David Pryce Invertebrate Surveys

Dry Gut (southern ridge) Invertebrate Survey

Commissioned by Basil Read, St. Helena Airport Project

David Pryce
May 2013

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

1.1 RATIONALE

As a result of potential changes to the engineering solution for management of water from periodic flow in Dry Gut it has been proposed that a section of the southern ridge of the gut be removed to allow the creation of an open water channel in bedrock adjacent to the fill from the Airport development. This is the contractor's alternative to the AECOM proposal of an attenuation dam above Dry Gut Gorge with a culvert running through the fill. If this proposed change goes ahead the end of the ridge will be removed in an area not previously surveyed in any great detail from an invertebrate, plant or lichen perspective as portions of the zone lie outside the ADA. In order to assess the significance of the site a snapshot invertebrate survey was commissioned. As the principal vegetation in the area consists of lichens it was agreed that endemic lichens would also be included in the survey.

When the survey was commissioned alignment A was the preferred option. Results after completion of the initial survey indicated that there were significant elements of interest for both lichens and invertebrates. Alternative alignments were considered and an extended survey undertaken to include areas beyond the footprint of the final works and within Little Dry Gut as this would now be more extensively impacted. The extended survey was undertaken with respect to alignment D.

1.2 CONSTRAINTS

This survey, taking place over a three week period, is very much a snapshot of the species found at that time of year. It should be noted that the period leading up to and through the duration of the survey had been unusually dry with drought conditions in portions of the island. It is impossible to say for certain how this will have affected the survey, but it is probable that tougher, more drought tolerant species will be over-represented and opportunistic species that feed on the grass that grows after the winter rains will be under-represented. It was not possible to identify all taxa to species level as specialist knowledge, skills and experience are needed for some groups (e.g. mites). While further endemic species would almost certainly be found among these groups this information would add little to the overall survey as almost nothing is known of their ecology or wider distribution on the island. One potential constraint is that this is one of the most highly surveyed portions of the island as a result of the airport development. It is possible that species are more widespread away from the area but as relatively little survey work has undertaken elsewhere our knowledge of their wider distributions is not as clear.

1.3 SITE DESCRIPTION

The ridge runs east from Bencoolen and is defined by Dry Gut to the north and Little Dry Gut to the south and is known locally as Pig Hill due to the distinctive erosion feature on its northern flank. The top of the ridge consists of a descending series of near horizontal terraces separated by low (~1-2m) rocky outcrops of unaltered trachyandesite; periodic surface flow has created washed areas of gravel, sand and silt on the steps (Figure 1). The washed terraces become progressively smaller as the ridge descends eastward. At the break of slope on the southern side of the ridge a cliff ranging from 2 to 6m in height runs for a distance of approximately 150m. At the base of the cliff are a series of small caves of up to $2m^3$ in volume (Figure 2); I will refer to this feature as Pig Hill Cliff. Several of these caves are noticeably damp and it is possible that a perched water table detected at 16.5m in test borehole 7 on top of the ridge allows permanent seepage here; GPS readings indicate that the caves are almost precisely this much lower than the borehole. It is potentially possible that the dampness is a result of condensation from sea mists; however, the caves appear to have formed along lines of weakness due to the presence of thin (1-2cm) gypsum veins which have created lines of weakness in the rock, thus allowing seepage. The presence of a salt crust on the rock and sand in some caves also points to the percolation theory rather than to condensation.

FIGURE 1: Panoramic view of the crest of Pig Hill with Bencoolen on the left and the Red Route out of Dry Gut in the distance on the right.

FIGURE 2: Panoramic view of the eastern end of Pig Hill Cliff and three of the six caves.

The slope running down into Dry Gut consists of outcrops of unaltered and slightly altered trachyandesite draped with a thin loose soil of material eroded from above. Areas of cliff are present although smaller than that at the top of the ridge; none of these are on the same alignment as Pig Hill Cliff.

Over the whole site (with the exception of the washed areas) the principal vegetation consists of lichen, predominantly the widespread endemic *Ramalina sanctae-helenae*. In the washed areas on the top of the ridge and more sporadically down the flanks Creeper (*Carpobrotus edulis*) has become established, but is not extensive. Numerous tufts of dead grass (*Eragrostis cilianensis*) were present, particularly on the southern slope; a few dead indigenous Ice Plant (*Mesambryanthemum crystallinum*) were found to the west of the proposed works.

2 METHODOLOGY

The initial survey ran over a two week period from 26th April to 10th May 2013. Invertebrates were collected using the following techniques:

- Hand searching. Any visible invertebrates were collected; stones were turned over and rocky areas carefully searched for invertebrates hiding in cracks and crevices.
- Suction sampling. A modified petrol-powered garden leaf vacuum ('BugVac') was used to collect invertebrates from areas of lichen, Creeper and grass.
- Pitfall trapping. Eight pitfall traps (five on top of the ridge and three in the caves) were installed for the duration of the initial survey. A mixture of white wine vinegar and disinfectant was used to hold the specimens until collection.
- Light trapping. A light trap was operated on one occasion outside of operational hours at the airport site (Sunday 5th May, 18:00 to 21:00) to avoid light pollution from the adjacent works.
- Berlese extraction. An accumulation of plant debris (chiefly Creeper) was removed and invertebrates extracted using a naphthalene vapour gradient in a large funnel.

The extended survey took place over the Bank Holiday weekend of 19-20 May 2013. Further survey work west of the initial survey area and in Little Dry Gut took place with using hand searching, suction sampling and Berlese extraction. A map of the principal survey locations superimposed on the footprint of alignment D is given in Figure 3.

