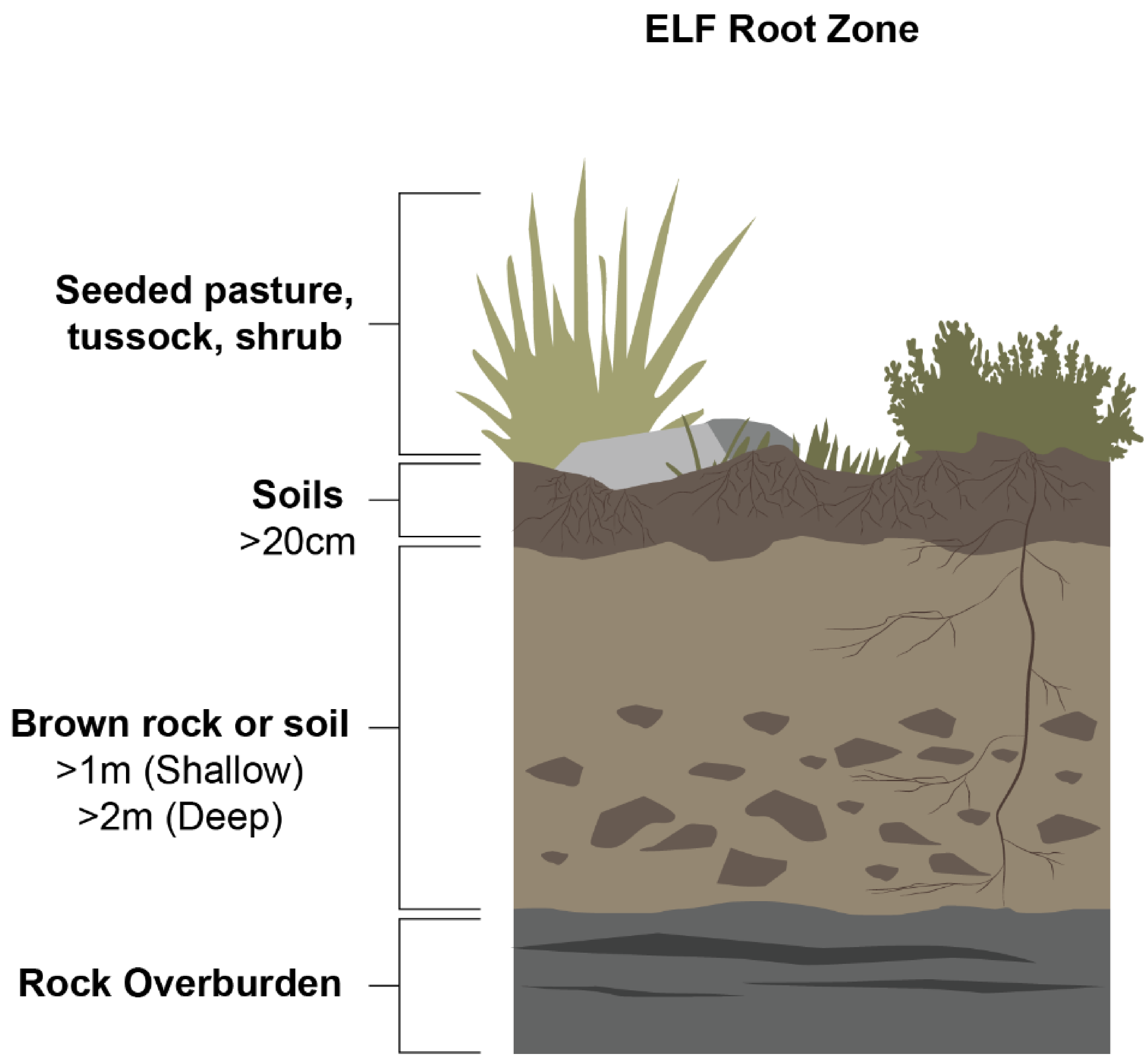
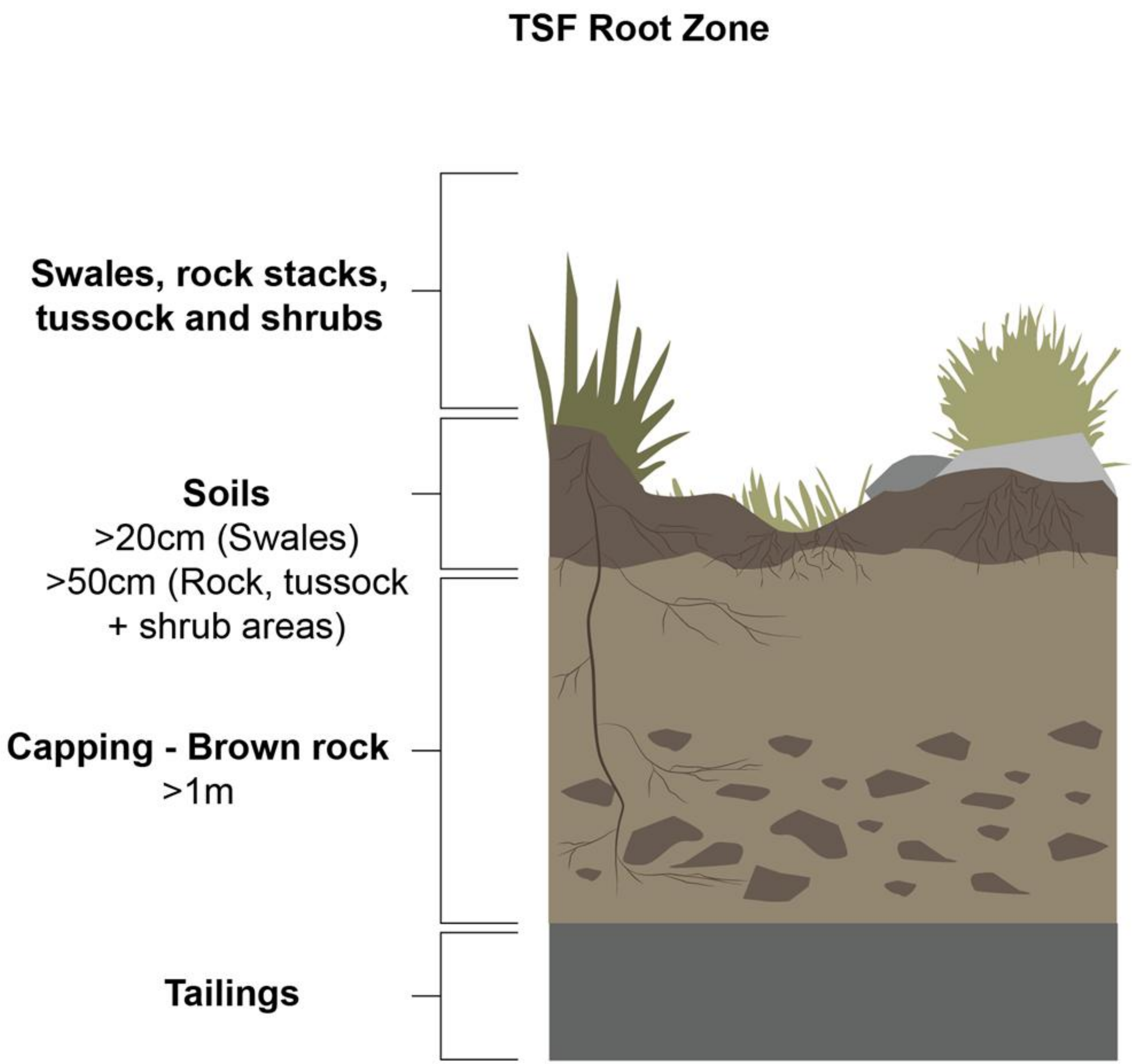



*Figure D-1: Cross-section of ELF Root Zone Showing Vegetation and Soil Layers*


TSF Root Zone
Swales, rock stacks, tussock and shrubs
Soils
>20cm (Swales)
>50cm (Rock, tussock + shrub areas)
Capping - Brown rock
>1m
Tailings

# APPENDIX E. PLANT SPECIES MANAGEMENT IN DDF AND MRZ

This appendix has seven parts:

**Part 1.** Summary of the current overall ecological values for the mapped vegetation communities and estimated ecological values in 2045 after 35 years of management interventions in a) the Direct Development Footprint (DDF) and b) Mine Regeneration Zones (MRZ). Estimated values are primarily based on average cover metrics for each vegetation association from the vegetation survey plots across the wider project site (i.e. Bendigo and Ardgour stations) and to cover metrics for each of the MRZ and DDF.

**Part 2.** A summary of revegetation methods used for each vegetation community, separated into DDF and MRZ. This information complements Appendix 2 on Establishment of lizard habitat features (rock stacks, rubble pits and rock) that lists plant species and densities at which they will be established.

**Part 3.** Plant species included in **enrichment planting** within **MRZ**. The species lists are restricted to native tree, shrubland and liane species and snow tussock, as short tussocks are not planned to be planted in MRZ. Short tussocks are expected to naturally spread and increase in cover in response to removal of stock and control of other mammalian browsers. If responses to browse reduction are less than expected, competition between non-native pasture/shrubs and tussock will be reduced to facilitate tussock spread.

**Part 4**. Plant species to be established in and around **lizard habitat features** of rock stack and rubble pits across the DDF (extracted from Appendix 2).

**Part 5**. **Wetland** plant species with elevated threat status that are proposed to be re-established in (new) DDF rehabilitated wetlands

**Part 6. Cushionfield** plant species that have elevated threat status and their provisional management. Specific management of cushionfields and annual spring herbs is refined in the Applied Research Plan for Cushionfields.

**Part 7.** All plant species with an elevated **Threat Status,** their presence within DDF, and anticipated response to management in the DDF and MRZ under proposed management.

**Part 8. Taoka plants.** Provisional list of toaka plants identified in the Cultural impact statements

### E.1. Part 1. Vegetation community types in DDF in 2024/25 and Rehabilitated Area after 35 years.

The DDF is the maximum area stripped of soils/ecosystems and includes contingency zones that may or may not be stripped. Community types for mosaics across the landscape are determined by drought and cold stresses linked to variations in natural and rehabilitated landform aspect, slope, root zones and management. Areas provided by Duncan Nicol, RMA Ecology 16 June 2025. Bold numbers in the 'rehabilitated columns' have high certainty that this is the area in which this vegetation is prioritised. Numbers in italics have less certainty and they depend on the speed of natural regeneration and increase in plant height and cover. Hence areas in mixed shrubland are expected to transition to 'native dominant scrubland' over 50 to 100 years. Given the absence of case studies/data on rehabilitation in these areas, outcomes are inferred from aerial photographs showing natural regeneration of grey shrubland from aerial imagery that shows an increase of 10-60 % in woody vegetation cover in suitable locations (i.e., some existing woody vegetation, and not north facing) over an 18-year period between 2003 and 2021 in grazed (Dry Creek Conservation Area) and ungrazed areas (Ardgour Station)( RMA Ecology Vegetation report Appendix 2); Olearia-matagouri-Coprosma at Ardgour and a mosaic dominated by kanuka at Rocky Point). However, uncertainty of outcomes is considered to be achievable given additional management of pest animal control, removal of browsers, targeted pest plant control, planting and control of competing weeds if needed.

Table 1.1. Vegetation associations in DDF and estimated outcomes 35 years after mine rehabilitation

| Vegetation Association | Area Removed hectares, % | Rehabilitated Ha, % | Notes |
|---|---|---|---|
| Exotic Pasture | 79 (13%) | 15 (2%) | Pasture is re-established on farmed flats: Ardgour Terrace soil stockpile (6.8 ha), temporary construction camp (1.2 ha), emulsions area (1.2 ha) magazine (0.64 ha) and Emulsion access roads (1.6 ha) and |

| Vegetation Association | Area Removed hectares, % | Rehabilitated Ha, % | Notes |
|---|---|---|---|
| | | | quarries (~4 ha);all other pasture converted to native over time |
| Mixed depleted herbfield and grassland (cushionfield) | 104 (17%) | 19 (3%) | Re-establishment focus for cushionfield trial slopes on Western Elf (maximum 5 ha) and CIT pit (13.8 ha). All other areas dependent on success of ARP cushionfields |
| Mixed tussock shrubland and exotic grassland | 187 (31%) | 8 [a] (1%) | Fire buffers within the site that are not cushionfields. Will have a low proportion of woody shrubs and higher proportion of bare ground. Usually overlapping with permanent tracks/roads. Area of buffers yet to be finalized. |
| Mixed scrubland | 124 (20%) | 432 (70%) | Dominant outcome in the first 20 years: nodes of low shrubs and nodes of tussock, with non-native and native grasses and herbs and rock. |
| Native dominant tussockland | 25 (4%) | 6 (1%) | Tussock will be scattered throughout the site in small patches with shrubland so rather |

| Vegetation Association | Area Removed hectares, % | Rehabilitated Ha, % | Notes |
|---|---|---|---|
| | | | than forming large tussock-dominated areas. |
| Native herbfield and shrubland | 2 | 1 [b] | Targeted area established with taramea being dominant (excluding Ardgour Rise Rd) |
| Native dominant scrubland | 85 (14%) | 7 | Small areas of south-facing slopes where drought and cold stress is lowest and root zones deep established early in mine life (e.g. Western ELF) |
| Wetland | 3 [c] | 7 (1%) | Minimum 2, 0.5 ha wetlands using stripped material established in years 1 and 2 with a further 6 ha of wetlands established on TSF (2 ha swamp and 4 ha marsh). |
| New cover types (117 ha total maximum [d]) | | | |
| Highwall rockland | NA | 92 (15%) | Maximum of 77.4 ha in RAS pit and 14.6 ha in SRX pit (surface area). Will include 20 m naturally-vegetated benches with root zones extending from contact zone with undisturbed ground |

| **Vegetation Association** | **Area Removed**<br><br>**hectares, %** | **Rehabilitated**<br><br>**Ha, %** | **Notes** |
|---|---|---|---|
| Lakes | NA | 19.4 (3%) | 0.5 ha of shallow open water within TSF wetland; deep 14 ha RAS pit lake and 4.9 ha SRX lake (both steep-sided with minimal marginal vegetation and rock-influenced water chemistry) |
| Infrastructure | NA | 6 [e] | |
| TOTAL | 606 | 606 | |
| Area containing tussock = 'mixed tussock shrubland and exotic grassland' + tussockland' | 25 + (187/2)<br><br>= 118 ha | (432/2) + 6<br><br>= 222 | Tussocks are established as small clusters or 'nodes' throughout the majority of the DDF, i.e. all areas other than cushionfield, highwalls, pit lakes or wetlands. No large areas of planted or transplanted tussockland are planned. But they are expected to spread and fill out along with shrubland under the management regime of no grazing with tussock in the drier more exposed parts of the landscape |
| Areas of indigenous woody shrub =<br><br>Mixed tussock shrubland + Mixed scrubland + Native dominant scrubland | (187/2) + 124 + 2 + 85 | (432/2) + 8 + 1 + 7<br><br>= 232 | Shrubs are established as small clusters or 'nodes' throughout the majority of the DDF, i.e. all areas other than cushionfield, highwalls, |

| Vegetation Association | Area Removed<br><br>hectares, % | Rehabilitated<br><br>Ha, % | Notes |
|---|---|---|---|
| | = 305 | | pit lakes or wetlands. These include at least 24 kowhai nodes and 0.5 ha of 'forest' in valley floor. Over time shrubs are expected to spread and fill out along with tussock under the management regime of no grazing, with shrubs dominating in shadier, wetter, lower parts of the landscape |

Notes:

[a] fire buffer estimate as these areas have not been finalised

[b] this is the unit where taramea was most common

[c] wetlands are not included in the total

[d] a maximum as this includes pit surfaces (not plan area) and includes bench edges with vegetation cover.

[e] areas to be finalised and include access road, water treatment plant (and associated hardstand, constructed wetland) that is operational beyond closure. The narrow width of current farm tracks means they are included within each vegetation unit.

Table 1.2. Current values for ecology and estimated values after 20 years of management interventions (including planting) in Mine Regeneration Zones and unstripped areas of the project footprint (contingency zones). Ecological values in black lettering are current condition, values in blue lettering are estimated values. EV = Ecological Value.

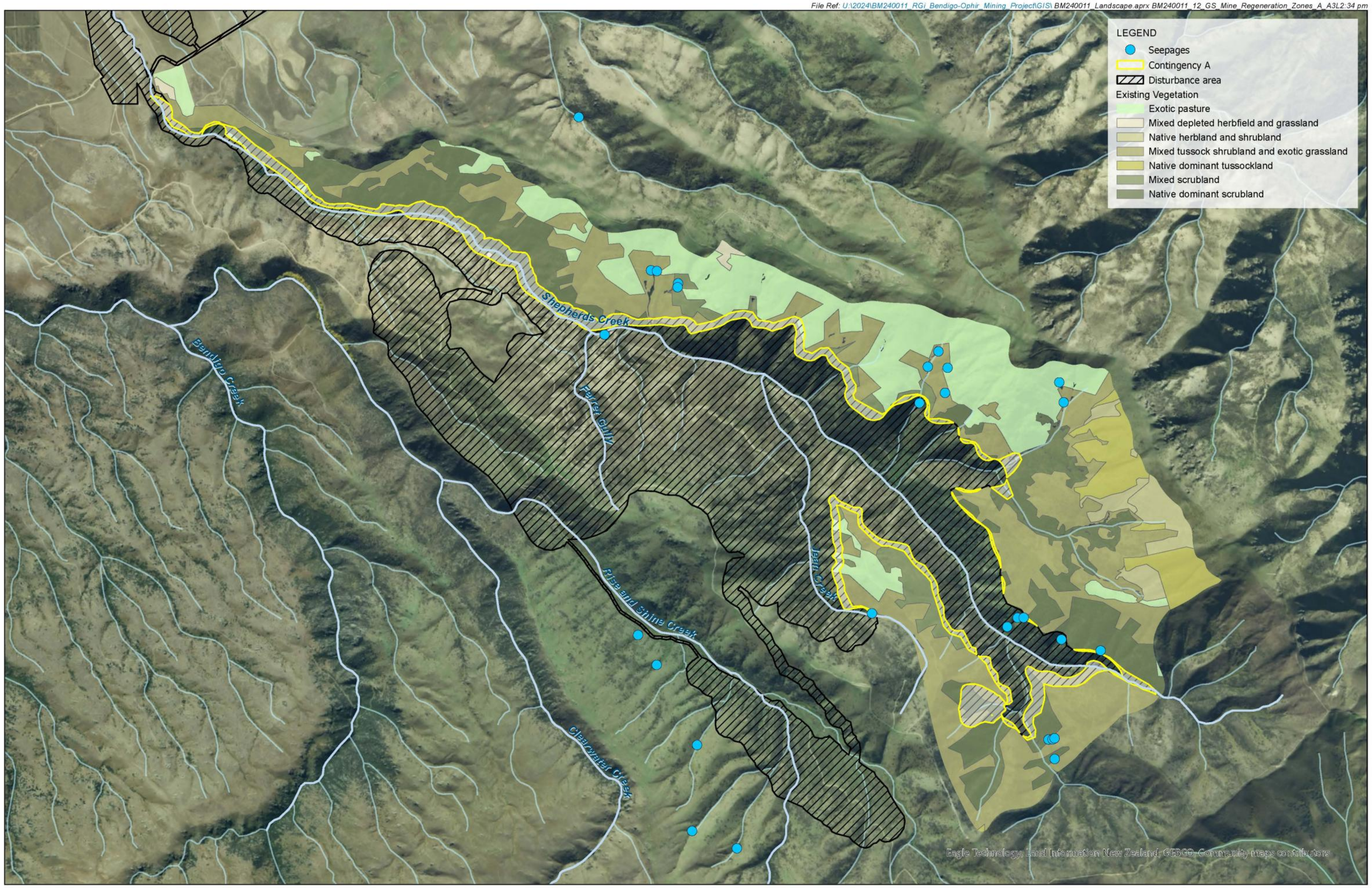
[1] Existing covers are the means of all vegetation plots across Ardgour and Bendigo (RMA Ecology). [2] The covers do not add up to 100% due to rounding to whole percentage values for individual cover types. [3] Values apply to Mine Regeneration Zones only.