Invertebrates were preserved in 70% ethanol and identified to species level (where possible) using a binocular zoom microscope at magnifications of 7 to 45x. Identifications were made using Ashmole & Ashmole (2000, 2004), Basilewsky (1970, 1972, 1976, 1977) and Lienhard & Ashmole (2011). Lichens were identified using Aptroot (2013).

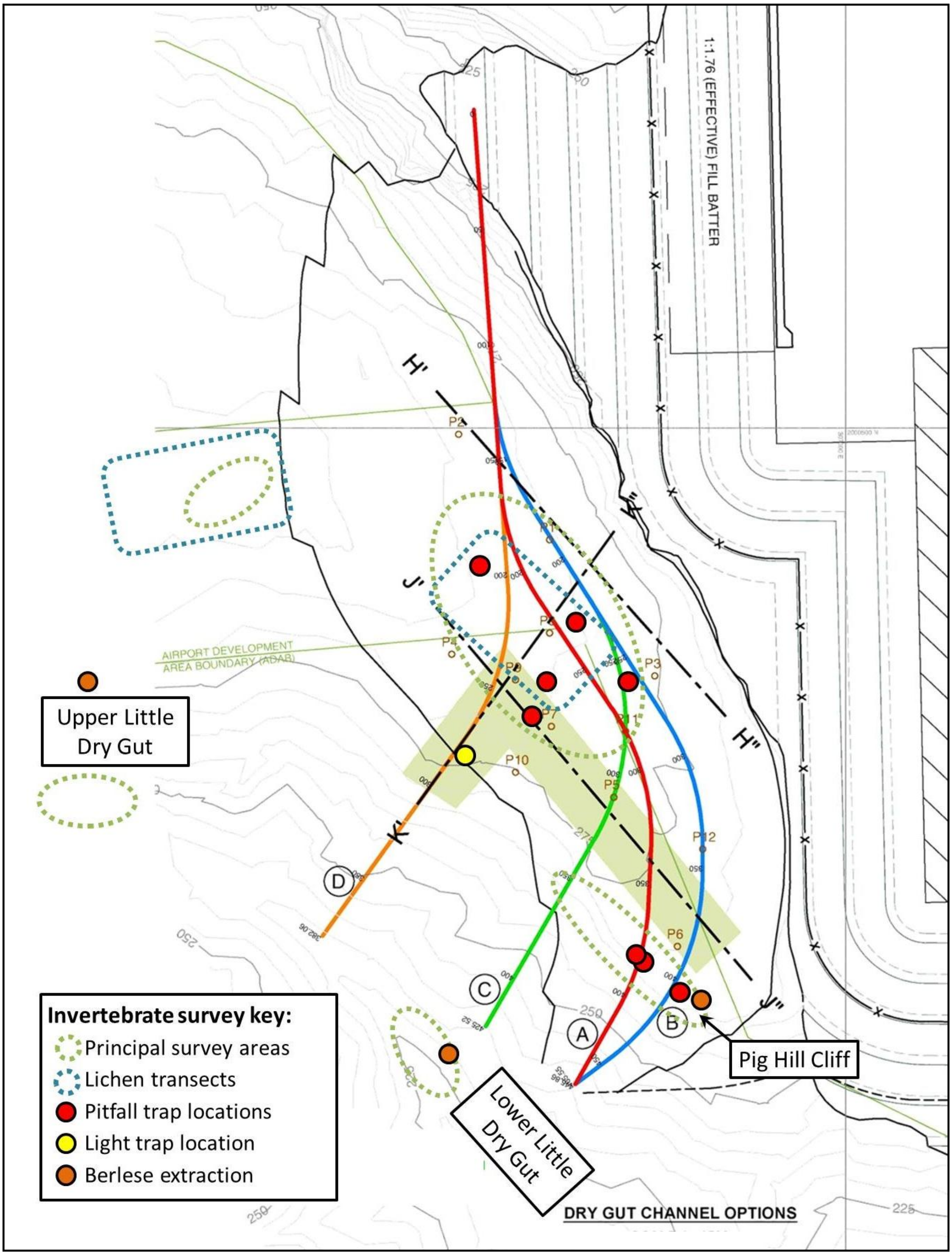

FIGURE 3: Site map with principal survey locations.

3 RESULTS

3.1 LICHENS

The site is important for its lichen assemblage. In the area of the initial survey at least four of the island's nine endemic species are present, these are:

- *Roccella sanctae-helenae* Aptroot & Schumm, 2011
- *Dimelaena triseptata* Aptroot, 2008
- *Dermatiscum pusillum* Aptroot, 2008
- *Ramalina sanctae-helenae* Aptroot, 2008

The site is particularly important for the first two of these species. *Roccella sanctae-helenae* (Figure 4A) is present in good numbers on Pig Hill Cliff; this is one of *very* few known sites for this species (see below). *Dimelaena triseptata* (Figure 4B) is common on the rocky outcrops across the top of the ridge; this species occurs sporadically from The Barn to Great Stone Top but appears to reach its greatest density and abundance at this site (Phil Lambdon pers. comm.). Cairns-Wicks & Lambdon (2012) found the species at only 3 other sites: DG15, SR22 and DG19 (this last site being adjacent to the survey area). *Dermatiscum pusillum* is relatively common across the island and *Ramalina sanctae-helenae* is the commonest species of the cliffs on the eastern side of the island.

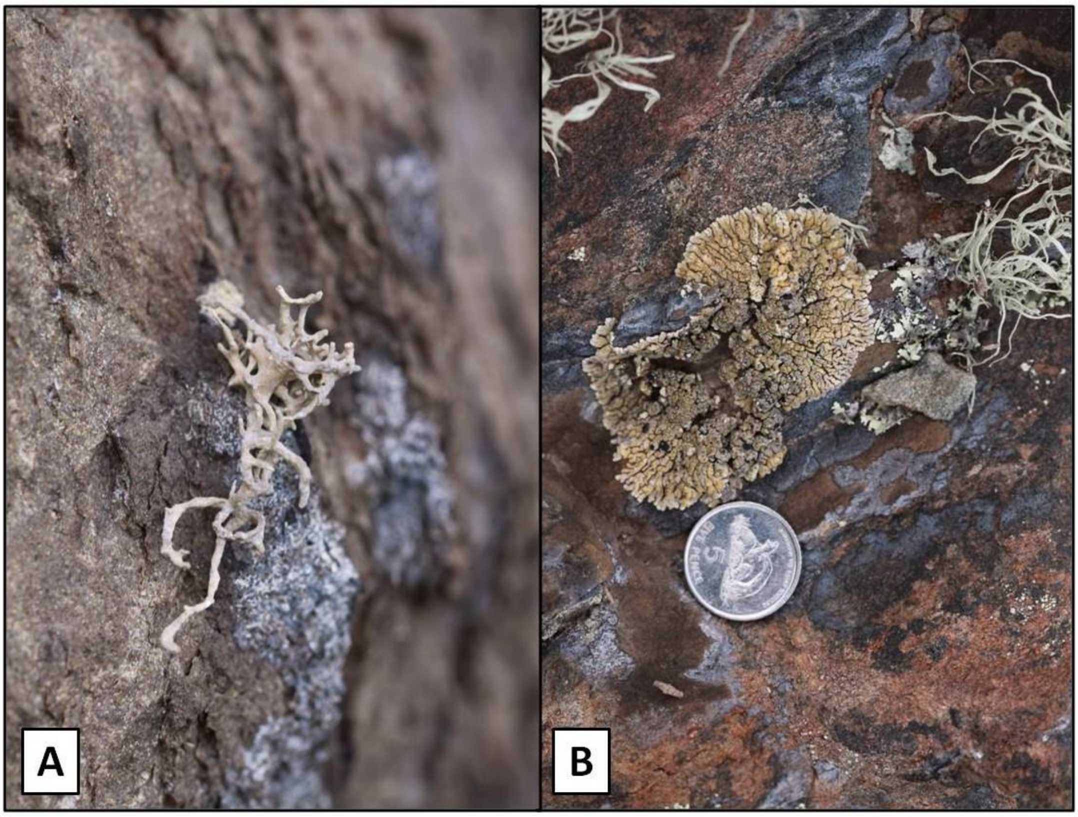

FIGURE 4: The principal lichens of interest. A – *Roccella sanctae-helenae* (approximately 30 mm long); B – *Dimelaena triseptata*.

Whereas *Roccella sanctae-helenae* has a preference for east-facing rocky outcrops that catch mists that sweep in from the sea on the prevailing wind, *Dimelaena* prefers more level sites immediately in the lee of these outcrops. To quantify the average density of *Dimelaena* within the two footprints three 50m transects were undertaken. As the lichen does not occur across the entirety of the site a semi-random methodology was used. An area where *Dimelaena* occurs was located and a 1m² quadrat randomly set down; the maximum dimensions of each colony within the quadrat were measured. The remainder of the transect was surveyed by moving successively 10m up the ridge towards areas of suitable-looking microhabitat and repeating the process.

A total of 60 colonies were found in the 15m² surveyed giving an average density of 4.00 colonies per m²; densities varied between 0 (6 sites) and 29 (1 site) colonies per m², confirming the patchy nature of the species. A histogram of the maximum dimensions of the colonies (Figure 5A) shows a healthy population structure with an average colony size of 33.6mm and a standard deviation of 17.1mm.

In the extended survey *Dimelaena* was found to be extensive to the west of the works proposed by both alignments A and D so a second identical density survey was carried out. A total of 64 colonies were found in the 15m² surveyed giving an average density of 4.27 colonies per m²; densities varied between 0 (5 sites) and 25 (1 site) colonies per m², again confirming the patchy nature of the species. The population was again found to be healthy with an average colony size of 26.1mm and a standard deviation of 17.3mm (Figure 5B). This species was also found to occur sporadically down the slope nearly to the base of Little Dry Gut, although becoming progressively rarer at lower altitudes.

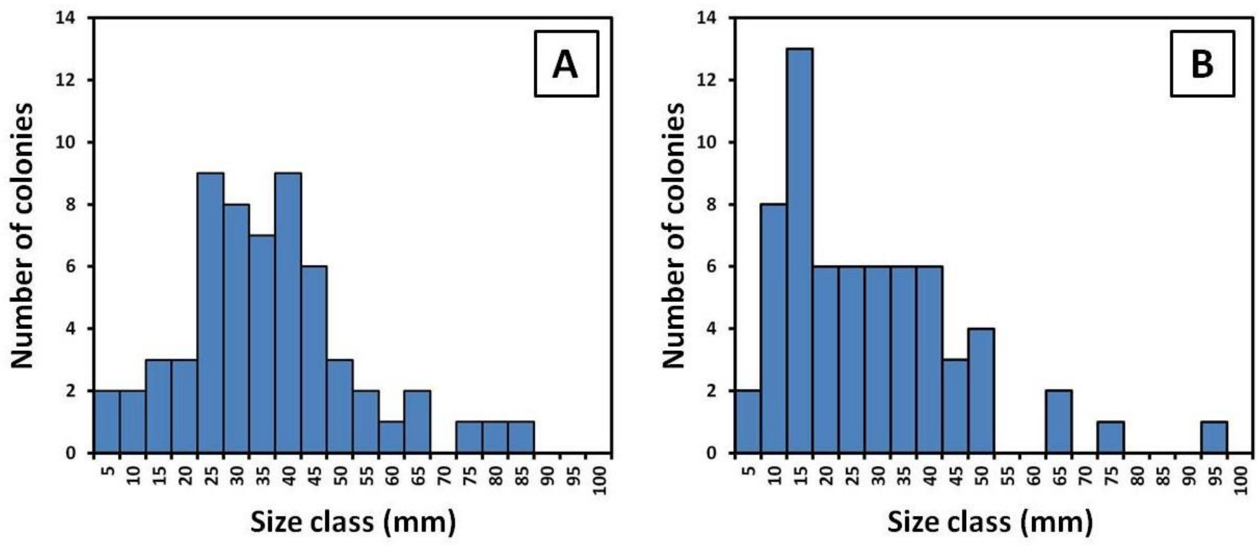

FIGURE 5: Histograms of *Dimelaena triseptata* colony size (maximum dimension) recorded from the three transects. A – initial survey; B – extended survey (west of proposed works).