| Vegetation community | Very low EV | Low EV | Moderate Ecological Values (EV) | High Ecological Values | Existing 2024 covers [1,2] |
|---|---|---|---|---|---|
| Exotic grassland in Mine Regeneration Zones (Ardgour and Bendigo)[3] | Current values | | | | 73% total exotic herbaceous = 46% grass + 27% herb<br>4% native shrub; 7% tussock; 2% exotic shrub<br>6% bare ground; 6% rock |
| Mixed depleted herbfield and grassland including annual native herbs | | | Current values range from moderate to high. Increase total area of this vegetation community by 10%.<br>Mange to decrease exotic shrub cover, increase tussock and native shrub cover to 10-15%<br>Delay/reverse transition from raoulia to woody vegetation or pasture by removing brier, not OSTD; and other experimental interventions including grazing management.<br>Slow increase in tussock and native shrub cover and diversity, e.g., Pimelea, porcupine bush – increasing values for invertebrates. In some places non-native, palatable weeds may expand with some being invertebrate habitat. Probably no change in bare ground. | | n/a total exotic herbaceous = 18% grass + 31% herb (incl native herbs)<br>3% native shrub; 2% tussock; 3% exotic shrub<br>21% bare ground; 15% rock |
| Mixed scrubland; Mixed tussock | | | Current values 'moderate' | Increase total area.<br>Increase native shrubland cover and tussock cover and native diversity by stock removal and | 45% total exotic herbaceous = 35% grass + 10% herb<br>19% Native shrub |

| Vegetation community | Very low EV | Low EV | Moderate Ecological Values (EV) | High Ecological Values | Existing 2024 covers [1,2] |
|---|---|---|---|---|---|
| shrubland and exotic grassland | | | | planting. Structure improves as tree, lianes, and groundcover under shrubs develops. Kowhai groves are established.<br><br>Increase invertebrate values with increased plant diversity, leaf litter development, structure and native plant biomass. Increase lizard values with shrub component and more invertebrates. Probably reduction in bare ground and rock. | 7% tussock<br><br>11% exotic shrub<br><br>10% bare ground; 5% rock |
| Native dominant tussockland | | | Currently values moderate as low species diversity and low structural diversity; mostly above 700 m | Increase total area.<br><br>Increase tussock cover and native shrub cover. Exotic shrub cover (brier) may increase. Increase invertebrate values increased plant diversity, leaf litter, structure, increased native plant biomass (unlikely to decrease tussock specialists). Increase lizard values with shrub component and more invertebrates<br><br>Increase in cover and resilience due to greater below-ground root biomass with removal of grazing; tussock seeding, increased native shrub diversity by planting diverse shrubs. New snow tussock >0.5 ha with celery pine, mountain totara seedlings. Reduction in rock cover as plants grow. | 47% total exotic herbaceous = 33% grass, 14% herb.<br><br>28% Tussock<br><br>6% native shrub; 3% exotic shrub<br><br>4% bare ground; 6% rock |
| Native dominant scrubland | | | (currently has as low species diversity in species and low structural diversity so considered to have moderate ecological value) | Increase total area.<br><br>Increase native shrub cover . and exotic shrub cover. Natural thickening on removal of grazing, herbicide and crushing. Plant diversity increased | 33% total exotic herbaceous = 22% grass, 11% herb.<br><br>44% native shrub |

| Vegetation community | Very low EV | Low EV | Moderate Ecological Values (EV) | High Ecological Values | Existing 2024 covers [1,2] |
|---|---|---|---|---|---|
| | | | | by planting woody species that are currently in very low densities and by natural expansion of palatable species (ferns, lianes, some coprosmas). Higher frequency and new breeding populations of forest birds (tui, bellbird) with expansion of woody species supplying nectar and fruit for birds and predator control (incl. kowhai). Probably no change in bare ground or rock. | 11% exotic shrub; 4% tussock<br>3% bare ground; 3% rock |

File Ref: U:\2024\BM240011_RGi_Bendigo-Ophir_Mining_Project\GIS\ BM240011_Landscape.aprx BM240011_12_GS_Mine_Regeneration_Zones_A_A3L2:34 pm




Boffa Miskell

www.boffamiskell.co.nz

This plan has been prepared by Boffa Miskell Limited on the specific instructions of our Client. It is solely for our Client's use in accordance with the agreed scope of work. Any use or reliance by a third party is at that party's own risk. Where information has been supplied by the Client or obtained from other external sources, it has been assumed that it is accurate. No liability or responsibility is accepted by Boffa Miskell Limited for any errors or omissions to the extent that they arise from inaccurate information provided by the Client or any external source.

0 1 km

1:20,000 @ A3

*Data Sources:*
Waterways sourced from LINZ data service
Vegetation data from RM Ecology

*Projection:* NZGD 2000 New Zealand Transverse Mercator

**BENDIGO OPHIR MINING PROJECT**

## Mine Regeneration Zone A and Vegetation Communities

**Date: 01 August 2025 | Revision: 0**

Plan prepared for Santana Minerals by Boffa Miskell Limited

Project Manager: rhys.girvan@boffamiskell.co.nz | Drawn: BMc | Checked: HWi

**Map 1**

Table 1.3. Current values for ecology and estimated values after 35 years of management interventions (including planting) in Mine Regeneration Zones and unstripped areas of the project footprint (contingency zones) based on cover/area (Map 1). This is expected to increase the overall area of the MRZ at closure. Enrichment planting with species described in Parts 3 to 6 is designed to provide ecological uplift through a) provision of additional food and shelter for lizards and invertebrates and b) enhance structural diversity of shrubland vegetation associations by increasing the cover of lianes and trees. Approximate hectares after 35 years are estimate only and account for the likely addition of rehabilitation extended into contingency zones as well as rehabilitated stockpiles and access.

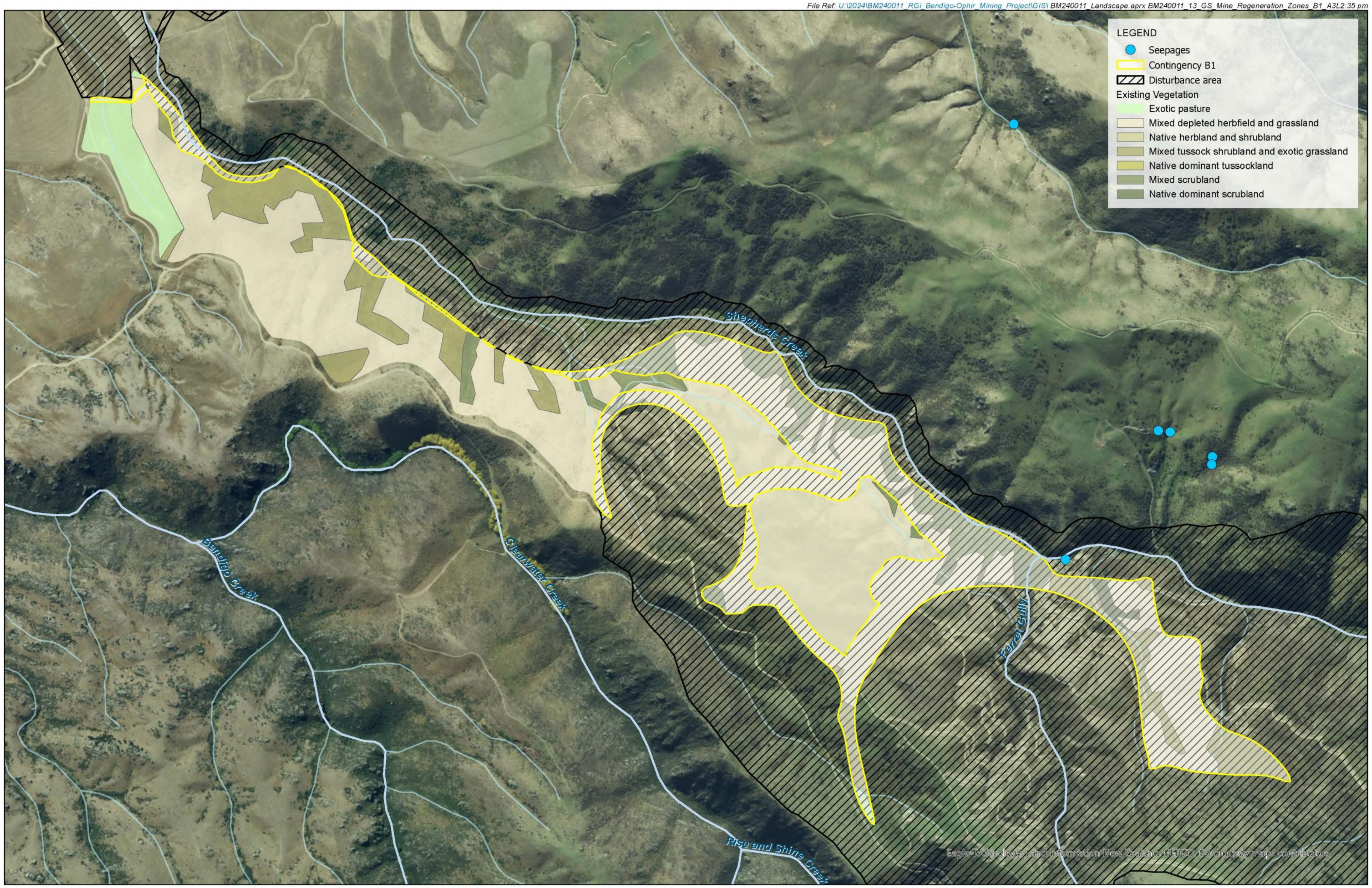
MRZ A – Ardgour slopes dominantly south facing

| Vegetation Association | MRZ -A (ha.) | + 35 yrs (approx. ha.) | Rationale |
|---|---|---|---|
| Exotic Pasture | 109.9 | 55 | Decrease by at least 50% with interplanting and expansion of tussock as most faces are south facing so favourable for regeneration and planting |
| Mixed depleted herbfield and grassland | 1.9 | 0 | Decrease to 0 as t hese are small areas amid taller vegetation will be outcompeted with removal of browsing and grazing |
| Native dominant tussockland | 23.6 | 26 | Increase by 10%. Expansion in response to no grazing and new snow tussock in high areas. Reduction in areas that transition to tussock shrubland (tussock understorey). |
| Native herbfield and shrubland | 15.9 | 20 | Increase by 25% as 800 m favours regeneration and planting but slower; taramea may expand by 10% and matagouri expand faster with cessation of grazing; management prevents brier from expanding |
| Mixed tussock shrubland and exotic grassland | 170.2 | 244 | Increases by ~40% as most faces are south facing so favourable for regeneration and planting but also transitions to mixed shrubland |

| Vegetation Association | MRZ -A (ha.) | + 35 yrs (approx. ha.) | Rationale |
|---|---|---|---|
| Mixed scrubland | 15.3 | 23 | Increases by 50% as most faces are south facing so favourable for regeneration and planting, and brier is maintained or increased |
| Native dominant scrubland | 97.6 | 117 | Area increases but slowly (10%) as tussock shrubland and mixed shrubland develops to scrubland (shading out brier and filling in gaps currently in pasture) |
| Wetland | 0.5* | 0 | Seepages are small, grazed, and artificially enlarged under grazing. With removal of stock sedges and adjacent shrubs dominant and begin to shade seepages, e.g. *Olearia bullata* |
| TOTAL | 434.4 | 485 | |

**** Extent of wetland areas are represented by seepages. Area of wetland is indicative only.***

File Ref: U:\2024\BM240011_RGi_Bendigo-Ophir_Mining_Project\GIS\ BM240011_Landscape.aprx BM240011_13_GS_Mine_Regeneration_Zones_B1_A3L2:35 pm




Boffa Miskell
www.boffamiskell.co.nz



0 1 km
1:10,000 @ A3

*Data Sources:*
Waterways sourced from LINZ data service
Vegetation data from RM Ecology

*Projection:* NZGD 2000 New Zealand Transverse Mercator

**BENDIGO OPHIR MINING PROJECT**

Mine Regeneration Zone B1 and Vegetation Communities

**Date: 01 August 2025 | Revision: 0**

**Plan prepared for Santana Minerals by Boffa Miskell Limited**

Project Manager: rhys.girvan@boffamiskell.co.nz | Drawn: BMc | Checked: HWi

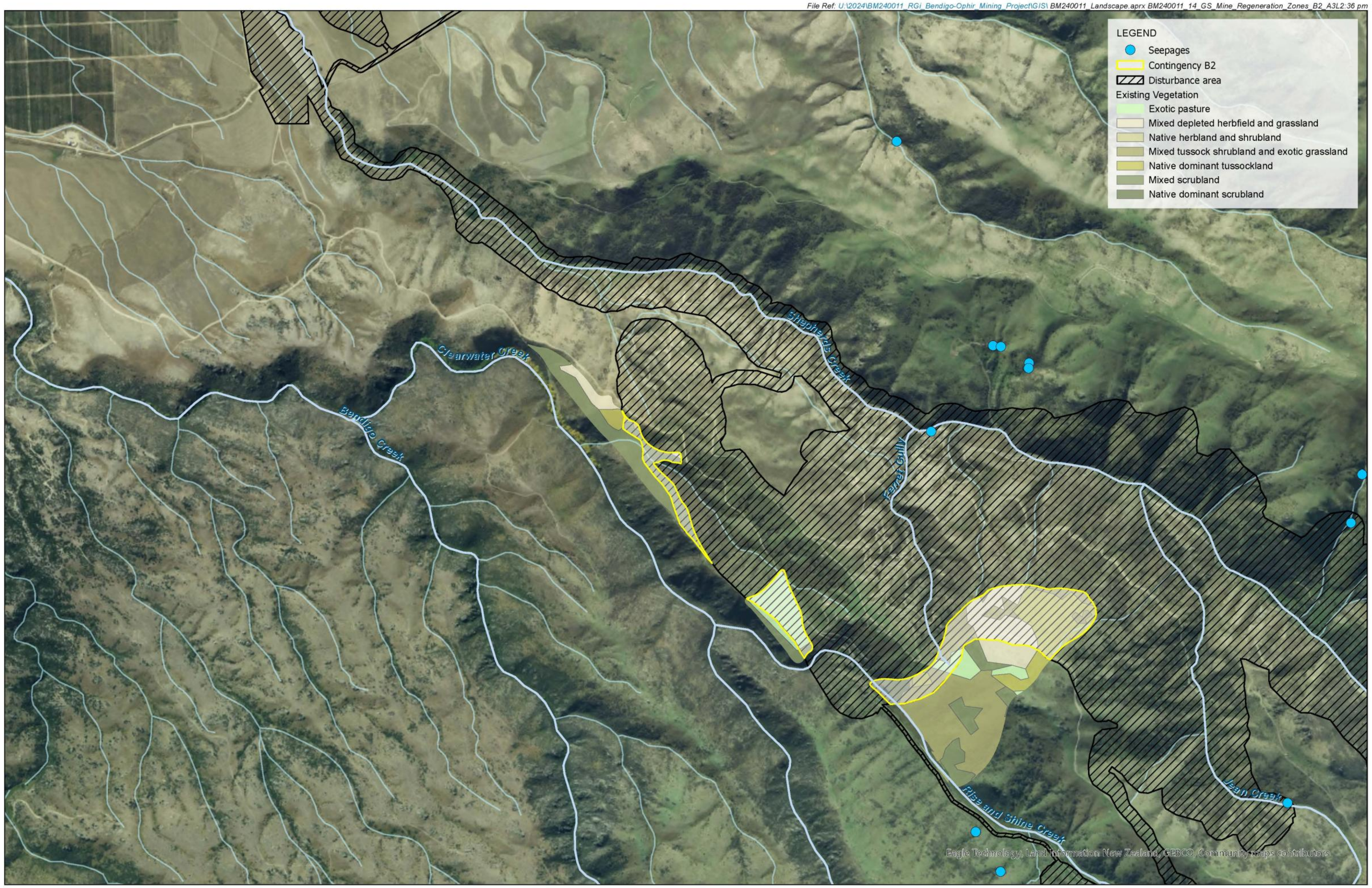
**Map 2**

Table 1.4. Current values for ecology and estimated values after 35 years of management interventions (including planting) in Mine Regeneration Zones and unstripped areas of the project footprint (contingency zones) (Map 2). Approximate hectares after 35 years are estimated only and account for the likely addition of rehabilitation extended into contingency zones as well as rehabilitated stockpiles and haul roads.

| **Vegetation Association** | **MRZ B1**<br>**ha** | **+ 35yrs**<br>**Approx. ha** | **Rationale** |
|---|---|---|---|
| Exotic Pasture | 5 | 24 | Decrease as although exposed slopes are slow to change ARP Cushionfields will develop methods to accelerate transition to cushionfield |
| Mixed depleted herbfield and grassland | 50.2 | 54 | Cushionfield ARP aims to expand noting outcome is uncertain and will change with detailed mapping of cushionfields in spring 2025/2026 |
| Native dominant tussockland | 0 | 0 | N/A |
| Native herbfield and shrubland | 0 | 0 | N/A |
| Mixed tussock shrubland and exotic grassland | 9.6 | 8 | Slight decrease through conversion either to herbfield or tussockland but change slowed by ongoing grazing that prioritises cushionfields |
| Mixed scrubland | 2.1 | 0 | Eliminated as brier is removed. Coverted to native dominant scrubland or mixed depleted herbfield |
| Native dominant scrubland | 0 | 3 | Created by removing brier from 'mixed scrubland' and establishing grey shrubland on some exotic pasture. |
| Wetland | 0 | 0 | No seepages present |
| TOTAL | 66.8 | 67 | |

**** Extent of wetland areas are represented by seepages. Area of wetland is indicative only.***

File Ref: U:\2024\BM240011_RGi_Bendigo-Ophir_Mining_Project\GIS\ BM240011_Landscape.aprx BM240011_14_GS_Mine_Regeneration_Zones_B2_A3L2:36 pm




Boffa Miskell
www.boffamiskell.co.nz

This plan has been prepared by Boffa Miskell Limited on the specific instructions of our Client. It is solely for our Client's use in accordance with the agreed scope of work. Any use or reliance by a third party is at that party's own risk. Where information has been supplied by the Client or obtained from other external sources, it has been assumed that it is accurate. No liability or responsibility is accepted by Boffa Miskell Limited for any errors or omissions to the extent that they arise from inaccurate information provided by the Client or any external source.