A few additional small colonies of *Roccella sanctae-helenae* (mostly single specimens) were located on outcrops around the northern branch of Little Dry Gut and on an outcrop immediately adjacent to (potentially within) the proposed exit point of alignment D. Two additional endemic lichens were found well outside of the area of the proposed works of both alignments; these were *Ramalina geniculatella* and *Ramalina ketner-oostrae*. It is likely that both of these species occur sporadically across the site, but both are relatively widespread on the island.

3.2 INVERTEBRATES

A total of 315 invertebrates representing 50 species were recovered during the initial survey from twelve samples. During the extended survey a further 473 invertebrates were collected from an additional eight samples bringing the total number of species to 73. Of all the species identified twelve are endemic to St Helena with six of these belonging to endemic genera. A complete species list, including details of their known scarcity and the number of specimens recovered is presented in Appendix 3.

It was not possible to name 18 taxa to species level as several groups such as Acari (mites) and Collembola (springtails) are extremely difficult to identify and would require specialist help or equipment in order to determine them. It is probable that several of these are also endemic species, particularly amongst the Acari. Of particular interest are the Lepidoptera (butterflies and moths), Araneae (spiders) and Collembola; these are discussed separately below.

3.2.1 LEPIDOPTERA

Five species of endemic moth were found during the survey. The most important species are three undescribed species of *Opogona*. Two of these make a small seed-like larval case and are found under stones or feeding on lichen (Figure 6A); the third makes a longer sock-like larval case and was only found under rocks on the northern side of the ridge below the break in slope (Figure 6B). Two species of adults were also collected, one being smaller and more common than the other. It is inferred that these two species match two of the three larval cases; however, it is possible that, four, five, or even more species could be present. These undescribed *Opogona*s are restricted to the Eastern Arid Area (EAA) of the island and certainly form a species complex. The St. Helenian species of *Opogona* are urgently in need of scientific revision; however, we are currently unable to find an expert in microlepidoptera who is interested in taking on the challenge.

The scarce endemic pyralid *Homeosoma privata* was represented by a single individual in the light trap, Tim Karisch found the species at Fisher's Valley, Sandy Bay Valley and Rose Hill (Karisch, 2007); it had previously only been found in 1875 at Plantation and Peak Dale (Ashmole & Ashmole, 2000). The endemic genus and species *Helenoscoparia nigritalis* is common and widespread.

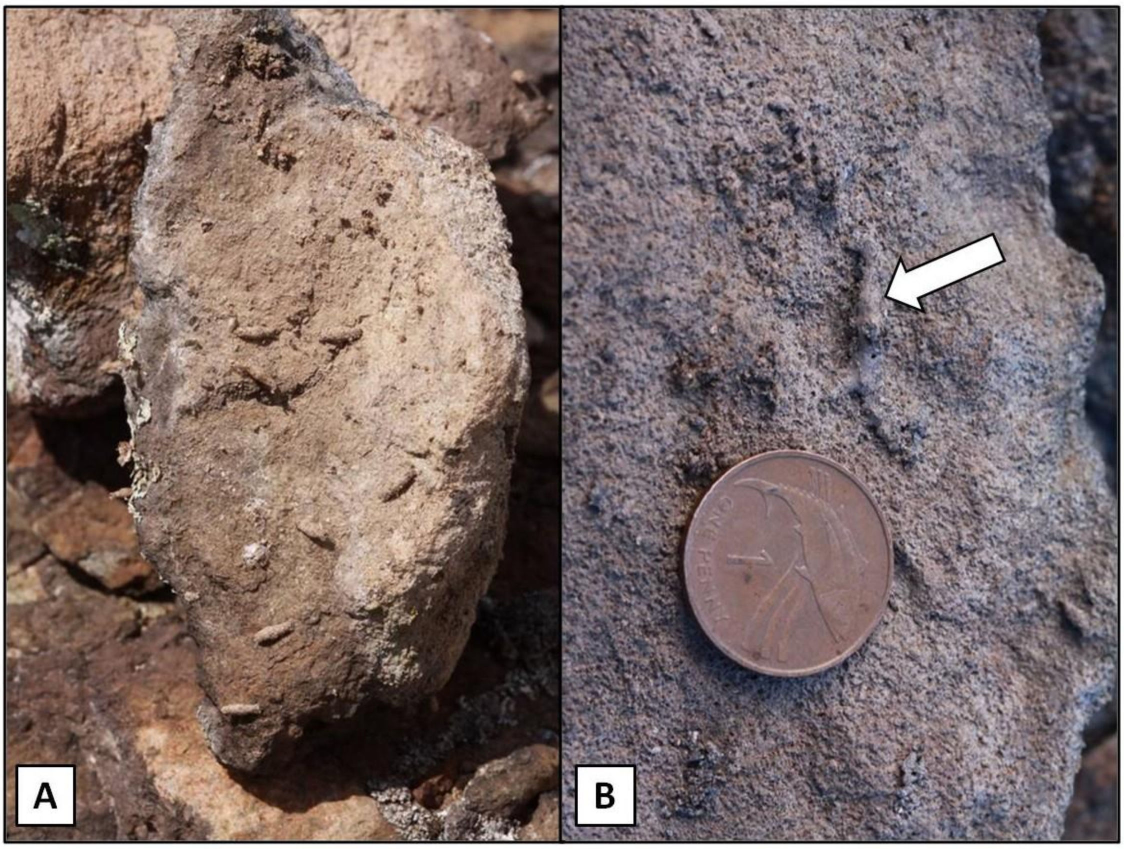

FIGURE 6: *Opogona* larval cases. A – seed-like case (several); B – sock-like case (arrowed).