0 1 km
1:15,000 @ A3

*Data Sources:*
Waterways sourced from LINZ data service
Vegetation data from RM Ecology

*Projection:* NZGD 2000 New Zealand Transverse Mercator

**BENDIGO OPHIR MINING PROJECT**

Mine Regeneration Zone B2 and Vegetation Communities

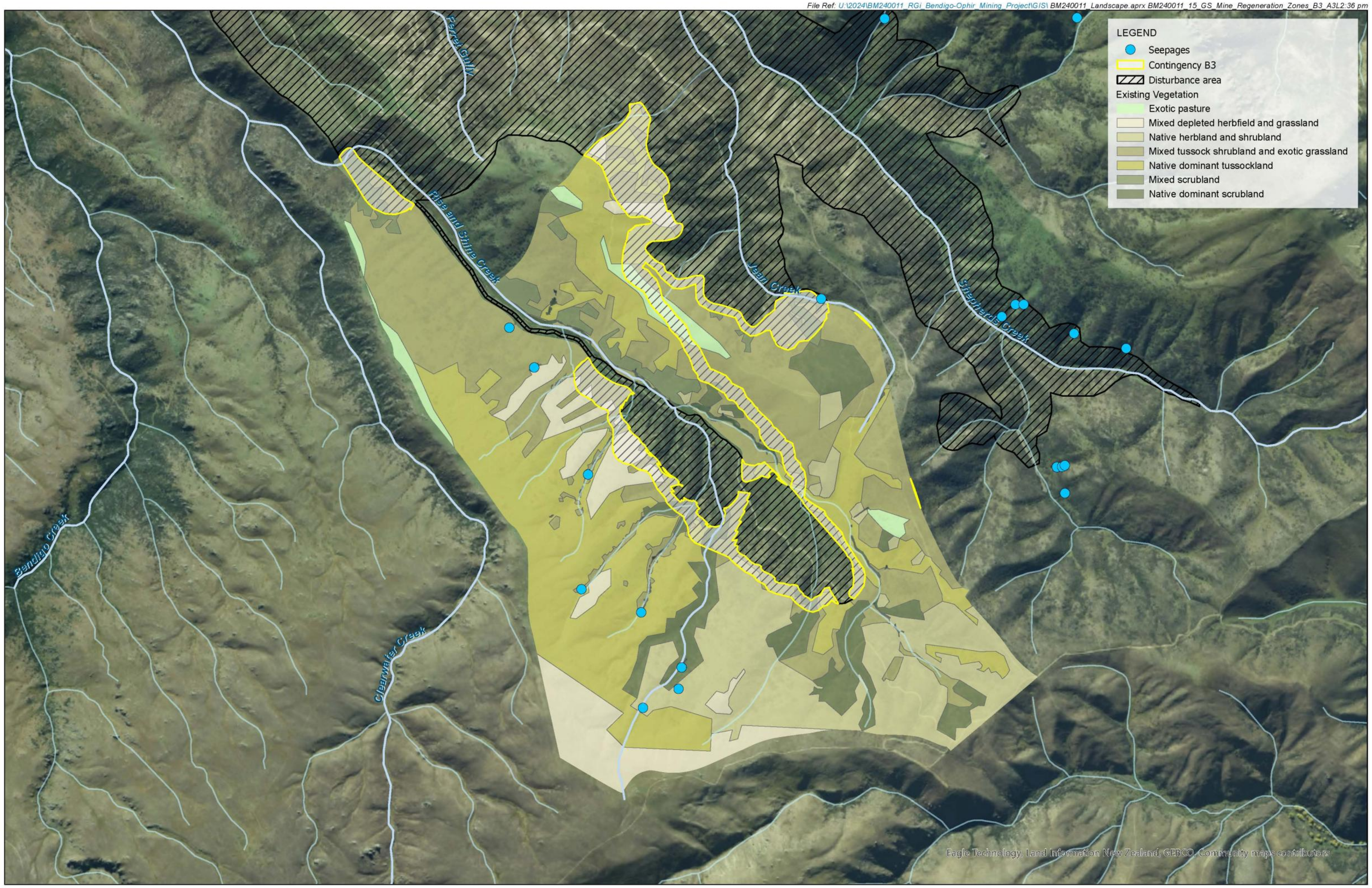
**Date: 01 August 2025 | Revision: 0**

**Plan prepared for Santana Minerals by Boffa Miskell Limited**

Project Manager: rhys.girvan@boffamiskell.co.nz | Drawn: BMc | Checked: HWi

**Map 3**

File Ref: U:\2024\BM240011_RGi_Bendigo-Ophir_Mining_Project\GIS\ BM240011_Landscape.aprx BM240011_15_GS_Mine_Regeneration_Zones_B3_A3L2:36 pm




Boffa Miskell
www.boffamiskell.co.nz

This plan has been prepared by Boffa Miskell Limited on the specific instructions of our Client. It is solely for our Client's use in accordance with the agreed scope of work. Any use or reliance by a third party is at that party's own risk. Where information has been supplied by the Client or obtained from other external sources, it has been assumed that it is accurate. No liability or responsibility is accepted by Boffa Miskell Limited for any errors or omissions to the extent that they arise from inaccurate information provided by the Client or any external source.

0 1 km
1:15,000 @ A3

*Data Sources:*
Waterways sourced from LINZ data service
Vegetation data from RM Ecology

*Projection:* NZGD 2000 New Zealand Transverse Mercator

**BENDIGO OPHIR MINING PROJECT**

Mine Regeneration Zone B3 and Vegetation Communities

**Date: 01 August 2025 | Revision: 0**

**Plan prepared for Santana Minerals by Boffa Miskell Limited**

Project Manager: rhys.girvan@boffamiskell.co.nz | Drawn: BMc | Checked: HWi

**Map 4**

Table 1.5. Current values for ecology and estimated values after 35 years of management interventions (including planting) in Mine Regeneration Zones B2 (Map 3) and B3 (Map 4). The boundaries of B2 are likely to change following detailed cushionfields and spring annual mapping (stage 1 in the ARP cushionfields). Small patches of cushionfield, or elements of cushionfield (i.e., Raoulia spp.) are found throughout other vegetation communities. MRZ B3 responds similarly to MRZ A but starts with more tussock; both are interplanted with diverse species. Approximate hectares after 35 years are estimate only and account for the likely addition of rehabilitation extended into contingency zones as well as rehabilitated stockpiles and haul roads.

| Vegetation Association | MRZ -B2 | + 35 yrs (approx. ha.) | MRZ B3 | + 35yrs (approx. ha.) | Notes |
|---|---|---|---|---|---|
| Exotic Pasture | 2.1 | 0 | 7.6 | 0 | Removed as pasture is transitioned to native tussock and shrubland |
| Mixed depleted herbfield and grassland | 3.3 | 3 | 32 | 0 | Herbfield in MRZ B3 is generally not raoulia cushionfield (too high so plan to transition to tussock and shrubland) |
| Mixed tussock shrubland and exotic grassland | 11.7 | 30 | 108.8 | 148 | Fire buffers within the site. Will have a higher proportion of bare ground and rocks and include tracks |
| Mixed scrubland | 10.7 | 18 | 10 | 40 | Dominant outcome in the first 35 years: low shrubs mixed with tussock, non-native and native grasses and herbs and rock and brier |
| Native dominant tussockland | 2.2 | 3 | 106.9 | 120 | Higher rain and more protection on MRZ B3 speeds transition of tussock into tussock-shrubland and mixed depleted herbfield into tussock |
| Native herbfield and shrubland | 0 | | 62.9 | 0 | Likely to become dominated by Matagouri with removal of grazing with expansion of taramea enhanced by planting if necessary |

| Vegetation Association | MRZ -B2 | + 35 yrs (approx. ha.) | MRZ B3 | + 35yrs (approx. ha.) | Notes |
|---|---|---|---|---|---|
| Native dominant scrubland | 0 | 0 | 28.7 | 91 | South-facing slopes where drought and cold stress is lowest with expansion fastest in MRZ B3 due to lower drought stress and higher initial density |
| Wetland | 0 | 0 | 0 | 0 | Seepages are present, but very small areas and 4 ha marsh |
| TOTAL | 30 | 54 | 356.9 | 399 | |

** Extent of wetland areas are represented by seepages. Area of wetland is indicative only.*

## E.2. Part 2. Summary of revegetation methods used for each vegetation community

Vegetation communities are separated into DDF (planting from scratch into recreated root zones) and Mine Regeneration Zones.

**Table 2.1 Mine rehabilitation revegetation methods summary for DDF areas**

| Feature | Vegetation establishment | Habitat Features | Other |
|---|---|---|---|
| ***Mine footprint – stripped areas*** | | | |
| Highwalls. (Rocky herbfield, grassland screes (highwalls) | Dense natural revegetation enabled by wedge of replaced soils extending at least 20 m from contact with natural ground. Seed rain enhanced in adjacent contingency zone by increasing native plants (transplant tussock), removing weeds. Small patches of grey | Nil (rock scree and rubble accumulates from weathering). Kowhai planted in deep root zones above pit lake, wetland root zone on haul road to 1 m water depth, emergent boulders in water and water edge. Rock | Ongoing pest plant control on benches by drone |

| Feature | Vegetation establishment | Habitat Features | Other |
|---|---|---|---|
| | shrubland on lower haul roads near pit lakes. Most pit walls not treated[17] | added to contingency strips onto pasture | |
| Mixed scrubland; Mixed tussock shrubland and exotic grassland | Sweet vernal or browntop sown at 2 to 3 kg/ha. Planting of >1500 native plants/ha as nursery-raised seedlings clustered on habitat features includes >20 nodes/ha of >10 tussocks and >30 shrub seedlings. Contingency zones have buffer zones adjacent to stripped ground enriched with transplants from adjacent areas (tussocks, sedges, taramea) and with woody weeds and other pest plants removed. | Rock stacks, rubble pits and rock. Short tussock inoculations of at least 10 salvaged plants >10 cm basal diameter per stack and rubble pit.<br><br>Rock added to areas of pasture within contingency zones<br><br>Kowhai exclosures; taramea planting | Ongoing pest plant and pest animal control<br><br>Long term stock exclusion |
| Native dominant scrubland<br><br>Native dominant tussockland | As above, develops from the above as a mosaic with tussock component (more exposed areas) | As above. | As above |
| Riparian/valley edges with areas of frost drainage and sheltered[18] | Patches (total 0.5 ha minimum) of native trees on deep replaced root zones and diverse woody species (>2500 plants/ha equivalent). | Thin barked totara, kowhai create long term structure and height | As above |
| Cushionfields and spring annual herbs | Application of ARP cushionfields trials and expansion of successful methods | Kowhai exclosures | ARP-specific pest plant / |

[17] Accessible shaded areas and edges to natural ground could be seeded with native seed balls and/or hydromulched with low rates of local native seeds with 1-2kg/ha sweet vernal and/or browntop but this is applied research with wider adoption dependent on results and costs.
[18] Not identified as a specific unit in the broad-scale mapping

| Feature | Vegetation establishment | Habitat Features | Other |
|---|---|---|---|
| | | | competing plant control |
| Sedgeland wetlands | 7500 nursery plants/ha planted and/or salvaged sods placed in herringbone pattern including 5 threatened Carex, Juncus and Rumex species; margins planted with toetoe, flax. | Emergent rocks and areas of open water on TSF | Pest plant control initially to help native plants to establish |

**Table 2.2 Mine rehabilitation revegetation methods summary for Mine Regeneration Zones**

| ***Mine Regeneration Zones*** | | | |
|---|---|---|---|
| Exotic pasture / grassland | 1500 native plants/ha transplanted or planted as nursery-raised plants in favourable microsites | >2000 riparian forest trees established | |
| Mixed depleted herbfield (cushionfield) | ARP cushionfield and spring annual herb management; removal of all brier and woody weeds; mini-exclosures for Pimelea on edges of cushionfield; kowhai exclosures in gullies | | Browsing managed (sheep, rabbits) |
| Exotic dominant scrubland; Mixed scrubland; Mixed tussock shrubland and exotic grassland | 500 native plants/ha transplanted or planted as nursery-raised plants (test decompaction, scarification, basal fertiliser, mulches, releasing). | Kowhai enclosures;<br>Taramea expansion.<br>Salvaged wood and mulches near outcrops to enhance invertebrates | |
| Native dominant tussockland; | 500 native woody plants/ha as nursery-raised plants in clusters to favourable | | Brier control to keep areas clean |

| | |
|---|---|
| | microsites; >5000 snow tussock at higher elevations, interplanted |
| Native dominant scrubland | 250 native woody plants/ha as nursery-raised plants to favourable microsites |

***All areas***

***Access to be defined: Roads for heavy vehicles (e.g. fire-fighting), Farm vehicle tracks/ stock movement, Public biking/walking tracks; ATV and walking tracks to long term monitoring sites are essential for efficient monitoring and need to be installed early; Fire buffers to public tracks.***

***Biosecurity includes specific provision at track entrances and along public tracks and roads. Pest plant and animal control is targeted by management unit.***

### E.3. Part 3. Species for enrichment planting in Mine Regeneration Zones

Enrichment planting is valuable because Vegetation plots across the DDL show very few abundant or common native species in native dominant scrubland, mixed scrubland, and mixed tussock scrubland. Only *Coprosma propinqua* (miki) and *Discaria toumatou* (matagouri) were abundant or common in all these vegetation types with native dominant shrubland also containing *Olearia odorata* (scented tree daisy – a priority species for invertebrates). The high-elevation herbfield and shrubland, containing the mega-herb taramea had the greatest number of common or abundant native woody species, with matagouri joined by *Pimelea oreophila lepta*, *Melicytus alpinus* (porcupine shrub) and *Styphelia nesophilia* (dwarf mingimini).

**Enrichment planting** targets woody species that are at very low densities (VLD) within or near to the Project Study Area. This means they may be functionally extinct and therefore are a target for enrichment planting to re-establish viable populations. It prioritises species that are propagated by nurseries, and that enrich habitat for lizards or invertebrates (i.e. extending and/or diversifying nectar, pollen or fruit resources). Although *Olearia odorata* is listed for lower elevation dryland shady faces, it will only be planted into the more open areas of pasture or tussockland and used to create shelter. The species lists are divided into environment types that occur across the landforms and are defined by aspect, altitude and drought stress. These include 'Kowhai exclosures' which are to be established to (re)establish habitat for native seed-dispersing and pollinating birds through expanding relic kowhai across North West to Eastern slopes and low elevation streamsides. Over the DDF and MRZ at least 24 kowhai exclosures will be created, each of which will be established with at least 30 seedlings representing diverse genetics by using seedlings from Bendigo (grown from cuttings salvaged from the oldest tree in each cluster that is removed), Ardgour and the wider Clutha Basin. The low-elevation streamsides are where more diverse, taller vegetation are targeted, including small pockets of (tall) forest in the small areas of deep soils in sheltered, frost-drained gullies/valley areas. At least 0.5 ha of this tall forest will also be established in mined areas.

Enrichment planting also includes planting vines as structural species that are both in low density in many areas and their early introduction can develop longer-term benefits for lizards, invertebrates and moderation of climate – and also protect shrub areas from potential future browse (after a minimum 20 years). Enrichment planting does <u>not</u> include ferns, as most are likely to establish from spores, spores are dispersed by wind over long distances, and remnant sources are within rock tors and other places inaccessible to browsers – hence removal of browsers, potentially combined with site amelioration and increase of woody cover is likely to enhance conditions for natural establishment and expansion. *Acrothamnus colensoi* is not included as it is noted as difficult to propagate, and kanuka is not proposed to be planted (or controlled if it establishes, other than in fire buffers). Some Threatened At Risk species found in cushion-fields and rock stacks are established by natural expansion facilitated by removing browse pressure around parent plants combined with grass control (if needed), e.g *Pimelea aridula, Carmichaelia crassicaulis* and *Carmichaelia monroi*. Direct seeding of *Carmichaelia petrei* (and *C. crassicaulis*) will be trialled in exclosures but is unproven (nursery-grown seedlings will be established in these areas if seeding fails).

Enrichment planting differs from **inoculation planting** in mined areas. Inoculation planting is based on rock stacks/rubble pits (where survival is expected to be highest as they are the most protected sites), and areas of short tussock. The short tussocks and hardy woody native species are expected to expand over decades. Most plants are able to supress low-biomass, non-native grasses that are initially established to supress erosion. Inoculation planting is therefore a much narrower range of species, which includes the woody species that are abundant or common in adjacent Mine Regeneration Zones.

Table 3.1 Plant species for enrichment planting of Mine Regeneration Zones that are NOT cushionfield

LF = provides fruit for lizards, LN = provides nectar for lizards, IF = important floral resources for invertebrates.

| Species | Proportion, Features | National, Regional Threat status |
|---|---|---|
| **Kowhai exclosures – W to NE facing between 330 and 880 m ASL. Enrichment planting, generally moderate drought stress** | | |
| All species to be established in all exclosures | | |
| *Sophora microphylla, kowhai* | >20 per exclosure. IF. Browse-sensitive tree | NT |
| *Carmachaelia petrei* | >10 per exclosure. IF. Browse-sensitive (shrub to 2 m) | AR -D |
| *Veronica cupressioides* | >5 per exclosure. IF. Fire sensitive | NT |
| *Scandia geniculata*[19] | >5 per exclosure..IF Liane | AR -D |
| *Carmichaelia kirkii*[20] | >5 per exclosure..IF. Highly – browse sensitive Shrub | T – NV |
| *Myrsine divaricata* | >5 per exclosure. LF. Shrub | NT |
| *Melicope simplex* | >5 per exclosure. LF. Shrub | NT |
| | | |
| **Low elevation dryland shady faces – S facing, part MRZ B1 (non-cushionfield), B2 & B3** | | |
| **Add 5% of suitable plants from lists 2 and 3 below** | | |

[19] Long creeping, lianoid, woody to subwoody, aromatic perennial shrub froming interwoven, tangled masses up to 3 x 3 m (especially when sprawling through other shrubs). Found West Wanaka Bluffs Conservation Area, just beside the road.

[20] Sprawling or climbing nearly leafless greyish brown shrub. Good population was in the Matukituki V, among Olearia hectori Matukituki Bluff Conservation Area (~1280400E,5051150N)

| Species | Proportion, Features | National, Regional Threat status |
|---|---|---|
| *Olearia hectorii* | 20%. IF (emergent deciduous shrub to 10 m, deeply furrowed bark on old trees) | NT |
| *Olearia lineata* | 20%. IF (shrub 3 to 8 m) | AR-D |
| *(Olearia odorata)* | 20% in gaps only. IF especially moths (shrub 2 to 4 m) | AR-D |
| *Coprosma virescens, mingimingi* | 20%. LF (shrub 3 to 5 m) | AR-D |
| *Coprosma intertexta* | 15%. LF bush to about 2 by 2 m | NT |
| **Lower elevation stream sides, gullies and lower shady faces (part MRZ A1, B2 small areas of B3 SRX)** | | |
| **Include 40% of '*' plants, 30% other woody plants, 20% lianes,and 10% from lists 2 and 3 below** | | |
| *Sophora microphylla (kowhai)* | Browse-sensitive, nectar for bellbirds, structure & bark in medium term | |
| *Aristotelia fruticosa* | IF, Fruit for birds and lizards | AR-D |
| *Carmichaelia petriei* | N-fixer, successional processes, only in stock-excluded areas | AR-D |
| *Coprosma intertexta* * | LF bush to about 2 by 2 m | AR-D |
| *Coprosma rugosa* | LF bush to about 3 by 2 m. Faster growing. | NT |
| *Coprosma dumosa* | LF erect shrub to 3 m tall.. Easy to propagate from fresh seed. | NT |
| *Coprosma virescens* | IF, Fruit for birds and lizards | AR -D |
| *Cordyline australis* | IF, Fruit for birds, only in stock-excluded areas | NT |
| *Coriaria sarmentosa* | N-fixer, successional processes | NT |
| *Corokia cotoneaster (korokio)* * | LF, IF reaches 1.5 to 2 m. Faster growing. | NT |
| *Hoheria angustifolia* | IF, nectar for bellbirds, structure, only in stock-excluded areas | NT |

| Species | Proportion, Features | National, Regional Threat status |
|---|---|---|
| *Griselinea littoralis (kapuka)* | Fruit for birds, structure & bark in long term, only in stock-excluded areas | NT |
| *Melicope simplex* | LF. | NT |
| *Myrsine divaricata* | Fruit for birds, very slow growing so only in stock-excluded areas | NT |
| *Olearia bullata* | IF (shrub to 3 m), only in stock-excluded areas | NT |
| *Olearia lineata ** | IF (shrub 3 to 8 m) | AR-D |
| *Olearia odorata ** | in gaps only. IF especially moths (shrub 2 to 4 m) | AR-D |
| *Olearia hectorii* | IF in the best sites | NT |
| *Ozothamnus leptophylla* | IF | NT |
| *Pittosporum tenuifolium T* | IF, nectar for bellbirds, only in stock-excluded areas | NT |
| *Plagianthus regius (ribbonwood) T* | IF, nectar for bellbirds, | NT |
| *Podocarpus laetus (totara) T* | LF, fruit for bellbirds, structure & bark in long term | NT |
| *Pseudopanax colensoi* | LF, Fruit for birds | NT |
| *Pseudopanex ferox, P. crassifolius* | Fruit for birds, only in stock-excluded areas | NT |
| *Veronica rakaiensis ** | bushy shrub to 2 m can supress grass only stock excluded areas | AR (regional) |
| *Veronica salicifolia* | IF, fast-growing to 2.5 m, frost sensitive only in stock-excluded areas | NT |
| *Veronica pimeliodes and V. lycopodioides* | only higher parts of MRZ A1 (locally common pre-settlement, lower Dunstan Range) | |
| **Lianes (20% of planting to be lianes, as a combination of the below species)** | | |
| *Clematis marata* | IF | NT |

| **Species** | **Proportion, Features** | **National, Regional Threat status** |
|---|---|---|
| *Clematis quadribracteolata* | IF | NT |
| *Parsonsia capsularis* | LF | NT |
| *Parsonsia heterophylla* | LF | NT |
| *Muehlenbeckia complexa var. complexa* | LF, IF | NT |
| *Muehlenbeckia australis* | LF. IF | NT |
| *Rubus cissoides* | LF | NT |
| *Rubus schmidelioides* | LF | NT |
| | | NT |
| **High elevation gullies and seepages MRZ A (plant snow tussock first then yr 3 interplant tree species within individual wire cages)** | | |
| *Chionochloa rigida* (snow tussock) | 5000 minimum individuals established | |
| *Phyllocladus alpinus* (celery pine) | 50% established planted once snow tussock is established, may also use cage protection | |
| *Podocarpus nivalis* (snow totara) | 25% established planted once snow tussock is established, also use cage protection | |
| *Olearia nummilarifolia* | 25% established planted once snow tussock is established | |

**Lists 2 and 3. Species to be added in low numbers to a combined total maximum of 5% of respective planting in suitable microsites above.**

The following species are recorded at very low densities in the project area so are planted in nodes to increase the abundance of seed sources. Sites are to be determined, however *C. cheesemanii, C. dumosa* and *C. rugosa* are noted as potential hydrophytes, so will be placed near seepages. At least 25 plants of each listed species to be planted every second year for 10 years, with establishment success and growth over 3 years recorded and at least 100 individuals of each species established.