3.2.2 ARANEAE

The EAA of the island is important for its spiders, in particular the Lycosidae. During the survey only one cast lycosid skin was found, but it was not possible to secure it before it disintegrated and blew off in the wind. Many lycosids are burrowers and numerous tunnels were noted under rocks, but these could not be excavated. It is to be expected that further survey work would confirm their presence. Two of the eleven species of spider found (*Clubiona dubia* and *Philodromus signatus*) are certainly endemic, but are relatively common. One species (*Oecobius* sp.) is certainly an undescribed endemic that is restricted to the EAA.

3.2.3 COLLEMBOLA

Several of the Collembola found are interesting. Three species were recovered from pitfall traps in the caves and one of these is blind indicating that it may be a cave specialist. Suction sampling on the top of the ridge produced a globular springtail. Only three species from this group have been found on St. Helena – *Sminthurinus aureus* (a yellow and black species), *Sminthurinus niger* (all black) and a damaged female collected off a Coffee leaf at Plantation by the Belgians and determined as *Katianna* sp. (Basilewsky, 1970). This specimen from the central portion of the ridge (inside the footprints of both alignments) is pale with numerous darker spots and purple antennae (Figure 7), it is certainly a katiannid but it is not possible to say this is the same as the

Plantation specimen. However, bearing in mind the huge difference in habitat it is very likely a previously unrecorded species. It is interesting that the widespread species *Entomobrya multifasciata* was found to be common in the extended survey (95 specimens from 5 samples) but was entirely absent from the initial survey.

FIGURE 7: Globular springtail 'Katiannidae indet.'

FIGURE 8: Two adults of the scarce endemic darkling beetle *Tarphiophasis leleupi*.

3.2.4 OTHER INVERTEBRATES

Five other endemic species were found. The darkling beetle *Tarphiophasis leleupi* (Figure 8) was described as new to science by the Belgians who found it at four sites: Prosperous Bay Plain, Great Stone Top, Long Range Cow and Sand Bay Beach (Basilewsky, 1972). Although described from 2,600 specimens it now appears that the species is very scarce and the Ashmole's only found five specimens during their survey, four of which were dead (Ashmole & Ashmole, 2004); it was not found during the most recent survey (Cairns-Wicks & Lambdon, 2012). In the initial survey one live and four dead specimens were found (the beetle is very robust and remains of dead specimens persist for long periods). In the extended survey two live and five dead specimens were recovered. The silverfish *Ctenolepisma sanctaehelenae* was common across the site. This species has only been recorded from Prosperous Bay Plain, Longwood Plain and Sandy Bay Beach. It was noticeably more common here than to the north of Dry Gut where a few dead fragments were found on the Southern Ridge but not recorded at the time due to lack of identification literature (Phil Lambdon pers. comm.). It appears that this species is replaced by the non-native *Ctenolepisma longicaudata* in and around the streambed of Little Dry Gut.

A single specimen of the extremely rare endemic asteiid fly *Anarista vittata* was collected in the upper portion of Little Dry Gut. This fly is known only from two specimens collected by the Belgians in 1967 from the lower portion of Fisher's Valley and in Rupert's Valley. The biology of this obscure group of flies is very poorly known; however, it is suspected they may be scavengers of the frass (excreta) of other insects (Sabrosky, 1987).

The remaining two endemic species, the grasshopper *Primnia sanctaehelenae* and the Blushing Snail (*Succinea sanctaehelenae*) are common and widespread on the island.

3.2.5 Other observations

While light trapping on 5th May at 20:00 Madeiran Storm Petrels (*Oceanodroma castro*) were heard calling near the site. This species has been under threat for a number of years, however, as a result of the control of feral cats as part of the Wirebird (*Charadrius sanctaehelenae*) conservation programme this species could be increasing. The species nests at Gill Point but this record was the first inland observation; it remains to be seen whether they are now nesting inland (Annalea Beard pers. comm.).

The invertebrates sampled below the discharge point of alignment D in Little Dry Gut were all found in at least one other sample taken from the site. The one exception was the phorid fly *Megaselia pleuralis* which is scarce on the island but is also introduced; no endemic species were found here and it is probable that the proposed works will have little impact ecologically on the lower portion of this water course.

One item of real concern is the presence of the highly invasive non-native weed Wild Mango (*Schinus terebinthifolia*) in the base of the gut. Increased water supply is likely to favour this species and its population may well explode if this happens – this can be illustrated by visiting the lower end of Sharks Valley which is nearly impenetrable as a result of this species.

Several invasive non-native problem species were encountered during the survey, these include the Red-headed Centipede (*Scolopendra morsitans*), the Lesser Brown Scorpion (*Isometrus maculatus*) and the spiders *Xeropigo tridentiger*, *Dysdera crocata* (Woodlouse Spider) and *Latrodectus geometricus* (Brown Widow) all of which will be predating endemic species. Interestingly there was no evidence of Java Geckoes (*Hemidactylus frenatus*) found at the site; these are abundant on the north side of Dry Gut (Phil Lambdon pers. comm.)

3.3 ANALYSIS OF SAMPLING EFFECTIVENESS

Sampling effectiveness was assessed using EstimateS v.8.2.0 statistical software for analysis of species richness and shared species (Colwell, 2009). This program produces a synthetic species accumulation curve from the samples collected. It is then possible to take the generated curve and fit a trendline in Microsoft Excel and, using the associated R^2 and trendline equation, estimate the effectiveness of the survey. First results after the initial survey indicated that doubling the size of the survey (to 24 samples) would recover an extra 46.26% (21.6 taxa) and tripling to 36 samples would recover an estimated 74.25% (37.1 taxa). From this it can be seen that the initial survey was far from comprehensive. Following the extended survey the data was recalculated as the additional eight samples would refine the results considerably.

The synthetic species accumulation curves generated from the data collected in the initial and completed survey are shown in Figure 9 (red data points). By fitting a power law trendline (dashed line) it can be seen that the data from the completed survey predicts that a higher number will be recovered than that generated after the completion of the initial survey. The fitted curve for the completed survey is also a better fit (R^2 value of 0.9999 versus 0.9997) despite using a larger number of points to fit the curve (nine versus six).

The formula for the power law trendline can now be used to predict the number of taxa that would be recovered if additional work were undertaken; a graph of this data is given in Figure 10. The black line is the expected number of taxa that would be recovered and the two grey lines are the upper and lower 95% confidence limits also generated by EstimateS. If a 'survey' is defined as 20 samples, the calculated figures for the number of taxa that should be recovered if two, three, four or five identical surveys were undertaken at this site is given in Table 1.

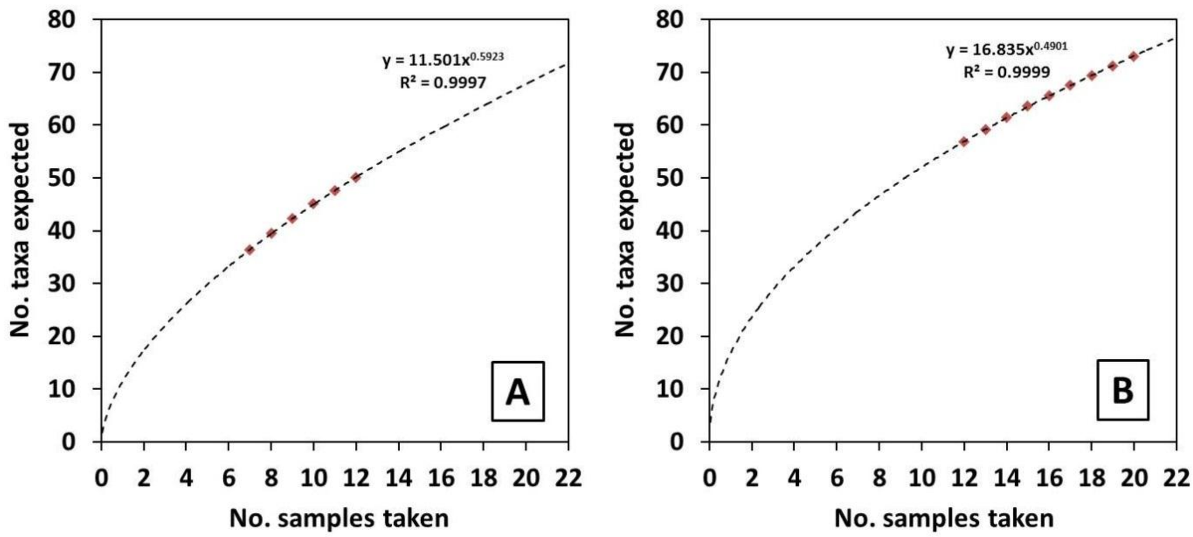

FIGURE 9: Synthetic species accumulation curve generated by EstimateS with fitted trendlines. A – initial survey (last six points used); B – complete survey (last nine points used).

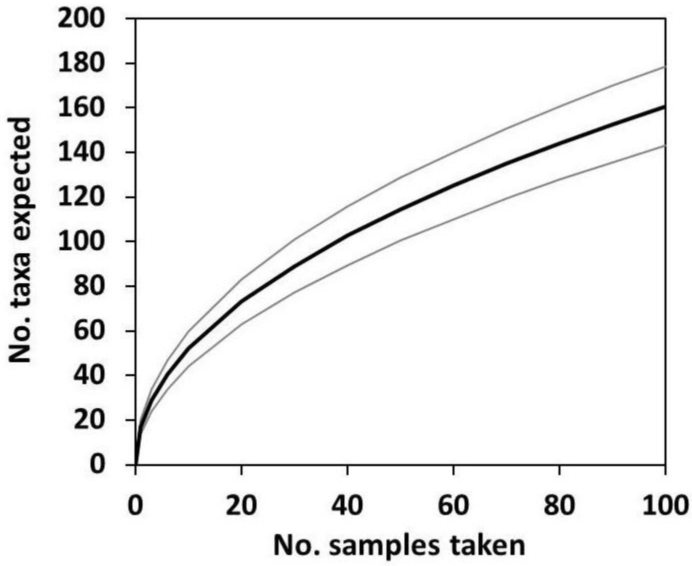

FIGURE 10: Predicted number of taxa (black line) and 95% confidence limits (grey lines) with increasing sample size as generated by EstimateS.

NO. OF SURVEYS	NO. TAXA EXPECTED	95% CONFIDENCE LIMIT	PERCENTAGE INCREASE
2	102.66	± 13.09	40.46
3	125.22	± 15.05	71.32
4	144.18	± 16.58	97.26
5	160.85	± 17.85	120.07

TABLE 1: EstimateS predictions of taxon diversity increase by multiplying survey effort.