- *Carmachaelia monroi*, dwarf broom, At risk-declining
- *Coprosma brunnea*. ~1 m tall x 1-2 m, fleshy fruit for lizards. At risk-declining; heavily browsed. Easy to propagate from fresh seed. At risk-declining
- *Coprosma cheesemanii* ~0.5 to 1 m tall x 1-2 m, orange fleshy fruit for lizards. Easy to propagate from fresh seed. Not threatened
- *Gaultheria antipoda*, snowberry bushy shrub 10-20 cm tall and 50 to 150 cm across. fleshy fruit for lizards. Not threatened
- *Gaultheria depressa novae-zealandiae*, snowberry low growing shrub 0.5 m high fleshy fruit for lizards. Not threatened
- *Helichrysum simpsonii* subsp. *Simpsonii*
- *Melicytus aff. crassifolius* (thick-leafed mahoe) fleshy fruit. At risk-declining
- *Olearia cymbifolia*. Shrub reaching 1 to 2 m. flowers important for invertebrates. At-Risk Regionally Naturally Uncommon.

The following Veronicas (Hebes) shrubs were not recorded but could be in the wider area and provide floral resources for invertebrates so are also included for planting in clumps of 5 to 10 at very low overall densities as enrichment plantings in suitable microsites. At least 25 plants of each species will be planted in each of 5 successive years into suitable microsites on MRZ and rehabilitation sites:

- *Veronica buchananii*
- *Veronica hectorii demissa*
- *Veronica pimeleoides pimeleoides*.

### E.4. Part 4. Plant species for lizard habitat rock stacks and rubble pits in DDF (mined) areas

This table is repeated from Appendix 2. Post Mining rehabilitation methods for lizard habitat. The selection of species for individual rock stacks and rubble pits will depend on the location of the habitat feature and is guided by microsites listed in Table 3 (orange text) above.

Table 4.1 Plant species established within rock stacks and rubble pit features in DDF

Conservation status is coded NT (Not Threatened), At Risk D (Declining), Threatened RE (Regionally Endangered), RV (Regionally Vulnerable), RNU (Regionally Naturally Uncommon). All plant species except *Myrsine divaricata* and *Pentachondra pumila* are confirmed as present on the site by RMA Ecology vegetation surveys. The ecological provision associated with each plant species is - (nil), + (present) or ++ (abundant/important).

| Species | Common name | Conservation Status | Provision for geckos and skinks | | | |
|---|---|---|---|---|---|---|
| | | National, Regional | Shelter | Fruit | Pollen/nectar | Invertebrates |
| Tussocks* (grasses) | | | | | | |
| *Anthosachne apica* | Blue wheat grass | AR-NU, T-RV | ++ | - | - | + |
| *Chionochloa spp.* | slim Snow Tussock | | ++ | - | - | ++ |
| *Festuca matthewsii* | | NT, R DD | ++ | - | - | ++ |
| *Festuca novae-zelandiae* | fescue tussock, hard tussock | NT | ++ | - | - | ++ |
| *Poa cita* | silver tussock | NT | ++ | - | - | ++ |
| *Poa colensoi* | blue tussock | NT | + | - | - | ++ |
| Herbs | | | | | | |
| *Aceana buchanani* | Bidibid / piripiri | NT, AR-D | - | - | - | + |
| *Acaena inermis* | Spineless acaena | NT, AR RD | - | - | - | + |
| *Aciphylla aurea* | golden Spaniard | NT | ++ | - | ++ | ++ |
| Lianes | | | | | | |
| *Muehlenbeckia axillaris* | creeping Wire Vine | NT | ++ | ++ | - | ++ |

| Species | Common name | Conservation Status | Provision for geckos and skinks | | | |
|---|---|---|---|---|---|---|
| | | National, Regional | Shelter | Fruit | Pollen/nectar | Invertebrates |
| *Muehlenbeckia complexa var. complexa* | small-leaved pōhuehue | NT | ++ | ++ | - | ++ |
| *Rubus schmidelioides var. subpauperatus* | white-leaved lawyer | NT | + | ++ | - | + |
| *Rubus schmidelioides var. schmidelioides* | | NT | + | ++ | - | + |
| Fern | | | | | | |
| *Cheilanthes sieberi* | Rock fern | NT, AR-NU | - | - | - | + |
| Shrubs** | | | | | | |
| *Acrothamnus colensoi* | Colenso's mingimingi | NT | ++ | ++ | - | + |
| *Carmaechaelia species (N)* | native brooms, incl C.petriei | AR-D, AR-RD (C. petrei) | - | - | - | ++ |
| *Coprosma brunnea* | | AR- D, T_RE | ++ | ++ | - | - |
| *Coprosma cheesemanii* | | NT | ++ | ++ | - | - |
| *Coprosma dumosa* | | NT | ++ | ++ | - | - |
| *Coprosma petriei* | turfy Coprosma | NT | - | ++ | - | - |
| *Coprosma propinqua var. propinqua* | miki | NT | ++ | ++ | - | - |
| *Coprosma rugosa* | needle-leaved mtn. coprosma | NT | ++ | ++ | - | - |
| *Coprosma virescens* | mikimiki | AR-D, T-RV | ++ | ++ | - | - |
| *Corokia cotoneaster* | korokio, wire-nettting bush | NT | + | ++ | - | + |
| *Discaria toumatou (N)* | matagouri, tāmatakuru | NT | + | - | - | + |
| *Melicytus alpinus* | porcupine Shrub | NT | ++ | ++ | - | + |

| Species | Common name | Conservation Status | Provision for geckos and skinks | | | |
|---|---|---|---|---|---|---|
| | | National, Regional | Shelter | Fruit | Pollen/nectar | Invertebrates |
| *Myrsine divaricata* | weeping matipo | NT | ++ | ++ | - | + |
| *Myrsine nummularia* | creeping Mapou | NT | - | ++ | - | + |
| *Olearia lineata* | Tree daisy | AR-D, AR-RD | - | - | - | + |
| *Olearia odorata* | scented tree daisy | AR-D, AR-RD | - | - | - | ++ |
| *Pentachondra pumila* | carpet heath | NT | - | ++ | - | + |
| *Pimelea aridula aridula* | Native daphne | AR-D, T-RV | - | ++ | - | + |
| *Pimelea oreophila lepta* | Native daphne | NT | - | ++ | - | + |
| *Pimelea notia* | Native daphne | NT, AR-RNU | - | ++ | - | + |
| *Pimelea prostrata subsp. prostrata* | Native daphne | NT, T-RV | - | ++ | - | + |
| *Styphelia nana* | | At Risk – D | - | ++ | - | + |
| *Styphelia nesophila* | dwarf mingimingi | NT | - | ++ | - | + |

### E.5. Part 5. Threatened wetland Plants to be established in DDF (mined areas)

Five plant species identified as species of importance due to their threat status are also robust enough to re-establish (i.e. form plants tall and dense enough to be able to establish within the grasses used for initial erosion control) and have established methods for successful propagation and production of nursery plants that can be planted to re-establish populations in suitable parts of wetlands including the TSF.

- *Carex buchananii.* Establish as nursery seedlings (more cost-effective than division of plants on site) to TSF swales and edges of wetlands
- *Carex diandra* Establish into wetlands as nursery seedlings (has a wide moisture tolerance)
- *Carex kaloides* Establish into wetlands as nursery seedlings and as divisions from salvaged plants placed in Ardour Terraces wetland
- *Juncus distegus* Establish into wetlands as nursery seedlings but has very specific site conditions so may not persist. Aim is to develop seed source that is blown or moved by water to areas where it is naturally competitive.

*Rumex flexuosus* will also be propagated and planted into mined areas. This is a native dock growing to ~25 cm height. The locations of dock will be identified. See will be collected, and if it can be found within the DDF, hand transplantation of rihzomes into Ardgour Terrace or Shepherd Stream wetlands will be attempted.

## E.6. Part 6. Cushionfield plants and their propagation

The vegetation survey included 23 plots within cushionfield. It records the threatened species, *Raoulia australis*, *Raoulia beauverdii* and *Poa maniototo* as abundant and *Hypericum involutum* as common. Other abundant and common native species recorded in the survey were *Cheilanthes sieberi* (rock fern), the herbs *Dichondra repens, Geranium brevicaule*, and *Oxalis exilis* and the dense, low shrub *Pimelea aridula* (up to about 60 cm but 10-15 cm in exposed rock outcrops[21]). *Raoulia australis* was the most frequently occurring native species but was at a lower frequency than *Anthoxanthum odoratum* (sweet vernal), *Trifolium arvense* (hare's foot trefoil) and *Rosa rubiginosa* (brier). Common smothering non-native herbs included *Cirsium arvense* (Californian thistle), *Echium vulgare* (viper's bugloss) and Verbascums (mulleins).

Most of the above native plants are vulnerable to competition from aggressive introduced plants (pasture species and herbs) and nearly all are wind-dispersed, exceptions being some spring annuals. Management in un-stripped areas of cushionfield therefore focuses on controlling competition to enhance health of native cushionfield plants and creating suitable sites for natural establishment in mined and unmined areas. In mined areas, management focuses on retaining as much cushionfield as possible through footprint minimisation (avoiding cushionfield) and creating very sharp edges with stripped /disturbed areas to minimise the distance from source zones to inoculation zones.

The methods for cushionfield and spring annual herb rehabilitation will be developed through the Applied Research Plan. However, nursery propagation and cultivation notes indicate nearly all the native species listed below that are not spring annuals are considered easy to propagate based on information primarily from NZPCN website (and personal experience with *Leptinella* and *Crassula* cultivation and translocation at small scales). *Pimelea aridula* will be planted into mined areas as seedlings (it is easily grown from semi-hardwood cuttings) and its natural propagation enhanced in unstripped areas using exclusion netting around existing plants. This is because it is a major floral resource for invertebrates. Burrows (2010) notes Pimelea flowers are pollinated by insects (solitary bees, flies, moths and butterflies) and the dry seeds are likely to be dispersed by lizards as well as by wind. It is likely that three common herbs will be grown from seed as all can be easily identified and probably efficiently collected: *Dichondra repens* (wind-dispersed seeds, easily and widely propagated from seed and

---

[21] Full article: Genus Pimelea (Thymelaeaceae) in New Zealand 5. The taxonomic treatment of five endemic species with both adaxial and abaxial leaf hair

rooted pieces for ‘no mow’ turf), *Geranium brevicaule* (wind-dispersed seeds, easily grown from fresh seed, with green to purple leaf colour variation) and *Oxalis exilis* (easily grown from seed, considered weedy) In contrast, *Colobanthis brevisepalus* may be difficult to propagate. It is unlikely transplanting will be used at scale to inoculate mined areas with live plants as many species have deep root systems so are unlikely to survive shifting, however the potential for the technique will be assessed in trials at sites where root systems are likely to be shallowest. The unattached lichen may be also transplanted if it is present in places that are efficient to collect. It is also important to ensure identification to have confidence that the threatened species are being promoted rather than common species that look similar, e.g. most likely for Crassulas, Myosotis and Daucus.

Table 6.1. Cushionfield species and Threat status, with conservation notes. SAS – spring annual species. * Not included in draft vegetation report as threatened.

| Species | National threat status | Regional Threat status | Note |
|---|---|---|---|
| *Ceratocephala pungens* | Threatened - Nationally Critical | Threatened – Regionally Critical | Spring annual. No previous propagation; threat is competition |
| *Myosotis brevis* | Threatened - Nationally Vulnerable | Threatened – Regionally Endangered | Spring annual, as above |
| *Myosurus minimus* subsp. *novae-zelandiae* | At Risk - Declining | Threatened – Regionally Endangered | Spring annual, as above |
| *Cheilanthes sieberi** | NT | At Risk Regionally Naturally uncommon | Fern, 'easily grown' cultivated using spores, maybe rhizomes, attempt salvage to rock stacks |
| *Colobanthis brevisepalus* | At Risk - Declining | Threatened – Regionally Vulnerable | Small perennial cushion (8cm across). By division. No reported success with direct transplants in field. |
| *Daucus glochidiatus*** | Threatened – Nationally Vulnerable | Threatened – Regionally Critical | Bi-ennial large herb (30 to 80 cm), easily propagated if seed can be collected (sow in place) |
| *Hypericum involutum** | At Risk – Declining | Regionally data deficient | Open herb up to 25 cm, large yellow flowers Easily grown, not commercially available 'inclined to be weedy' |
| *Pimelea aridula** | At Risk - Declining | At Risk – Regionally Declining | Erect shrub to 60 cm, mass flowering. Propagated using semi-hardwood cuttings or seed |
| *Poa maniototo* | At Risk – Declining (abundant here) | At Risk – Regionally Declining | Propagate by spring division or autumn seed. Seed wind-dispersed |
| *Raoulia australis* | At Risk – Declining (abundant here) | At Risk – Regionally Declining | Tight perennial cushion to ~1 m. In cultivation and available from nurseries. Little reported success with transplanting |

| Species | National threat status | Regional Threat status | Note |
|---|---|---|---|
| *Raoulia beauverdii* | At Risk – Declining (abundant here) | Threatened – Regionally Vulnerable | As above. Easily grown from rooted pieces and fresh seed. Wind blown (daisy) seed. |
| *Raoulia monroi* | At Risk - Declining | Threatened – Regionally Critical | Loose cushion to ~X cm. Easily grown from rooted pieces. Wind blown (daisy) seed. |
| *Xanthoparmelia semiviridis* | At Risk - Declining | No status available | Unattached lichen. When dry forms 30 mm balls that are blown and accumulate in large numbers along fencelines/among shrubs. Could be collected, stored and 'sown' in rubble pits. |

## E.7. Part 7. Plants with a threat status within the DDF and rehabilitation management

The following table lists Nationally and Regionally At Risk and Threatened plant species, their abundance within each vegetation community within the Direct Disturbance Footprint (based on surveys by RMA Ecology reported in Vegetation Values Assessment, August 2025, Table 4) and rehabilitation management, specifying the method of propagating nursery-raised species from seed (SD), cuttings (CT) or division (DV), and the species that will be salvaged /transplanted from the DDF footprint. Salvage of live Threatened or At Risk plants from the DDF is restricted to wetland plants and some shallow rooted grasses as most woody plants have deep root systems (1-3 m or more) that cannot be salvaged intact. The large MRZ is the source of most plant propagules and is managed to enhance the health and natural expansion of many threatened plant species. This provides flexibility for seed collection that is likely to maintain the local genetic variability of most plant species except for wetland species. The MRZ therefore acts an enhanced ‘nursery stock population’ of mature plants with their natural pollinators. The exception is the three spring annual herbs listed in the ARP as a large proportion of their populations in within the DDF.

NOTES

Regional Threat Status is coded as AR-D (At Risk – Declining), AR-NU (At Risk – Naturally Uncommon), RDD (Data Deficient), T-C (Threatened – Critical), T-E (Threatened – Endangered), T-V (Threatened – Vulnerable). NT (Not Threatened) is placed in national and regional columns.

BLUE indicates wetland plants; GREY indicates widespread species recorded in 4 or more vegetation associations; ORANGE indicates the species is restricted to 1 or 2 vegetation associations. GREEN indicates species that were not detected in the DDF.

Abundance is assessed according to the ACFOR scale: A = Abundant; C = Common; F = Frequent; O = Occasional; R = Rare.

Vegetation community codes: EXP – Exotic pasture or herbfield; MDH – Mixed depleted herbfield (cushionfield) and grassland; NDT – Native dominant tussockland; NDS – Native dominant scrubland; EDS – Exotic dominant scrubland; NHS – Native herbfield and shrubland; MSC – Mixed scrubland; MHW – Mixed herbaceous wetland; MTS – Mixed tussock shrubland and exotic grassland.

The anticipated response for DDF (i.e. establishment into mined areas after mining) is 'present' or 'absent' as plant numbers at establishment are generally very low. The anticipated response for MRZ is based on the species being present in the surrounding MRZ and considers the management used including planting, weed control, pest browser control and grazing management (stock exclusion or managed grazing by sheep). Divisions will be restricted to plants salvaged from DDF, seed will generally be collected from the DDF and MRZ. Exceptions may be for species with very low number of individuals in the DDF and MRZ to ensure genetic variation from across the upper Clutha basin.

**Numbers of established individuals will be consistent with conditions, i.e. a minimum of 100 individuals of all species**

**Table 7.1. Plants with a threat status that are present in the DDF within each mapped vegetation association and Anticipated response to management.**

| Species | National threat stat. | Regional Threat Stat. | Direct Disturbance Footprint | | | | | | | | Anticipated Response | | Rehabilitation Approach (estimated 2025 population in DDF) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | EXP | MDH | NDT | NDS | NHS | MSC | WL | MTS | DDF | MRZ | |
| *Acaena buchananii* | At Risk – Declining | T-V | R | R | R | R | R | R | X | R | present | stable | Plant as nursery seedlings grown from SD into DDF rock stacks and rubble pits in DDF. Not planted in MRZ as existing seed sources are in most vegetation associations (>500) |
| *Acaena inermis* | NT | AR-D | X | X | R | R | X | X | X | R | present | stable | Plant as nursery seedlings grown from SD into DDF rock stacks and rubble pits in DDF. Not planted in MRZ as existing seed sources are in most vegetation associations (>10) |
| *Agrostis muscosa* | NT | AR-D | X | O | X | X | X | X | X | X | present | decrease | Short cushion grass spread by wind and water. Plant nursery seedlings grown from SD and DV into DDF cushionfields (>100) |
| *Anthosachne aprica* | At Risk – Naturally Uncommon | T-V | X | R | R | O | R | R | X | R | present | increase | Salvaged within tussock sods, replanted into DDF rock stacks and rubble pits as well as wider areas along with nursery plants from DV (>1) |

| Species | National threat stat. | Regional Threat Stat. | Direct Disturbance Footprint | | | | | | | | Anticipated Response | | Rehabilitation Approach (estimated 2025 population in DDF) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | EXP | MDH | NDT | NDS | NHS | MSC | WL | MTS | DDF | MRZ | |
| *Carex buchananii* | At Risk – Declining | T-V | X | X | O | O | X | O | O | O | increase | increase | Nursery-grown plants from SD planted into DDF moist areas (e.g. wetland edges and TSF swales); Increase in MRZ in short term with grazing removal; readily available (>100) |
| *Carex diandra* | NT | AR-NU | X | X | X | X | X | X | O | X | increase | increase | Nursery-grown seedlings from SD planted into rehabilitated wetlands on DDF including TSF (>200) |
| *Carex kaloides* | At Risk – Declining | T-E | X | X | X | R | X | X | R | X | increase | increase | Salvage in wetland sods to Ardgour Terrace wetland. Plant nursery-grown seedlings from divisions and SD in rehabilitated wetlands on DDF (>100) |
| *Carex talboti* | At Risk – Declining | T-V | X | X | X | X | X | X | X | R | absent | decrease | Very small sedge will not be propagated, likely to be overtopped in areas where grazing is stopped (>100) |
| *Carmichaelia crassicaulis crassicaulis* | Threatened – Nationally Vulnerable | T-V | X | X | X | X | X | X | X | X | present | present | Natural expansion facilitated by removal of browse in MRZ and grass control. Seed from DDF also used to propagate plants to establish in Ardgour Restoration Area |