From this data it can clearly be seen that the area is still considerably under-sampled and that many more invertebrates are present in the area than were found in this survey (four times more effort would approximately double the number of taxa recovered). It should be born in mind that this was only a snapshot survey and the invertebrate fauna will vary seasonally. In arid areas like this many invertebrates aestivate[1] so are not likely to be present in the samples or, if they are found, be easy to identify. To gain a true picture of diversity at this site it would be necessary to repeat it at least twice, preferably three times over the course of a year.

4 IMPACT OF THE PROPOSED WORKS ON ENDEMIC SPECIES

As the survey covered an extensive area, including sections well outside the footprint of the proposed works, it is necessary to assess the potential impact on endemic species found within

[1] Aestivation is the opposite of hibernation, in this instance it specifically refers to invertebrates timing their life-cycle so that they are able to pass through the hottest and driest part of the year in a life stage that is less vulnerable to water loss such as the egg or pupa.

footprints of the two propositions. The final column of the table of species in Appendix 3 indicates which alignment would potentially impact the species recorded; this includes the potential impact of increased flows in lower Little Dry Gut that may occur sporadically as a result of the diversion in alignment D.

4.1 INVERTEBRATES

Invertebrates sampled across the top of the ridge and on its southern flank all fall within the footprint of both alignments A and D. The only samples from this area that fall within the footprint of alignment A only are those from the Pig Hill Cliff area; the known endemic invertebrates from this area were all found elsewhere. Table 2 lists all of the endemic species found within the footprints of the two alignments, it also gives information on whether the species was found outside of the footprints in this survey, if it has been found elsewhere in the EAA, how common it is on the island in general and lastly an assessment of the impact of these works on the species as a whole. It has not been possible to come up with an impact assessment for the three known but undescribed species as we have no information on their wider distribution or ecology.

Species	Within footprint?	Outside footprint?	In EAA?	Elsewhere on island?	Impact?
Araneae					
Clubiona dubia	Yes	No	Yes	Common	None
Oecobius sp.	Yes	Yes	Yes	?	**?**
Philodromus signatus	Yes	No	Yes	Common	None
Coleoptera					
Tarphiophasis leleupi	Yes	Yes	Yes	2 sites*	**Low to Medium**
Lepidoptera					
Helenoscoparia nigritalis	Yes	Yes	Yes	Common	None
Homoeosoma privata	Yes	Yes	Yes	Rare	**Low**
Opogona sp. 1 (seed)	Yes	Yes	?	?	**?**
Opogona sp. 2 (sock)	Yes	Yes	?	?	**?**
Orthoptera					
Primnia sanctaehelenae	Yes	Yes	Yes	Yes	None
Thysanura					
Ctenolepisma sanctaehelenae	Yes	Yes	Yes	No	**Low to Medium**

* Sandy Bay and Long Range Cow – both particularly dry locations comparable to the EAA.

TABLE 2: Assessment of potential impact on endemic invertebrates.

While the rare moth *Homoeosoma privata* was caught in the light trap within the footprints of both alignments A and D the insect itself is likely to have been attracted in from outside the immediate area. As the ecology of this species is unknown the collection of a single specimen cannot therefore be seen as significant. The only two invertebrate species that might be affected adversely by these works are the beetle *Tarphiophasis leleupi* and the silverfish *Ctenolepisma sanctaehelenae*.

4.2 Lichens

This survey has already shown the importance of Pig Hill Cliff for lichens. As they are immobile and many species have specific microhabitat requirements it is necessary to tabulate the potential effect of the two proposals separately (Table 3).

Species	Within footprint?	Outside footprint?	In EAA?	Elsewhere on island?	Impact?
Alignment A					
Roccella sanctae-helenae	Yes	A few	Rare	No	**High**
Dimelaena triseptata	Yes	Yes	Yes	No	**Medium**
Dermatiscum pusillum	Yes	Yes	Yes	Common	None
Ramalina sanctae-helenae	Yes	Yes	Yes	Common	None
Alignment D					
Dimelaena triseptata	Yes	Yes	Yes	No	**Medium**
Dermatiscum pusillum	Yes	Yes	Yes	Common	None
Ramalina sanctae-helenae	Yes	Yes	Yes	Common	None

Table 3: Assessment of potential impact on endemic lichens for the two alignments.

In alignment A the removal of Pig Hill Cliff would have a high impact on the rare lichen *Roccella sanctae-helenae*. While this species was located sporadically on a few small outcrops on the northern side of Little Dry Gut these are few and far between, often just a single specimen each. The precise number of large colonies of this species is unknown as André Aptroot (who conducted the island-wide survey for his recent book) has not submitted his records; however, currently only one other large colony of this species is known to exist (Phil Lambdon pers. comm.). The loss of Pig Hill Cliff would result in the removal of a substantial percentage of the known population of this species. Alignment D retains the cliff, thus saving this important population, provided that care is taken during construction.

While *Dimelaena triseptata* is known from a number of sites from The Barn to Great Stone Top it is entirely restricted to the EAA and is generally uncommon within its range. From other observations across the area it appears that this species occurs at its highest densities at this site. It is, however, found at these high densities outside the footprint of both alignments; should suitable remediation be put in place it should be possible to mitigate some of this loss.

5 Implications for Remediation

Were remediation to be attempted for some of the key landscape elements that could potentially be lost it would require far more effort to reconstruct those removed by alignment A than the alignment D. Pig Hill Cliff is, so far as we know, unique in its elevation, alignment and scale for at least a mile in all directions. Of particular importance is its elevation with respect to the mists which periodically sweep in from the sea. If an attempt were made to recreate this habitat it would have to be diagonally up-slope on a line from the sea cliff to Pig Hill Cliff; it should be of the same height and alignment and should also be in rock with thin veins of gypsum that seem to be the lines of weakness that have initiated cave development.