| Species | National threat stat. | Regional Threat Stat. | Direct Disturbance Footprint | | | | | | | | Anticipated Response | | Rehabilitation Approach (estimated 2025 population in DDF) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | EXP | MDH | NDT | NDS | NHS | MSC | WL | MTS | DDF | MRZ | |
| *Carmichaelia monroi* | At Risk – Declining | T-C | X | X | X | X | X | X | X | X | present | present | Established from nursery plants (SD) into MRZ. Natural expansion with removal of browse in MRZ using cages. |
| *Carmichaelia petriei* | At Risk – Declining | AR-D | O | O | F | F | O | O | X | O | present | present | Established from nursery plants (SD) in DDF rock stacks and kowhai exclosures (nursery plants and direct seeding) and lower elevation stream sides, gullies and lower shady faces MRZ. Seed from DDF also used to propagate plants to establish in Ardgour Restoration Area (>1000) |
| *Ceratocephala pungens* | Threatened – Nationally Critical | T-C | X | R | X | X | X | X | X | X | ? | present | Collection and propagation from seed is a focus of the Applied Research Plan (129) |
| *Chaerophyllum ramosum* | Data Deficient | R NT | X | X | X | O | X | X | X | O | absent | decrease | Not attempted. Not threatened. Small herb often in wetter sites likely to decrease in seepages when stock removed (>100). |
| *Cheilanthes sieberi sieberi* | NT | AR-NU | O | A | R | R | R | R | X | R | present | increase | Wind-dispersed spores allow self-establishment and existing seed sources in suitable locations within most vegetation associations with removal of stock. Trial salvage from DDF and replanting of rhizomes to DDF rock stacks and MRZ (>5000). |

| Species | National threat stat. | Regional Threat Stat. | Direct Disturbance Footprint | | | | | | | | Anticipated Response | | Rehabilitation Approach (estimated 2025 population in DDF) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | EXP | MDH | NDT | NDS | NHS | MSC | WL | MTS | DDF | MRZ | |
| *Colobanthus brevisepalus* | At Risk – Declining | T-V | X | O | X | X | X | X | X | X | ? | present | ARP Cushionfields (by division) (>5000) |
| *Colobanthus strictus* | NT | AR-D | R | F | O | O | F | R | O | O | present | decrease | Planted into DDF cushionfields as nursery seedlings grown from DV. May decrease where taller plants establish in MRZ where grazing is removed as very low cushion (>10) |
| *Coprosma brunnea* | At Risk – Declining | T-E | X | X | X | X | X | X | X | X | present | increase | Nursery seedlings from SD planted into DDF rock stacks and rubble pits and into MRZ as enrichment species |
| *Coprosma virescens* | At Risk – Declining | T-V | X | X | R | O | R | R | X | R | present | increase | Nursery seedlings from SD planted into DDF rock stacks and rubble pits and into MRZ (lower elevation stream sides, gullies and shady faces) as enrichment species (>1). |
| *Cystopteris tasmanica* | NT | AR-NU | X | R | R | O | X | R | X | O | present | increase | Not planted, probably palatable (10-40cm leaves), wind-dispersed spores allow self-establishment and existing seed sources in most vegetation associations so likely to expand in MRZ rock outcrops where grazing is stopped (>500) |
| *Daucus glochidiatus* | Threatened – Nationally | T-C | X | X | X | X | X | X | X | X | ? | NA | Not in DDF. This large biennial herb (30 to 80 cm) could be seeded in suitable MRZ cushionfield microsites if seed can be collected from Ardgour Restoration Area. |

| Species | National threat stat. | Regional Threat Stat. | Direct Disturbance Footprint | | | | | | | | Anticipated Response | | Rehabilitation Approach (estimated 2025 population in DDF) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | EXP | MDH | NDT | NDS | NHS | MSC | WL | MTS | DDF | MRZ | |
| | Vulnerable | | | | | | | | | | | | |
| *Deschampsia chapmanii* | NT | RDD | X | X | X | X | X | X | X | X | absent | NA | Not in DDF and not proposed to be introduced to DDF |
| *Epilobium hectorii* | At Risk – Declining | AR-D | X | O | R | X | X | X | X | R | present | present | Small, wind-dispersed herb easily grown from seed that establishes into open stony ground. Low plant numbers so plant nursery seedlings from SD into DDF and MRZ (>50). |
| *Euchiton traversii* | NT | AR-NU | X | X | X | X | X | X | X | X | absent | NA | Not in DDF, not proposed to be introduced to DDF |
| *Festuca mathewsii subsp. mathewsii* | NT | RDD | X | X | O | X | O | X | X | O | present | present | Salvage as tussock sods and replanted into DDF rock stacks and rubble pits as well as wider areas along with nursery plants from SD collected from DDF and MRZ; increase in MRZ in short term with grazing removal. Commonly grown by nurseries (>100). |
| *Geranium aff. microphyllum* | At Risk – Naturally Uncommon | NT | R | R | O | O | R | R | R | O | present | stable | Short-lived small herb in all 7 terrestrial vegetation associations. Low plant numbers so plant nursery seedlings (easily grown) from SD into DDF and MRZ (>1) |

| Species | National threat stat. | Regional Threat Stat. | Direct Disturbance Footprint | | | | | | | | Anticipated Response | | Rehabilitation Approach (estimated 2025 population in DDF) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | EXP | MDH | NDT | NDS | NHS | MSC | WL | MTS | DDF | MRZ | |
| *Geranium potentilloides* | NT | RDD | O | R | O | O | R | R | R | O | present | stable | Per *Geranium aff. microphyllum*. |
| *Hypericum involutum* | At Risk – Declining | RDD | X | C | X | X | X | X | X | X | present | present | Open herb up to 25 cm, wind dispersed. Planted into DDF using nursery-seedlings from SD (easily grown). Likely to be naturally maintained in MRZ B1 Cushionfields (>5000) |
| *Isolepis praetextata* | NT | AR-NU | X | X | X | X | X | X | X | X | absent | NA | Not in DDF, not proposed to be introduced to DDF |
| *Juncus distegus* | NT | AR-D | X | X | X | X | X | X | X | O | present | present | This 25 to 75 cm rush with tightly packed stems is likely to persist and could expand with removal of grazing; Nursery-plants from SD established into DDF wetlands (>100). |
| *Lagenophora barkeri* | At Risk – Declining | T-RE | X | X | X | X | X | X | O | X | ? | present | Very small, wind dispersed daisy. Unknown propagation. Plant into DDF using nursery-seedlings from SD to establish source in suitable sites with low competition (>5) |
| *Luzula banksiana var. rhadina* | Data Deficient | AR-NU | R | O | O | O | O | O | X | O | present | decrease | Not attempted (small herb, likely to self-establish as it is in all 7 terrestrial vegetation associations including pasture) |
| *Luzula leptophylla* | At Risk – Naturally | AR-NU | X | X | X | X | X | X | R | X | absent | decrease | Not attempted (very small herb, probably propagated by transplanting but difficult to maintain free of competition) (>5) |

| Species | National threat stat. | Regional Threat Stat. | Direct Disturbance Footprint | | | | | | | | Anticipated Response | | Rehabilitation Approach (estimated 2025 population in DDF) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | EXP | MDH | NDT | NDS | NHS | MSC | WL | MTS | DDF | MRZ | |
| | Uncommon | | | | | | | | | | | | |
| *Myosotis brevis* | Threatened – Nationally Vulnerable | T-E | X | O | X | X | X | X | X | X | ? | ? | Applied Research Plan (>3000) |
| *Myostis antarctica subsp. antarctica* | At Risk - Naturally Uncommon | RAR-NU | X | O | X | X | X | X | X | X | ? | ? | Applied Research Plan (>1000) |
| *Myosurus minimus novae-zelandiae* | At Risk – Declining | T-E | X | R | X | X | X | X | X | X | ? | ? | Applied Research Plan (>100) |
| *Myriophyllum pedunculatum subsp.* | NT | AR-NU | X | X | X | X | X | X | O | X | absent | present | Not attempted (mat forming herb, easily propagated by divisions/stems and seed but difficult to maintain free of competition) (>10) |

| Species | National threat stat. | Regional Threat Stat. | Direct Disturbance Footprint | | | | | | | | Anticipated Response | | Rehabilitation Approach (estimated 2025 population in DDF) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | EXP | MDH | NDT | NDS | NHS | MSC | WL | MTS | DDF | MRZ | |
| *novae-zelandiae* | | | | | | | | | | | | | |
| *Olearia bullata* | NT | AR-NU | X | X | R | X | X | X | X | R | absent | increase | Nursery-seedlings from SD planted into MRZ (>1) |
| *Olearia cymbifolia* | NT | AR-NU | X | X | X | X | X | X | X | X | absent | present | Nursery seedlings from SD planted into MRZ |
| *Olearia lineata* | At Risk – Declining | AR-D | R | R | R | O | X | R | X | R | present | increase | Nursery seedlings from SD planted into DDF (rock stacks and rubble pits) and MRZ (lower elevation dryland shady faces) (>50) |
| *Olearia odorata* | At Risk – Declining | AR-D | O | O | F | A | R | F | X | F | present | increase | Nursery seedlings grown from SD planted into DDF (rock stacks and rubble pits), MRZ (lower elevation dryland shady faces in larger gaps) (>5000) |
| *Pellaea calidirupium* | At Risk – Naturally Uncommon | AR-NU | X | O | X | X | X | X | X | R | present | present | Not planted, wind-dispersed spores allow self-establishment. Cushionfields ARP (>1000) |
| *Pimelea aridula aridula* | At Risk – Declining | T-V | X | C | R | R | R | R | X | R | present | increase | Nursery seedlings grown from SD planted into DDF (rock stacks and rubble pits) and MRZ. Backup of semi-hardwood cuttings but no more than 20% of nursery seedlings. Exclusion |

| Species | National threat stat. | Regional Threat Stat. | Direct Disturbance Footprint | | | | | | | | Anticipated Response | | Rehabilitation Approach (estimated 2025 population in DDF) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | EXP | MDH | NDT | NDS | NHS | MSC | WL | MTS | DDF | MRZ | |
| | | | | | | | | | | | | | fenced in MRZ-B1 to promote natural seedling establishment and growth (200) |
| *Pimelea notia* | NT | AR-NU | X | X | X | R | X | X | X | X | present | increase | Nursery seedlings grown from SD planted into DDF (rock stacks and rubble pits) and MRZ (semi-hardwood cuttings as backup and no more than 20% of seedlings). Exclusion fenced in MRZ-B1 to promote natural seedling establishment and growth (>10). |
| *Pimelea prostrata subsp. prostrata* | NT | T-V | X | X | R | R | R | X | X | R | present | increase | Nursery seedlings grown from SD planted into DDF (rock stacks and rubble pits) and MRZ (semi-hardwood cuttings as backup and no more than 20% of seedlings). Exclusion fenced in MRZ-B1 to promote natural seedling establishment and growth (>50). |
| *Poa incrassata* | At Risk – Naturally Uncommon | AR-NU | X | X | X | X | X | X | X | X | absent | NA | Not in DDF, not proposed to be introduced to DDF |
| *Poa lindsayi* | NT | AR-D | R | O | R | R | X | X | X | R | absent | decrease | Small fine grass similar to P. maniototo, not proposed for management, likely to reduce in areas where stock grazing is reduced as other plants thicken and be maintained in MRZ B1 (>50) |

| Species | National threat stat. | Regional Threat Stat. | Direct Disturbance Footprint | | | | | | | | Anticipated Response | | Rehabilitation Approach (estimated 2025 population in DDF) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | EXP | MDH | NDT | NDS | NHS | MSC | WL | MTS | DDF | MRZ | |
| *Poa maniototo* | At Risk – Declining | AR-D | X | A | R | X | X | X | X | R | present | decrease | Small fine grass likely to be maintained in MRZ B1 with maintenance of grazing. Wind-dispersed. Planted into DDF as part of ARP cushionfields as nursery seedlings from spring division or autumn seed (>5000) |
| *Raoulia australis* | At Risk – Declining | AR-D | O | A | F | O | O | O | X | F | Present | ? | Applied Research Management cushionfields aims to expand in MRZ B1 and develop introduction methods. Planted into DDF as nursery seedlings using SD and cuttings from edges Little reported transplant success. Wind-dispersed. Likely to reduce in areas where grazing is stopped (>5000) |
| *Raoulia beauverdii* | At Risk – Declining | T-V | O | A | F | O | O | O | X | F | Present | ? | Applied Research Management cushionfields aims to expand in MRZ B1 and develop introduction methods. Planted into DDF as nursery seedlings by CT/DV and SD. Wind-dispersed. Likely to reduce in areas where grazing is stopped (>5000). |
| *Raoulia parkii* | At Risk – Declining | T-V | X | O | O | R | R | R | X | O | Present | ? | Applied Research Management cushionfields aims to expand in MRZ B1 and develop introduction methods Likely to reduce in areas where grazing is stopped. Planted into DDF as nursery seedlings using CT/DV (rooted pieces). Wind-dispersed (>500) |
| *Rumex flexuosus* | NT | AR - NU | R | X | X | X | X | X | O | X | present | present | Tall herb to 25 cm. Collect seed and attempt direct seeding; transplant rhizomes in DDF within large sods (>0.5 by 0.5*0.5 m) to Ardgour Terrace or Shepherds wetlands (>2) |

| Species | National threat stat. | Regional Threat Stat. | Direct Disturbance Footprint | | | | | | | | Anticipated Response | | Rehabilitation Approach (estimated 2025 population in DDF) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | EXP | MDH | NDT | NDS | NHS | MSC | WL | MTS | DDF | MRZ | |
| *Rytidosperma buchananii* | At Risk – Declining | AR-D | X | R | X | X | X | X | X | R | present | reduce | Nursery seedlings grown from SD planted into DDF and MRZ, likely to be maintained in MRZ B1 and reduce in areas where grazing is stopped. Wind-dispersed (>50) |
| *Rytidosperma corinum* | Data Deficient | NT | R | O | O | O | R | R | X | O | present | reduce | Not proposed for specific management, likely to be maintained in MRZ B1 with maintenance of grazing and reduce in areas where grazing is stopped; may self-establish in suitable areas of DDF through wind-blown seed from adjacent MRZ as has wide distribution (>500) |
| *Rytidosperma maculatum* | At Risk – Declining | T-V | X | O | X | X | X | X | X | X | absent | reduce | Not proposed for specific management, likely to be maintained in MRZ B1 with maintenance of grazing and reduce in areas where grazing is stopped. Wind-dispersed (>100) |
| *Rytidosperma pumilum* | NT | AR-D | X | O | R | R | R | R | X | R | present | present | Planted in low numbers in DDF with rock stacks. Orange fruited so if established may be lizard dispersed. Not commercially propagated so will be a trial species. Likely to gradually reduce in sites where grazing is withheld. Wind-dispersed (>500) |
| *Styphelia nana* | At Risk – Declining | NA | R | O | O | O | R | R | X | O | present | present | Nursery seedlings from SD planted in DDF rock stacks and rubble pits. Likely maintained in MRZ B1 with maintenance of grazing and reduce in areas where grazing is stopped (>500) |

| Species | National threat stat. | Regional Threat Stat. | Direct Disturbance Footprint | | | | | | | | Anticipated Response | | Rehabilitation Approach (estimated 2025 population in DDF) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | EXP | MDH | NDT | NDS | NHS | MSC | WL | MTS | DDF | MRZ | |
| *Veronica rakaiensis* | NT | AR-NU | X | X | X | X | X | X | X | X | present | present | Nursery-seedlings from SD planted in MRZ lower elevation stream sides, gullies and lower shady faces by streams and equivalent areas of DDF. Expect rapid increase. |
| *Vittadinia australis* | NT | AR - NU | R | R | O | R | O | R | X | O | present | present | Nursery-seedlings from SD planted into DDF to establish seed sources to supplement wind-blown seed from adjacent MRZ as has wide distribution and easily grown in nursery from fresh seed (>50). |

## E.8. Part 8. Taoka Plants

The following table is a provisional list of taoka plants. Rehabilitation will be implemented in a manner that recognises and provides for mātauraka Māori and the exercise of kaitiakitaka by mana whenua (Kāi Tahu), including their relationship with indigenous flora and fauna. Implementation of this Management Plan will align with Cultural Impact Assessment recommendations and contribute to long-term outcomes for mana whenua. The Ngāi Tahu Claims Settlement Act (NTCSA, 1998) lists taonga/taoka species that have special importance to Kāi Tahu. Many of these species are specifically included in planting and those, and other species are likely to directly benefit from the management proposed in this management plan. However, not all species that are important to mana whenua are listed in the NTCSA. In consultation with Kāi Tahu, species additional to those listed in this Appendix will be established. These might be taoka species or other species that have important values to mana whenua. Species will need to be appropriate for the environmental conditions present in the MRZ and DDF as well as the overall objectives of restoration management.

In the following table:

- blue highlights those species identified in the cultural impact statement and evidence.
- green highlights species that are proposed for planting into the MRZ and/or DDF
- yellow highlights species that could be established in limited area, depending on the results of consultation with Kai Tahu
- pink highlights species that will not be deliberately planted are identified by (one species, kanuka).

Blue = identified in JW para 25 Terrestrial Ecology JWS (and see cultural evidence) who added *Pātōtara (Styphelia nesophila – Dwarf Mingimingi)*

| # | Māori Name | English Name | Scientific Name | Comments |
|---|---|---|---|---|
| 53 | **Aruhe** | Fernroot (bracken) | *Pteridium aquilinum var esculentum* | Present within the Direct Disturbance Footprint (DDF). Unlikley to be planted but may regenerate (may need management in fire buffers as highly flammable) |
| 54 | **Harakeke** | Flax | *Phormium tenax* | Absent. Found locally alongside Clutha River nearby but not within the Ecological Study Area (ESA), despite some suitable habitat existing. |
| 55 | **Horoeka** | Lancewood | *Pseudopanax crassifolius (and P. ferox proposed)* | Absent. Closest locations for this species are near Lakes Wakatipu, Hāwea, and Wānaka. May have been present in past but has been possibly extirpated from the Dunstan Mountains. |
| 56 | **Houhi** | Mountain ribbonwood | *Hoheria lyalli and H. glabata At this site H. angustifolia proposed* | Absent. May have been present in past but has been possibly extirpated from the Dunstan Mountains. *H. glabrata* is present on Pisa Range. *H. lyalli* is present near Lakes Wakatipu, Hāwea, and Wānaka. |
| 58 | **Kāmahi** | Kāmahi | *Weinmannia racemosa* | Absent. Closest locations for this species are near Lakes Wakatipu, Hāwea, and Wānaka. |
| 59 | **Kānuka** | Kānuka | *Kunzea ericoides* | *Kunzea serotina* and *Kunzea robusta* are present within the Direct Disturbance Footprint (DDF). Not proposed to be planted in DDF or MRZ; (may need management in fire buffers) |
| 60 | **Kāpuka** | Broadleaf | *Griselinia littoralis* | Absent. Was likely present in the past but is now rare in the Ecological District. |
| 67 | **Korokio** | Wire-netting bush | *Corokia cotoneaster* | Present within the Direct Disturbance Footprint (DDF). |
| 68 | **Koromiko / Kōkōmuka** | Koromiko | *Hebe salicifolia* | *Veronica salicifolia* not present within the Direct Disturbance Footprint (DDF), but present in the wider Ecological Study Area (ESA). |
| 69 | **Kōtukutuku** | Tree fuchsia | *Fuchsia excorticata* | Absent. Closest locations for this species are near Lakes Wakatipu, Hāwea, and Wānaka. May have been present in past but has been possibly extirpated from the Dunstan Mountains. |
| 70 | **Kōwhai** | Kōwhai | *Sophora microphylla* | Present within the Direct Disturbance Footprint (DDF). |
| 71 | **Mamaku** | Tree fern | *Cyathea medullaris* | Absent. Not found or is very rare in Otago. |
| 72 | **Mānia** | Sedge | *Carex flagellifera* | Absent. Not found locally in the Ecological District or nearby. |
| 73 | **Mānuka** | Tea-tree | *Leptospermum scoparium* | Absent in the Ecological Study Area, although found elsewhere in the Ecological District. |
| 74 | **Māpou** | Red matipo | *Myrsine australis* | Absent. Closest locations for this species are near Lakes Wakatipu, Hāwea, and Wānaka. May have been present in past but has been possibly extirpated from the Dunstan Mountains. |
| 75 | **Matai** | Matai / Black pine | *Prumnopitys taxifolia* | Absent. Closest locations for this species are near Lakes Wakatipu, Hāwea, and Wānaka. May have been present in past but has been possibly extirpated from the Dunstan Mountains. |
| 76 | **Miro** | Miro / Brown pine | *Podocarpus ferrugineus* | Absent. Closest locations for this species are near Lakes Wakatipu, Hāwea, and Wānaka. |

| # | Māori Name | English Name | Scientific Name | Comments |
|---|---|---|---|---|
| 80 | **Pātōtara** | Dwarf mingimingi | *Leucopogon fraseri* | Present within the Direct Disturbance Footprint (DDF). |
| 84 | **Rātā** | Southern rātā | *Metrosideros umbellata* | Absent. Closest locations for this species are near Lakes Wakatipu, Hāwea, and Wānaka. May have been present in past but has been possibly extirpated from the Dunstan Mountains. |
| 85 | **Raupō** | Bulrush | *Typha angustifolia* | Absent. Found locally alongside Clutha River nearby but not within the Ecological Study Area (ESA), despite some suitable habitat existing. |
| 86 | **Rautāwhiri / Kōhūhū** | Black matipo / Māpou | *Pittosporum tenuifolium* | Absent. May have been present in past but has been possibly extirpated from the Dunstan Mountains. |
| 89 | **Taramea** | Speargrass, spaniard | *Aciphylla spp.* | *Aciphylla aurea* present within the Direct Disturbance Footprint (DDF). |
| 90 | **Tarata** | Lemonwood | *Pittosporum eugenioides* | Absent. Closest locations for this species are near Lakes Wakatipu, Hāwea, and Wānaka. |
| 91 | **Tawai** | Beech | *Nothofagus spp.* | Absent. Remnant silver beech is found on Pisa Range but not in Dunstan Ecological District. May have been present in past but has been possibly extirpated from the Dunstan Mountains. |
| 93 | **Tī rākau / Tī Kōuka** | Cabbage tree | *Cordyline australis* | Absent. Was likely present in the past but is now rare or absent in the Ecological District. |
| 94 | **Tikumu** | Mountain daisy | *Celmisia spectabilis and C. semicordata* | Absent. Both absent in the Ecological District.<br>Check – evidence of historic harvesting |
| 96 | **Toatoa** | Mountain Toatoa / Celery pine | *Phyllocladus alpinus* | Absent. Present in the Ecological District |
| 97 | **Toetoe** | Toetoe | *Cortaderia richardii* | *Austroderia richardii* present within the Direct Disturbance Footprint (DDF) |
| 98 | **Tōtara** | Tōtara | *Podocarpus totara* (at this site *P. laetus* | Absent. *Podocarpus totara* rare or absent in Central Otago. *P. laetus* found nearby on Pisa Range and possibly extirpated from the Dunstan Mountains. |
| 99 | **Tutu** | Tutu | *Coriaria spp.* | Absent. *C. sarmentosa* and *C. plumosa* found in ED or nearby. |
| 100 | **Wharariki** | Mountain flax | *Phormium cookianum* | Absent. Found locally but not within the Ecological Study Area (ESA). |
| 102 | **Wī** | Silver tussock | *Poa cita* | Present within the Direct Disturbance Footprint (DDF) |
| 103 | **Wīwī** | Rushes | *Juncus spp* and *J. maritimus* | *Juncus distegus, Juncus edgariae, Juncus novae-zelandiae* present within the Direct Disturbance Footprint (DDF). |

# APPENDIX F. PHOTOGRAPHIC SUMMARY OF REHABILITATION OBJECTIVES AND OUTCOMES

The following photographs help explain the proposed mine rehabilitation methods and anticipated outcomes for the Bendigo Ophir project[22]. Specific target vegetation types and (mine) rehabilitation features occur across multiple Landscape Management units, mine regeneration zones and sanctuaries. The vegetation types are based on those mapped by RMA Ecology. In summary, they are:

**Native Dominant Scrubland**. Large areas will be rehabilitated. More diverse Olearia shrublands (fire resilient species) with enrichment nodal planting of palatable species that are currently sparse or absent (but would have been present in the past), will extend habitat, fruiting and flowering resources for native fauna, as well as increasing structural complexity (e.g. through increase in vines and structural diversity, including through emergent shrubs). Plants will be prioritised that could feasibility reach >0.5 m height (above rabbit and hare browse with margin for snow) within 20-30 years or form dense thickets.

**Cushionfield**. Rehabilitation aims to expand this priority ecosystem in MRZ and re-establish the ecosystem in the DDF. Techniques need to be developed through the Applied Research Plan. These techniques are likely to include methods to slow and reverse (natural) succession to tussock and shrubland in MRZ by a) removing brier in these areas b) removing some native woody seedlings and if needed, maintaining grazing by rabbits and/or sheep, c) increasing cushionfield species dominance in areas of non-native pasture by reducing the proportion of non-native species (grasses, taller herbs and legumes) and planting or seeding raoulia. The Applied Research Plan develops rehabilitation methods for mined areas alongside spring annual herb management. Cushionfield forms the core of low and mid-elevation fire buffer zones along with pit high walls.

**Kowhai Refugia.** Twelve individuals or small clusters of kowhai are present, most are in the DDF although some are in the contingency zones. Rehabilitation will establish at least 24 kowhai clusters, each with at least 30 saplings (planting and seeding may be used) taller than 2 m at closure. Kowhai will be included in 0.5 ha of **Gully Forest**. Both kowhai clusters and gully forest will be mostly located in zones with low fire risk and buffered from fire. Additional kowhai will be established in the fenced riparian areas

[22] Descriptions of each vegetation type and rationale are provided in vegetation succession doc (later version of ‘Vegetation success_bendig_&Rocky_Point4_5March2025.docx)

adjacent to the Ardgour Terrace wetland and lower parts of SRK and RAS in-pit haul roads with deep root zones. Kowhai refugia will be protected from grazing for the duration of the consent (20-30 years post establishment), the gully forest protected in perpetuity. Kowhai are faster-growing than podocarps, are sparsely regenerating under current management, and ecologically valuable for lizards and native honey-eating birds which, if increased in numbers are important seed dispersal agents for some plant species.

**Native dominant tussockland**. Tussock in MRZ will be managed to allow natural thickening and expansion, except where part of a buffer to mixed depleted herbfield or fire buffers. Large areas are expected to slowly transition to 'native dominant scrubland with tussock', by facilitating woody shrub expansion. This approach is expected to retain and enhance habitat for Southern grass skink (while increasing fruit and floral resources) where tussock persists as a major component of ground-cover, i.e. both between and under most areas of open shrubland. Tussock is expected to slowly decrease in areas of dense shrubland. Tussock will be planted in most mined areas in clusters that include salvaged plants and more generally as nursery-grown seedlings.

**Wetlands**. About 2 ha of wetlands are present within the DDF (2025). Rehabilitation will include salvaging at least 0.5 ha of these wetlands in year 1 as direct transfer to establish the Ardgour Terrace constructed wetland. Another 0.5 ha in years 1 and 2 to establish the Lower Shepherd's wetland using direct transfer and planting of individual plants into salvaged wetland soils. At the end of mine life at least 6 ha of wetlands and 0.5 ha of open water will be established on the TSF using nursery plants, and at least 0.5 ha of wetland established in Lower Shepherd Creek near and downstream of the disestablished plant area (again largely using planted nursery species).

**Taramea**. Increasing the area of taramea is a priority due to its ecological importance for both threatened invertebrates and invertebrates that use its abundant floral resources, and due to its cultural values. The natural spread of taramea will be enhanced by reducing seedling browse by hares/rabbits and reducing damage from pigs. Planting of taramea will be largely restricted to mined areas targeting suitable rock stacks and rubble pits (a minimum 5 per stack targeting areas above 800 m), and attempting transplanting of taramea seedlings from stripped areas, e.g. haul road to SRX into undisturbed areas of contingency zone (expecting high mortality).

Each of the above vegetation types, other than cushionfields or taramea may include

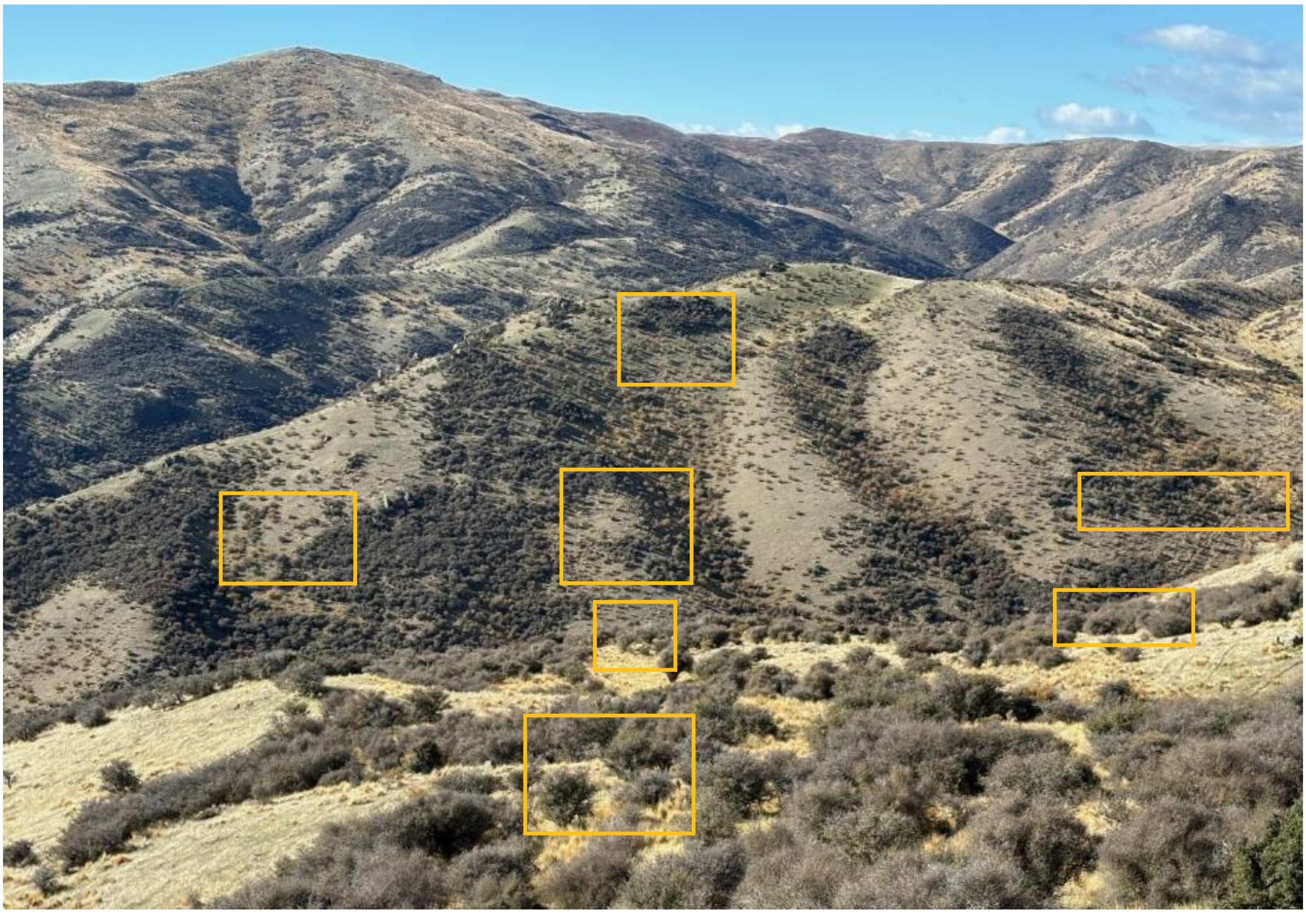
- Embedded rock tors and rocks for lizards (primarily Kawerau gecko and southern grass skink) with tussock inoculation and node planting
- Enriched buffers (generally within contingency areas) along final edges, e.g. Stream diversion channels

- Small wetlands (e.g. upslope of diversion drains, stock water holes) and seepage zones.

In-stream and riparian areas of permanent watercourses and permanent diversion drains are detailed in an aquatic rehabilitation management plan.

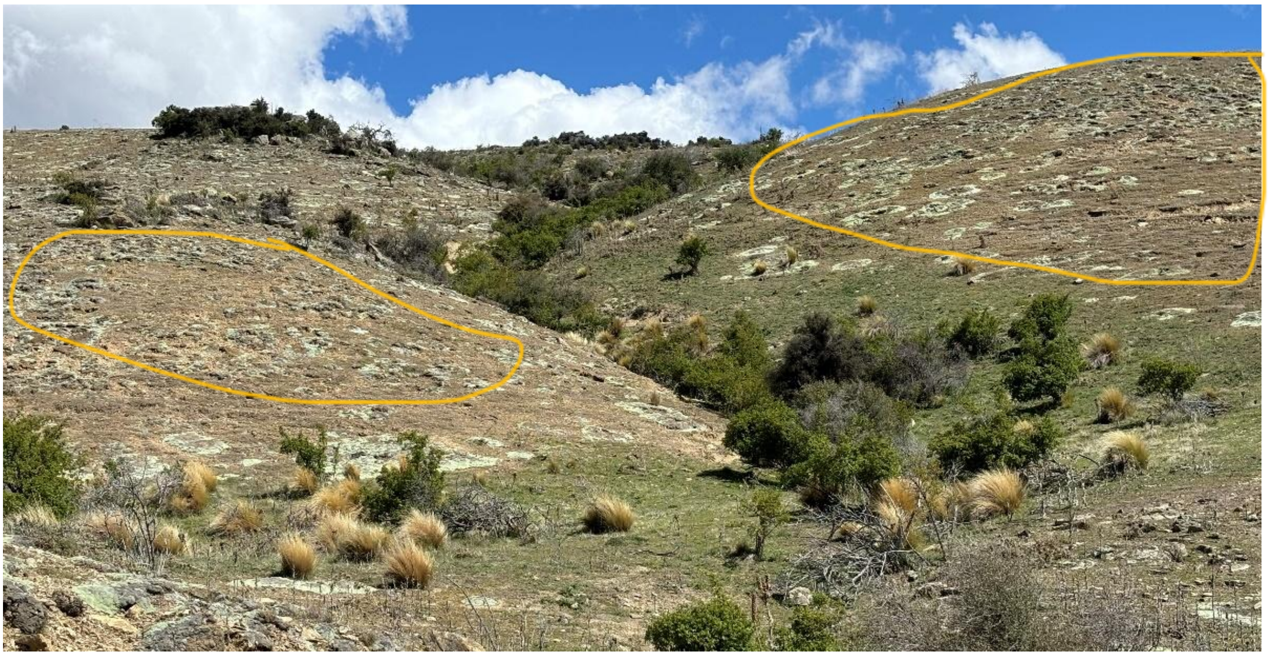
### F.1. SHRUBLAND

*Left. Patches of tussock and depauperate matagouri/Olearia with high pasture cover is favourable for infill (MRZ B2/B3). Removal of stock and interplanting with nursery-grown seedlings in favourable areas is expected to reduce pasture grasses and increase woody cover and more structure (due to native lianes). Right. Naturally thickened scrub with yellow-flowering korokio in the foreground (Bendigo Station adjacent to DOC reserve gorge, October 2024).*



*Landform, altitude and aspect combine to create a mosaic of more-sheltered, less-stressed areas with higher cover of woody plants (predominantly grey shrubland). Mid- to higher-altitude areas are mosaics of pasture, short tussock and scrubland (photo April 2024). Enrichment planting begins when stock are removed and low-density weeds are killed (to minimise their seeding and spread as stock are removed). Enrichment planting will be done as clusters in areas with sparse to nil shrub canopy that are relatively protected – the shelter provided by tussock and scattered shrubland should improve survival of nursery-raised seedlings selected to re-establish the original taller, more diverse grey shrubland structure with vines. NOTE: Important exceptions are areas where non-native plant species may support native moths near the airstrip.*

## F.2. CUSHIONFIELD



*A cushionfield dominated area showing distribution on the most exposed parts of slopes. Cushionfields in such areas will be managed to enhance health and slow succession to shrubland by retaining grazing (rabbits and sheep grazing) and removing brier (which facilitates shrubland establishment). The native shrubs matagouri, porcupine bush and pimelea will be maintained as providing valuable invertebrate habitat. The green area in foreground has pasture grass cover which may be planted with a stand of kowhai and highly palatable species protected by rabbit fencing, as this is an area where the low biomass provides resilience to fire (Bendigo in vicinity of MRZ B1 October 2024). High invertebrate values are associated with raoulia herbfields and the mosaics they form with shrubs and tussocks on North-facing slopes, although there is no clear statistical relationship due to highly variable data and most habitats having values for invertebrates.*

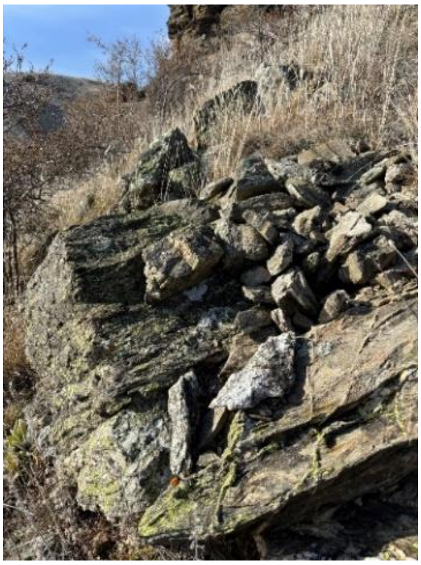
*Pimelea aridula within cushionfields provide high floral resources for a range of native invertebrates when flowering. Few seedlings are present; individual plants will be netted to facilitate natural seedling recruitment.*

## KOWHAI SEED ISLANDS

*There are 12 patches of individual or small clusters of kowhai in the project area. The largest was in full flower in October 2024 (**top row, left** with person for scale and right showing multiple trunks). Where such trees are outside the stripped areas, they will be surrounded by a rabbit/stock exclosure fence into which genetically diverse kowhai seed and seedlings and nursery-plants of other highly palatable plant species will be established, creating 'seed islands' or 'enrichment nodes'. Diverse kowhai genetics are needed to ensure resilient, fertile saplings. High protection from browse is needed as germinating seedlings are highly palatable – as shown by the very slow rate of natural increase under current management.*

***Lower Left**: this kowhai sapling was able to establish due to physical protection from browsers provided by a porcupine shrub and was on of 7 smaller trees. Lower Centre: Another group of 7 kowhai of various ages on Ardgour station with the largest having a DBH of 33cm and others7 to 13 cm. **Lower right:** all kowhai, and especially large kowhai trees like this would have been much more common before fires. Pollination between trees is now severely limited as nectar-feeding native birds are sparse – an aim of establishing kowhai groves is to increase abundance of these birds. The kowhai were being visited by high densities of bumblebees. This individual tree on Bendigo station outside disturbance footprint.*

## F.3. ROCKS AND BOULDERS, OUTCROPS



***Left**. Clusters of boulders 2-3 m across and with many deep, horizontal and narrow cracks are valuable habitat for Kawarau gecko, are refugia for plants from browse, and locations of lower plant stress as the rocks concentrate rain runoff, help retain soil moisture in pockets and provide shelter. Sunny areas are important for lizard basking. Large boulders like this are likely to need breaking up to enable salvage but are vital to salvage.*

***Right.** Jumbled large and small rocks in small patches 1-3 m wide) also enriches habitat by slowing runoff and retaining soil moisture, providing lizard basking space/shelter and providing shelter for adjacent plants.*

***Left:** High-value outcrop with woody native shrubs. This rock would also need to be broken up to salvage. Note the depth of cracks at least 1 m below the surface, providing enhanced protection for lizards against very cold conditions. Woody plants will also be salvaged mixed with topsoils with the exception of porcupine shrub which provides long-lived woody habitat. Salvaged (dead) porcupine shrub will be wedged between rocks in rock stacks and rubble pits where they create microsites for nursery-plants and invertebrates.*

***Right: S**ome outcrops in the mine regeneration zone are compacted sheep camps. In de-stocked Mine Regeneration Zones, some of these areas will be enhanced by hand scarification and decompaction followed by enrichment planting of nursery-raised seedlings and/or salvaged tussocks. A more diverse, dense native plant cover will enhance habitat for invertebrates and lizards and help provide long-term protection from browsers.*

## F.4. WETLANDS, SEEPAGES, RIPARIAN AREAS

***Left and Centre**: Seepages and small streams in the mine footprint typically show heavily grazed sedges (or no sedges), a high cover of non-native pasture grasses, and pugged ground. Such areas will have cattle and sheep removed, allowing regeneration of native plants from seeds and rhizomes, supplemented with small-scale planting of nursery-grown toetoe and shrubs.*

***Right:** Bendigo Historic Kanuka Reserve riparian area with low browse pressure allowing dense, tall sedge cover immediately adjacent to densely vegetated shrubs and vines including pohuehue (Muehlenbeckia – providing fruit and physical protection for lizards). This outcome is expected in MRZ (but with Olearia species kanuka)*

*Large wetland in vicinity of plant area contains Carex kaloides which is the primary target for salvage as rectangular sods with attached soils that will be close-packed within a minimum 0.5 ha of new permanent wetland and adjacent riparian areas planted mainly with nursery-grown seedlings near the mouth of Thomspon's Gorge and temporary camp.*

## F.5. TUSSOCK

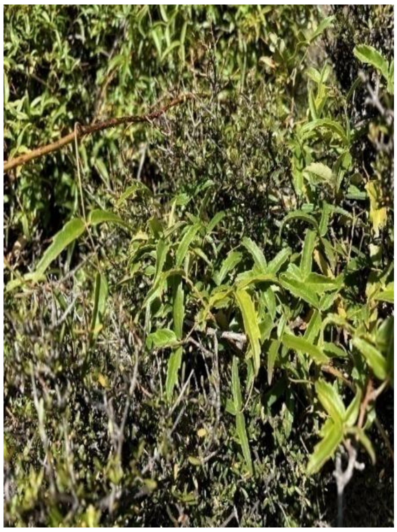
*Tussocks, like cushionfields, are an induced vegetation type from grey shrubland. Tussocks are likely to expand in all MRZ when cattle are removed, and may expand in MRZ B1 depending on response to sheep and rabbit browse.*

***Top left**. Heavily browsed short tussocks persisting in a natural swale or 'crease' and adjacent to a boulder on an exposed north-west slope – rehabilitation provides for adding boulders and concentrating planting in these sites where moisture stress is lower. The rehabilitated ELFs are not terraced; rolling topographies and scalloping to slow runoff are key actions.*

***Top Centre**: Unbrowsed short tussock with 0.5 m measuring tape.*

***Top Right and Lower photos**: Relatively dense tussock on valley floor and gentle slopes will be targeted for live salvage with their entire root zone (20-40 cm depth) and placement into storage areas or areas ready for rehabilitation. Tussock in areas identified for live salvage are not grazed for 12 months prior to removal to enable tussock to build carbohydrate stores, thereby increasing success.*

## F.6. TARAMEA, BRYOPHYTES, VINES



***Left*** *The edges of areas of Taramea will also receive enrichment planting of 'open-formed' woody species (Olearia, Veronica and Coprosma) to support the diverse invertebrate fauna by extending the diversity of flowering and fruiting species; grazing in these are will stop, hare and rabbit numbers supressed to allow regeneration of taramea seedlings, and pig numbers also reduced to reduce damage to roots and high-value invertebrates that feed on taramea roots.*

***Centre****: Right: The Bendigo Historic Kanuka Reserve has thick mats of mosses on the wetter, lee and shaded sides and development of leaf litter layers – both features that are sparse in most grazed areas within the project area where moss cover is less than 2%. Moss has an important ecosystem engineering role, increasing moisture supply in summer and moderating soil temperatures. Although it may supress seedling germination, it probably assists seedlings that do establish, and it is also habitat for a range of endemic moths. Removal of grazing may allow moss cover to increase.*

***Right****: Increasing the cover of native vines in grey shrubland and on rock stacks is a key rehabilitation approach to enhance value of these ecosystems for lizards and invertebrates and provide longer-term resilience against browsers for palatable species by creating a barrier of thorns (this plant is Rubus, bush lawyer) and dense entwined leaves.*

## APPENDIX G. MAPS OF REHABILITATED ASPECT, SLOPE, AND TOPOGRAPHY

Figure 1: Landscape Management Units

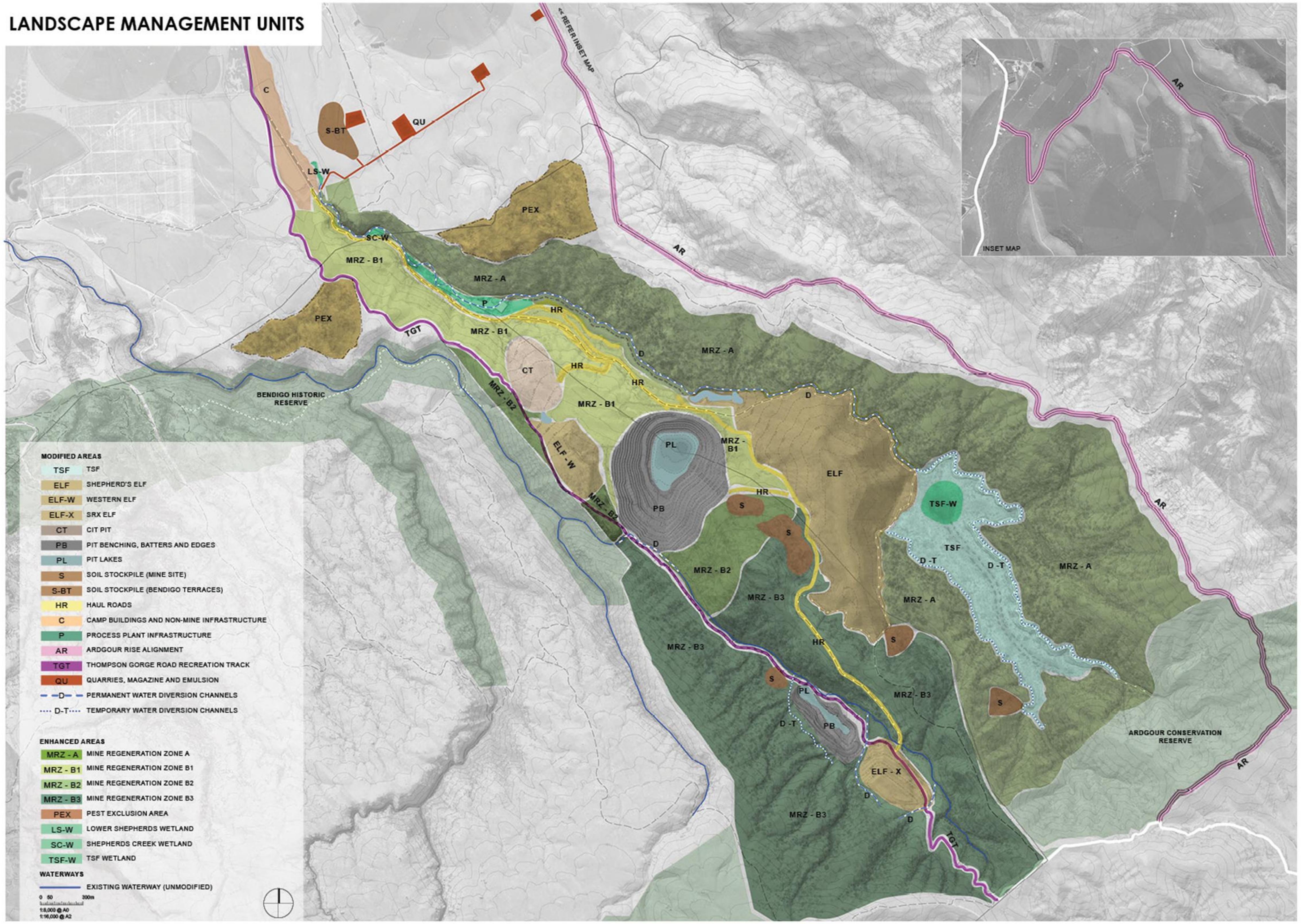
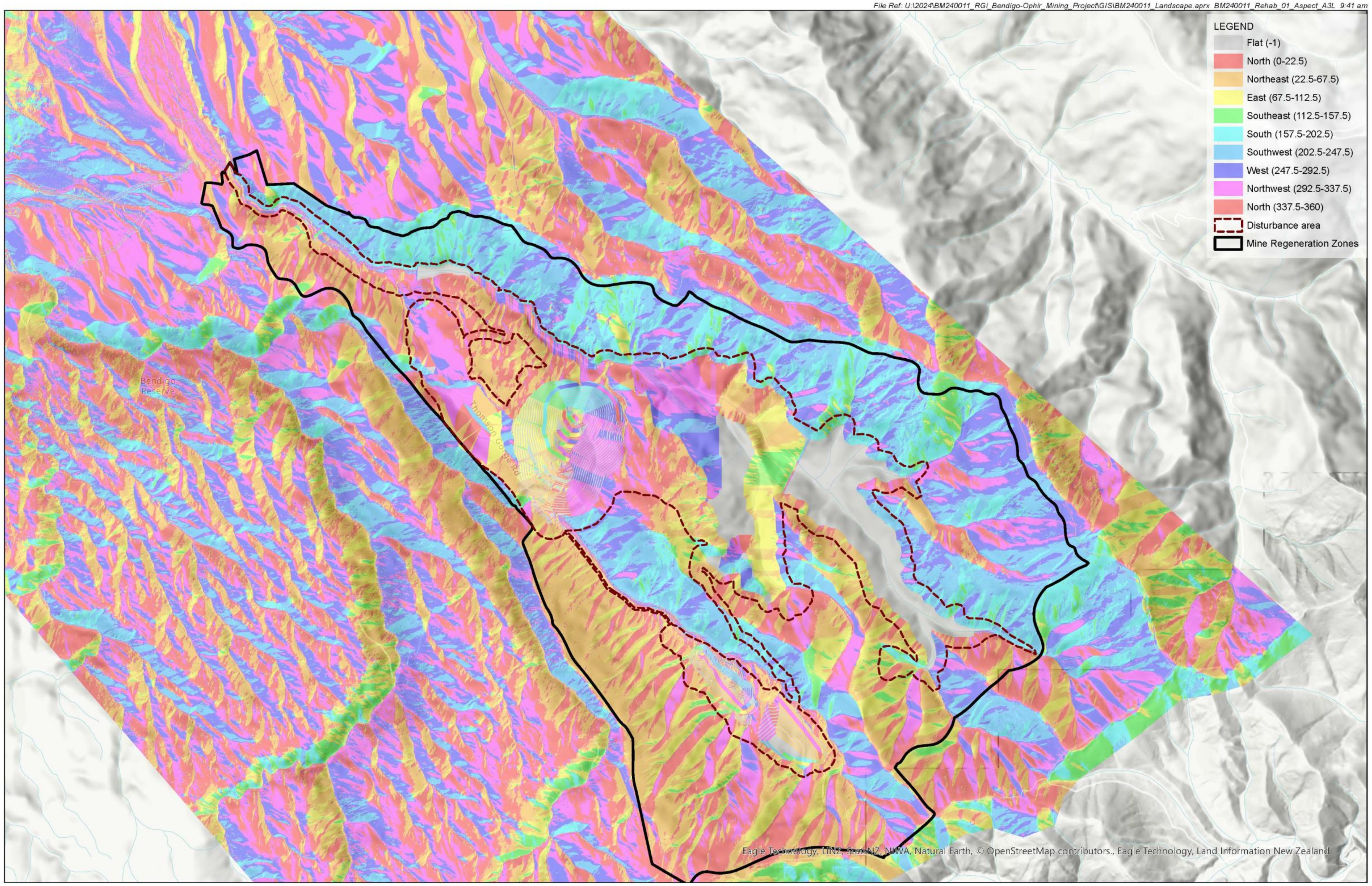


Figure 2: Rehabilitated Aspect

File Ref: U:\2024\BM240011_RGi_Bendigo-Ophir_Mining_Project\GIS\BM240011_Landscape.aprx BM240011_Rehab_01_Aspect_A3L 9:41 am




Boffa Miskell
www.boffamiskell.co.nz

This plan has been prepared by Boffa Miskell Limited on the specific instructions of our Client. It is solely for our Client's use in accordance with the agreed scope of work. Any use or reliance by a third party is at that party's own risk. Where information has been supplied by the Client or obtained from other external sources, it has been assumed that it is accurate. No liability or responsibility is accepted by Boffa Miskell Limited for any errors or omissions to the extent that they arise from inaccurate information provided by the Client or any external source.

0 — 1 km
1:25,000 @ A3

Data Sources:

Projection: NZGD 2000 New Zealand Transverse Mercator

**BENDIGO OPHIR MINING PROJECT**

Rehabilitated Aspect

**Date: 11 July 2025 | Revision: 0**

Plan prepared for Santana Minerals Ltd by Boffa Miskell Limited

Project Manager: rhys.girvan@boffamiskell.co.nz | Drawn: BMc | Checked: HWi

**Figure 2**

Figure 3: Rehabilitated Slope

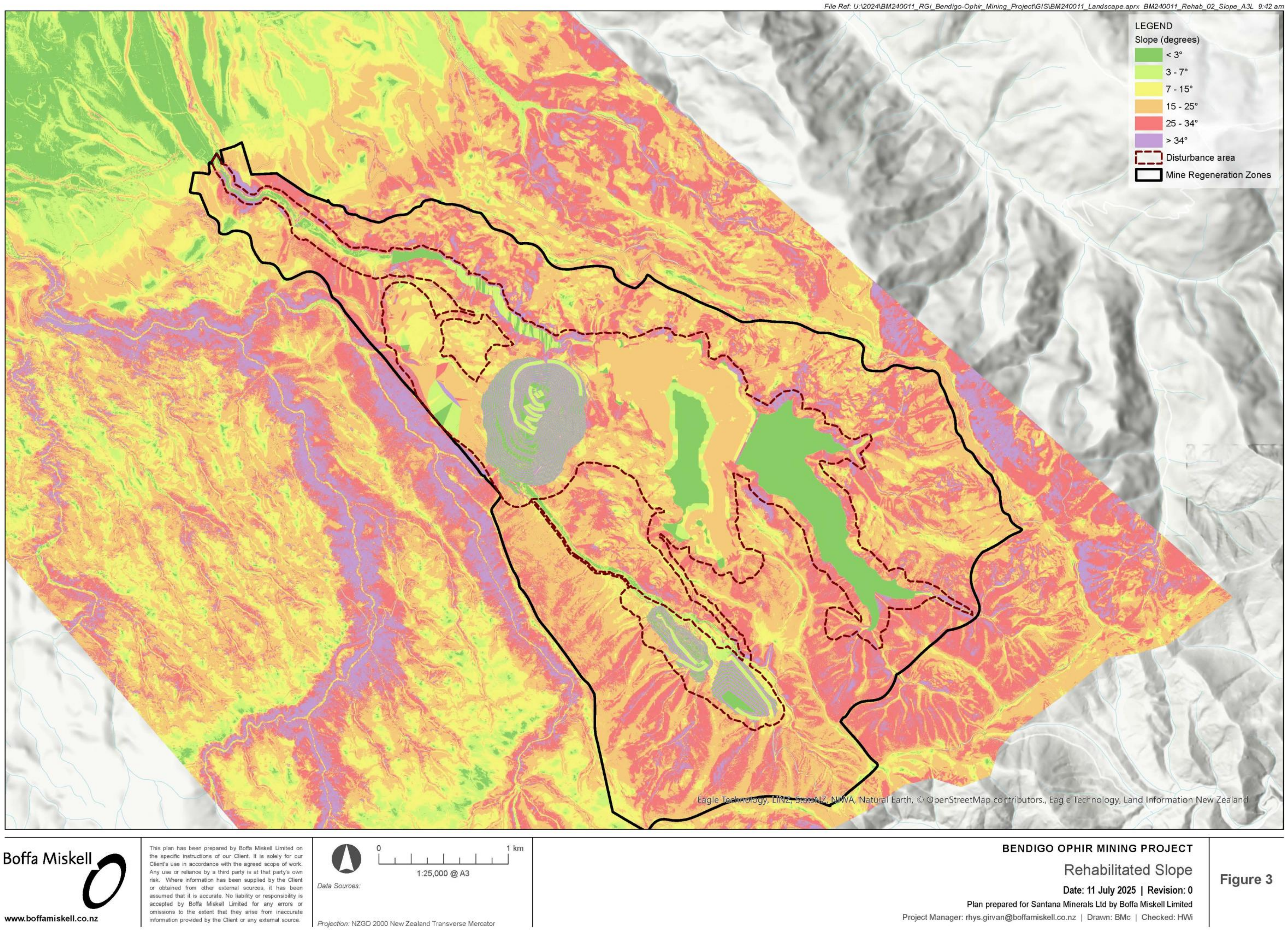
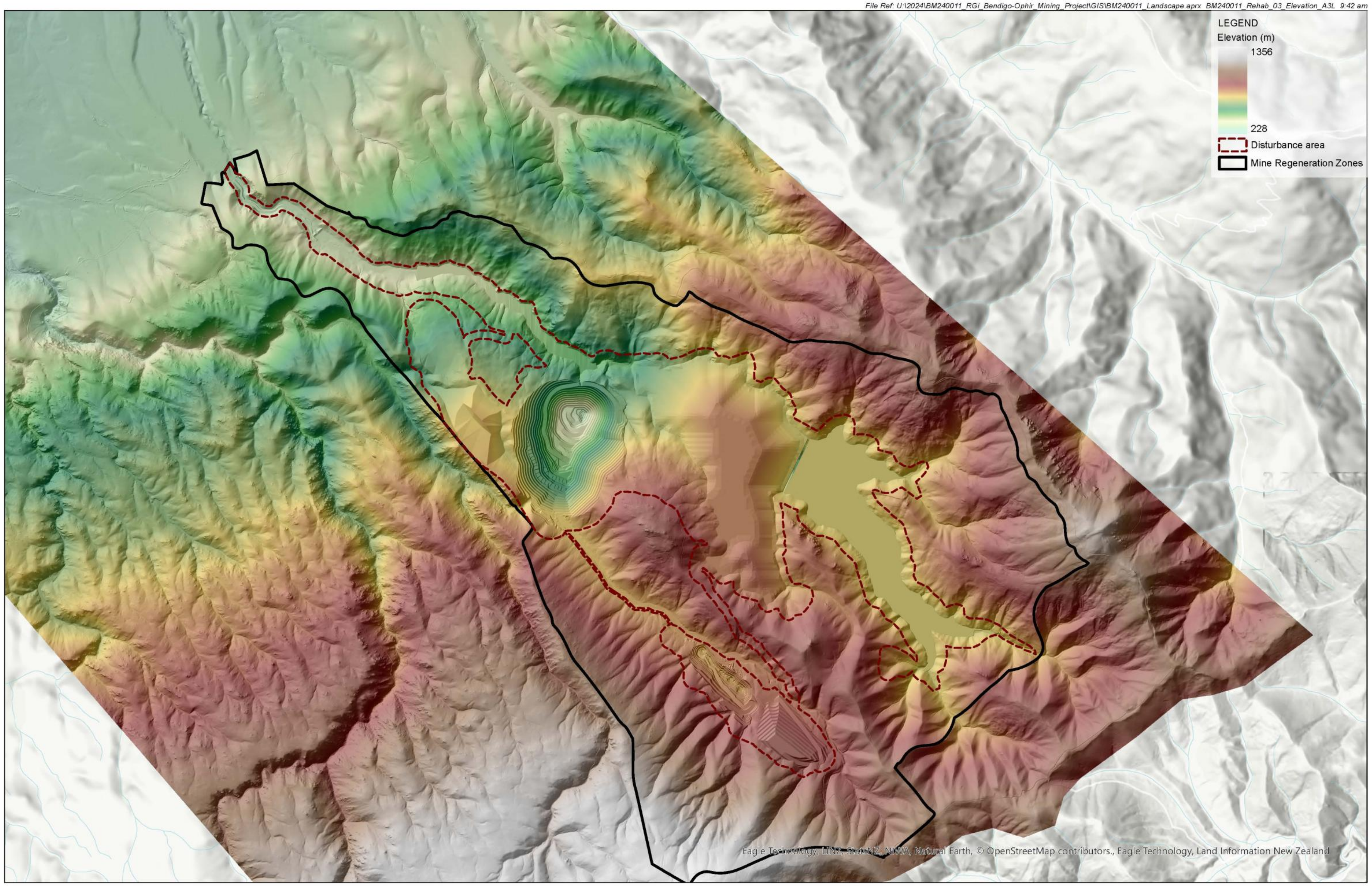


Figure 4: Rehabilitated Topography




Boffa Miskell

www.boffamiskell.co.nz

This plan has been prepared by Boffa Miskell Limited on the specific instructions of our Client. It is solely for our Client's use in accordance with the agreed scope of work. Any use or reliance by a third party is at that party's own risk. Where information has been supplied by the Client or obtained from other external sources, it has been assumed that it is accurate. No liability or responsibility is accepted by Boffa Miskell Limited for any errors or omissions to the extent that they arise from inaccurate information provided by the Client or any external source.

0 1 km
1:25,000 @ A3

*Data Sources:*

*Projection:* NZGD 2000 New Zealand Transverse Mercator

**BENDIGO OPHIR MINING PROJECT**

Rehabilitated Topography

**Date: 11 July 2025 | Revision: 0**

Plan prepared for Santana Minerals Ltd by Boffa Miskell Limited

Project Manager: rhys.girvan@boffamiskell.co.nz | Drawn: BMc | Checked: HWi

**Figure 4**

## APPENDIX H. FACTORS INFLUENCING REHABILITATION

Rehabilitation aims to deliver a mosaic of vegetation types that are sustained over the long term, largely delivered over the long term by natural establishment from seed (and other propagules). This approach is a response to the key environmental influences on regeneration and plant growth at this site. Approaches will be refined as the Applied Research Programme for cushionfields and spring annual herbs is progressed, and the Rehabilitation Management Plan implemented. The key environmental influences controlling rehabilitation outcomes are fire, climatic stress (drought and cold) and browse by mammals. These three major stressors interact, and severity of all three is moderated by geology, soils and topography (aspect, slope, elevation) and vegetation cover as discussed below.

### H.1. Fire

Fire was infrequent prior to human settlement, and then became more frequent after early Māori settlement, when it was used periodically to clear scrub for hunting and travel. A wave of very frequent burning accompanied early European settlement, first when mining commenced and soon after for pastoralism, when tussock was burned approximately annually to stimulate growth for grazing. Frequent pastoral fires from about 1850, combined with grazing, led to widespread depletion of tall snow tussock; at some stage it was almost completely eliminated from the highest areas on Bendigo Station and has not returned. The local removal of high-altitude snow tussock provided space for an initial expansion of shorter tussocks from lower elevations; and then, on drier landforms, such as north- to west-facing slopes, the fire-depleted tussock grassland was converted to bare ground and/or sparse cover of annual plants and plants with cushion and mat growth forms. The dramatic increase in fire frequency removed vulnerable ecosystems (i.e., high biomass and/or high flammability and/or slow growing such as totara and kowhai). Fire interacted with browse by creating a flush of growth close to the ground. Sites with sunny low- to mid-altitude faces created ideal conditions for rabbits which can maintain short plant cover through their grazing and remove young palatable seedlings before they can grow above browse height. Although the deliberate use of fire is now infrequent, with a consequent expansion of kanuka and grey scrub, the risk of fire is predicted to increase under climate change along with the intensity of fires[23].

### H.2. Climatic Stress: drought and cold

Central Otago is characterised by a semi-continental climate with high stresses due to hot summers with strong, drying north-west winds combined with relatively low precipitation (snow and rainfall). Winters are characterised by heavy frosts in exposed areas. Low temperatures are more severe where cold air settles in calm conditions (valley floors, hollows and the base of slopes) and where freezing winds move down larger valleys. Severe moisture deficits and very cold events, especially unseasonal cold in late spring or early autumn, are drivers of plant and animal distribution and mortality. Average daily minimum temperatures in winter can fall to -2 °C, while in summer average daily maximum temperatures can rise to 22 °C. Moisture deficits and drought stress is most severe on lower to mid-altitude, north- to north-west facing slopes. Cushionfield generally occupies spurs on these slopes, while taller grassland and shrubland grows on more sheltered, shadier swales and gullies where evapotranspiration losses are lower and moisture supply is higher (Images 1 and 2). Average annual rainfall ranges from 450 to 650 mm and increases with elevation. Snow falls on the range tops in winter. Rainfall data from Cromwell (annual average of 395 mm) and Alexandra (Table 1) show relatively little seasonal variation in rainfall, however year to year rainfall can vary markedly. Data from a weather station at Bendigo (500 m asl, NIWA station no. 5242, 1955-1979) had slightly higher average annual rainfall of 445 mm, with a minimum annual rainfall of 281 mm and maximum of 575 mm. The average monthly rainfall shows little variation, (from 24 mm to 46 mm). The driest month received 0 mm (June 1964) and wettest month 172 mm (September 1970). Infrequent, wetter-than average late spring / early summers (and maybe back-to-back moist summers) may be important for establishment of some native plants as rainfall in September and October extends the growing season which is limited by soils reaching wilting point deficit (Table 1) as evapotranspiration rates exceed 100 mm/month.

Landscape features can provide relief from the effects of climatic stress in localised areas of the landscape such as rock tors, especially those with abundant deep cracks that extend well below the surface. Such features are important warmer refuges for lizards and some invertebrates. The dense, deep leaf bases of tussocks and taramea also provide insulated refugia against cold as do deep leaf-litter layers. Rehabilitation uses engineering landscape features that mimic these natural features by creating rock stacks, rubble pits, swales and dimpled or undulating surfaces.

---

[23] Regional Projections: Zone 6,NIWA Taihoro Nukurangi, https://niwa.co.nz/climate-change-adaptation-toolbox/projected-regional-climate-change-hazards/regional-projections-zone-6

*Image 1: In the Santana project area landform, altitude, and aspect combine to create a mosaic where woody plants are concentrated in the more-sheltered, less-stressed areas found on the protected aspect of gullies.*

*Image 2: The right photo shows cushionfields with Raoulia australis cushions in the foreground and on the higher slopes above a band of sparse short tussock and shrubland that occurs at a change of slope that has locally-increased soil moisture supply and probably has deeper soils (photo September 2024 before the browning-off of exotic herbs and pasture species).*

Table 1. Evapotranspirarion, rainfall, number of days at which plants experience severe drought stress (soil at Wilting Point Deficit, WPD), and the frequency of months with WPD and Runoff for soils with 40 mm storage and soils with 160 mm storage at Alexandra, based on 1942 to 1982 (NZ Meterological Service 1986).

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Evapotranspiration | 134 | 101 | 74 | 32 | 12 | 4 | 6 | 19 | 47 | 83 | 112 | 133 | 757 |
| Rainfall | 39 | 33 | 38 | 29 | 31 | 23 | 18 | 18 | 22 | 32 | 31 | 35 | 349 |
| no. days with WPD | 24 | 22 | 17 | 11 | 5 | 0 | 0 | 1 | 5 | 20 | 24 | 24 | 153 |
| **Soil profile with 40 mm storage** | | | | | | | | | | | | | |
| Frq of months with WPD | 100 | 98 | 98 | 85 | 51 | 2 | 2 | 2 | 61 | 98 | 100 | 100 | |
| Frq of months with Runoff | 3 | 13 | 10 | 10 | 37 | 61 | 76 | 54 | 24 | 10 | 5 | 2 | |
| **Soil profile with 160 mm storage** | | | | | | | | | | | | | |
| Frq of months with WPD | 100 | 95 | 95 | 80 | 48 | 3 | 3 | 3 | 25 | 70 | 93 | 100 | |
| Frq of months with Runoff | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 3 | 0 | 0 | 0 | 0 | |

## H.3. Geology and Soils

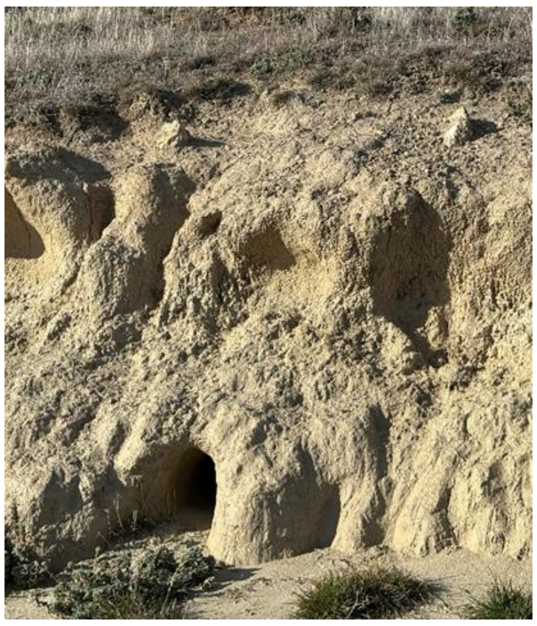

*Image 3: TZ4 intercepting TZ3 along Thomson Gorge Fault (source Santana Minerals)*

The geology and geomorphology of the area have been influenced by glacial and water erosion and tectonic uplift which formed the iconic Otago Schist landscape present today. During the Tertiary period, the Upper Clutha catchment's mountainous landscapes were uplifted, including the Dunstan Mountains. Key features of these landscapes include the elevated schist tors, like Haehaeata (Leaning Rock), formed by erosion. These tors, together with smaller rock outcrops and surface boulders are present throughout the area and are critical ecological features. Larger features provide refugia from fire; even smaller rocks help mitigate extreme cold, and moisture stress. The hills are generally gently and finely dissected – this is probably a relict feature associated with water erosion during a warmer, wetter interglacial period of the ice ages as most of the water courses are now ephemeral (Molloy 1998).

The valleys within these mountain ranges were shaped by glacial and alluvial processes, leaving moraine deposits. The Dunstan Mountains' geology includes metamorphic rock between the Dunstan and Pisa Faults and bisected by the inactive Thomson Gorge Fault (Rise and Shine Shear Zone). Gold mineralisation present within the Rise and Shine Shear Zone (RSSZ) occurs in Textural Zone 4 (TZ4) and is similar to Macraes Mine deposits. The TZ4 rocks are strongly foliated and segregated schist (Image 3). This geology has a higher density of rock outcrops which also have deeper and more numerous horizontal fissures than occur in the Textural Zone 3 (TZ3) geology (well foliated, slightly segregated Haast schist).

In much of the project area the underlying TZ3 and TZ4 geology has a partial loess cover; this even-sized silt was blown from riverbeds by the prevailing north-westerly winds in the Quaternary ice ages. Loess is supplemented on downwind slopes more recently by topsoils mobilised when soils were exposed after the protective vegetation was removed by burning and farming. Widespread soil erosion, redistribution and loss is described by Hewitt (1996) from the climatically similar Conroy land system. Loess layers are thicker on gentle, broad and north-west facing slopes. However, on all slopes, these loess layers are disrupted and/or mixed where water erosion has exposed and/or mobilised weathered gravels, forming colluvial deposits (Image 4). Loess is absent on steeper slopes in areas with deeply weathered alluvial deposits – these soils tend to have a high content of weathered stones throughout deep profiles (Image 5). The rate of soil development in all these materials is influenced by soil organic matter build-up (from plant growth) and leaching of nutrients (by rainfall). These are largely controlled by moisture deficit and age since last disturbance. The most well-developed soils are Brown Soils. These are generally on landforms above 950m ASL where moisture deficits are lowest (due to lower temperatures and higher rainfall). Brown Soils grade to Pallic Soils on slopes and Pallic Soils to Semiarid Soils at the lowest altitudes[24]. The Pallic and Semi-Arid Soils have circumneutral pH and typically have no nutrient limitations for native plants. These soils have high base cation status. Pastoral farmers have applied phosphate and sulphur to promote growth of clovers established to supply nitrogen for non-native pasture grasses. Pallic Soils typically have low organic matter contents because drought stress and low winter temperatures limits production of plant biomass and slows soil mineralisation(Image 6). Central Otago plants have an unusually high proportion of native nitrogen-fixing plants which provides them a growth advantage over other plants. Many of the native plants also allocate a high proportion of their biomass to develop unusually large (and deep) root systems which increases their access to both water and phosphorus. Roots of woody plants follow subsoil cracks between blocks of dense soils (fragipans) seeking moisture (Image 7). The weak structure, low organic matter and presence of fragipans means Pallic Soils on slopes are vulnerable to gully erosion and to wind erosion if vegetation is removed.

The wider valley floors of Shepherds' and Jean's creeks are filled with alluvial material that forms layers of contrasting textures that range from coarse gravels to organic-enriched silts. The latter are associated with historical or modern wetlands; moa bones are sometimes found in alluvial deposits. Small areas of Anthropic Soils were deposited in valley floors by historical gold mining that used sluices to remove overburden and process gold-bearing gravels. Some of these areas contain naturally elevated concentrations of Arsenic. No saline soils have been identified within the hills of the project area – such soils, where present, are important as they sustain a distinct native flora.



[24] These soil orders are used in New Zealand, were developed by Allan Hewitt (2010) and are described by Hewitt 2013 Survey of New Zealand soil orders and Soil orders » New Zealand Soils Portal - Manaaki Whenua - Landcare Research

*Image 4: Eroded Soils have very thin topsoils. The left photo shows a droughty, north-west facing slope a deep Pallic Soil with at least three layers of pale loess and very thin topsoil has a lower loess unit burrowed by rabbits.*

*Image 5: The right photo shows a colluvial Semi-Arid Soil with highly weathered stoney subsoils and much thinner to absent loess layer.*

*Images 6 and 7: Mid-altitude Pallic Soils below Battery hill showing relatively deep, dark brown topsoil with sharp boundary to pale silt-textured subsoil which has eroded, as it is more susceptible to erosion (as well as easier for rabbits to excavate). Note the contrasting rooting strategies of short tussocks (left photo, with shallow but dense roots largely confined to topsoil) and Olearia (right photo, with some roots extending at least 2 to 3 m deep into subsoils).*

## H.4. Topography (aspect, slope, elevation)

### H.4.1. Aspect

The Site is characterised by a folded sequence of valleys which extend north of Mount Moka from Thomson Saddle to the east and the Upper Clutha to the west. The Site primarily maintains a mix of north-east and south-west facing aspects which fall west along the catchments of Shepherds and Rise and Shine Creek.

Aspect has a large influence on severity of drought stress through influencing evapotranspiration and soil moisture. North to north-west aspects are exposed to higher temperatures and the dry north-westerly winds which increase plant water demand and evaporative soil losses. Aspect is therefore a primary driver of vegetation patterns on moderate (not steep) slopes between 400 and about 800 m altitude. Here, cushionfields are dominant on north to north-west aspects, being the most drought-stressed sites, sometimes exacerbated by historical topsoil erosion reducing soil water storage capacity. In contrast, south and south-west (and east) slopes receive more shade (less solar radiation), cooler temperatures and some sheltered from the drying north-west wind. The lower moisture stress favours regeneration of native woody cover which has thickened faster in these areas over the last 30 to 50 years (based on analysis of aerial imagery).

The formation of the proposed mine and associated infrastructure will extend north - south through the landform to the west of Battery Hill. The RAS pit, being circular has a full range of aspects. Extensive highwalls facing north to northwest will be very slow to gain even a sparse bryophyte cover given extremely high drought stress. Grasses and woody plants will be restricted to benches areas where weathering and erosion develops a root zone or where a root zone is added. South-facing slopes will be faster to revegetate, particularly benches meeting natural slopes where root zones are created by placing brown rock and soil.

### H.4.2. Slope and microtopography

Mining will result in open pits, engineered landforms and stockpiles with sloping faces and benches alongside the broad flattened surface of the tailings storage facility. The resultant faces in the mine pits are approximately 15 metres in height and reach 65o (approximately 2(v):1(h)) in some areas. In addition to the pits, haul road batters will be constructed at a gradient of 1:1 and the ELF slopes will have an overall gradient of 1(v):3(v) to support the establishment of native vegetation.

The shape of pits, ELF, TSF and valley floors will influence cold air flows, with cold air likely to pond on the top of the TSF as air drainage is mediated by the Shepherd's ELF. The variety of slopes and aspects created across the engineered ridges, basins and valley floors are important as drivers of the heterogeneous ecosystem patterns. Microtopography is also important, particularly in relation to steep faces (i.e. where horizontal scarification is used to create small depressions that store and retain water); and within slopes, where swales generally have taller vegetation. Microtopography may be a driver of succession in cushionfields where small depressions are often the first places colonised by briar, which then moderates climate for other less tolerant species. At a slightly larger scale, native spring annual herbs appear to be more common on broad, gently sloping spurs immediately below steeper slopes as this location receives runoff, delivering higher spring soil moisture and deeper soils (providing greater moisture storage).

Areas with greater shelter, moisture (e.g. deep soils and/or water flows) and with cold-air drainage are important ecologically, as sites for species that are less tolerant of extremes. The lower parts of valleys and steeper gorges are such areas, and historically where patches of totara and matai forests were able to persist; wetlands and seepages are other areas. It is therefore important to create large and small topographic complexity in rehabilitated landforms and avoid larger smooth areas, especially on ELF and TSF. The creation of topographic complexity on the TSF is limited by the depth of root zone that can be imported to cap the large area of almost-level tailings. The complexity is therefore accentuated by design that a) includes extensive wetlands, and b) by creating swales that can transport runoff from the higher landforms over the tailings surface and have adjacent bunds of deeper soils which provide shade and shelter to help reduce moisture losses in these areas.

### H.4.3. Elevation

Elevation influences the native vegetation present, as precipitation increases, and temperature and moisture stress decrease with elevation. On gentle slopes the reduced moisture stress is enhanced by the higher organic matter accumulated in Brown Soils. This historically allowed some trees to survive at higher elevations. Lower winter temperatures at higher altitudes also influence vegetation distribution and phenology, with flowering often later at higher altitudes and earlier at lower altitudes (Figure 3). Within the site distinctive changes occur with altitude as matagouri, olearia, and kowhai at lower elevations transition to short tussocklands that are mainly above 800m across a variety of aspects and slopes. The highest exposed ridgelines from about 800 to 1100 m ASL and including the Thomsons Gorge Saddle have native herbfields that have a significant component of the distinctive megaherb taramea. Key features within the Site and local context include Battery Hill (916m asl), Thomsons Saddle (900m asl), and Mount Moka (1,222m asl).

### H.4.4. Hydrology and wetlands/seepages

The site predominantly comprises 1-3 order streams, largely due to low rainfalls and steep topography within short, small catchments. These are fed by seepages.

Shepherds Creek is the larger of the two catchments which each comprise several ephemeral, intermittent, and perennial streams. Flows within the creek are influenced both from several springs throughout the catchment, and rainfall. The headwaters of the creek are located immediately west of Thomsons Saddle and are separated by a narrow ridgeline forming two tributaries. The upper headwaters are characterised by sand and gravels in creek beds that have a gentle gradient and narrow habit. The headwaters of Shepherds Creek meet the confluence of Jean Creek, an intermittent stream, approximately 3.5 kilometres downstream. The upper reaches of Jean Creek are characterised by a narrow active bed, although being intermittent the creek is more vegetated. The gentle reaches, including those in the upper reaches of the catchment, are dominated by run habitat[3] with sections of riffles and pool sections[25].

A narrow gorge is present at the mid-point of Shepherds Creek which is characterised by a rocky active bed, waterfalls, boulders, and pools. Unlike the upper reaches, the active bed is primarily characterised by cobbles, before reaching the lower valley floor characterised by an alluvial outwash. The creek becomes gentle in habit and characterised by sand and gravels similar to the upper reaches but remains narrow within the context of the broader valley. Modification to the active bed is in the form of a now broken dam structure, although a small pond remains upstream of the dam. Many stream margins in lower areas of Shepherds Creek are also pugged by cattle along with some seepages (which are used to supply stock water in the absence of a reticulated supply). Pugging is combined with grazing of palatable sedges, removing overhanging and filtering vegetation in lower areas. Extraction of up to 50% of the natural flow for stock water and irrigation also has an impact on stream values in the lowest areas of Shepherd's stream before it disappears into alluvial gravels.

To the west of the catchment beyond the foothills of the Dunstan Mountains, the stream quickly becomes ephemeral with surface water passing into the ground. The upstream sections are still legible and associated with grazing. The stream path is therefore evident during periods of high rainfall. Downstream however, evidence of the stream course has been removed and replaced with farming activity, including pasture.

Rise and Shine Creek is located immediately south of Shepherds Creek and is a tributary of Clearwater and Bendigo Creek (beyond the Site boundary). The RAS creek is characterised by four main components being the steep tributaries to the true left of the creek towards Mount Moka, the upper valley floor, the lower valley floor, and gorge[26].

The headwaters to the true left of the Rise and Shine creek are fed by several springs which provide a permanent flow throughout the year. These creeks are steep and narrow in habit and become gentler in gradient towards the valley floor. The active bed of these streams comprises mud, sand and gravels within the upper reaches, transitioning to boulders within the gorge.

The valley floor has a broader character in comparison to the adjacent Shepherds Creek. This is largely due to the accumulation of sedimentation resulting from historic gold workings within the valley during the Otago gold rush of the 1860s up until the 1940s. This has created a broader active bed of the creek, with several wetland areas and pools present. The active bed largely comprises mud, gravels, and sand, and downstream, a dam and pond are present which is accessed by stock.

At the base of the valley (and edge of the Site boundary) is a gorge which is characterised by boulders, pools, and riffles, not present within the upper catchment.

---

[25] Bendigo Ophir Aquatic Assessment of Effects, Water Ways Consulting, 2024.
[26] Bendigo Ophir Aquatic Assessment of Effects, Water Ways Consulting, 2024.