If this cliff were to be lost an attempt should be made to rescue the extremely rare lichen *Roccella sanctae-helenae* which, although occurring sporadically further up Little Dry Gut, is never met with in the densities found at Pig Hill Cliff. It would be necessary to remove as many colonies of lichen as possible (bearing in mind health and safety considerations) to a nearby sheltered location for the duration of the work, and then seeding the newly created habitat with these saved specimens. So far as I am aware transplantation of cliff lichens has never been attempted on this scale anywhere.

Alignment D (which saves the cliff) would not require this work. There are a few small outcrops near the lowermost point of discharge that have a few *Roccella sanctae-helenae* on them. As these are down-slope and downwind of Pig Hill Cliff it is quite possible that they are daughter colonies derived from it. Removal of these few specimens back to Pig Hill Cliff by cementing the lichen and the rock that it came from onto currently lichen free areas is recommended.

One concern is that alignment D will intersect the perched water table that probably feeds seepage in the caves. The only suggestion that could mitigate for this would be to slope the uppermost two terraces back towards the eastern wall of the cutting, thus creating pools after rainfall which may compensate for the lost water table by allowing some percolation.

The flat terraces created during construction will provide suitable habitat for the recolonisation of *Dimelaena triseptata* in the long term. However, it is recommended that loose stones with this species on them be removed to areas outside the footprint for the duration of the works. These will then be available later to seed the terraces created during channel construction. As this area is of primary interest for its lichens it would be advisable to leave the surfaces of the terraces as bare rock. It is suspected that seeding will only be truly successful on the upper two or three terraces as deeper ones are likely to present a very different microclimate to that where the species is currently found. Should this seeding take place it is also suggested that an experimental approach be taken. This could be a unique opportunity for the long term-monitoring of a newly created 'habitat' as lichens colonise following completion of the project.

Should either alignment go ahead it is recommended that the alien invasive plant species, Wild Mango (*Schinus terebinthifolia*) in particular (Figure 11), be removed from Dry Gut and Little Dry Gut. This would be easy to achieve at present, but given a few years it could become a serious problem, potentially resulting in blockage of the watercourse during extreme rainfall events. It is recommended that this work is undertaken by specialist contractors and that future maintenance programmes have this built in to them.

Alignment D also requires the construction of an access road to its southern end for construction and future maintenance. This road will pass close below Pig Hill Cliff; care should be taken during its construction and use to minimise dust in this area.

It is recommended that prior to commencement of the works specialist contractors are used in an attempt to mitigate disruption (as far as is possible) for the two most likely invertebrate species to be affected by these alignments. A few days work searching for live specimens of the beetle *Tarphiophasis leleupi* and the silverfish *Ctenolepisma sanctaehelenae* (along with any other endemic species that are encountered such as larval cases of the moth genus *Opogona*) and relocation of these well outside of the footprint would help retain genetic diversity within these species.

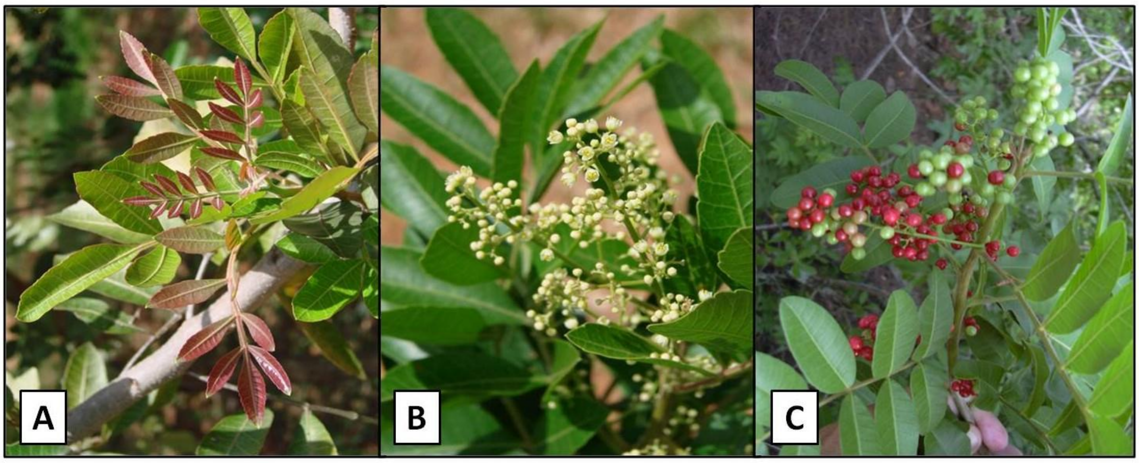

FIGURE 11: Wild Mango (*Schinus terebinthifolia*). A - leaves; B - flowers; C - fruit.

With regards to the engineering of the final design it is requested that the sides of the cliff are left as rough and variable as possible. This allows the creation of multiple microhabitats within a very small area; if the terraces can wander a bit here and a bit there areas will be created that get a bit more sunlight in one area and less in others. This creates gradients which will help encourage lichen and surrounding invertebrate populations to enter the newly created habitat. It is also recommended that the walls of the cliff and the terraces be left quite rough and the base of the channel more naturally sculpted to create pools for the same reasons.

It is recommended that a long-term invertebrate, lichen and vegetation monitoring system be set up within the airport management plan. The potential use of high powered night-time illumination during operation of the airport, changes in hydrology to Little Dry Gut and the outcomes of proposed remediation will require assessment at an initial two year frequency for ten years, dropping to a five year frequency after that for an additional 20 years (and possibly longer if no stabilisation is determined).

6 CONCLUSIONS

The site is unique in the area for the following reasons:

- its invertebrate assemblage;
- its lichen assemblage;
- the south-facing cliff and damp caves;
- (possibly) the unusual landscape elements.

Despite its almost barren appearance this area holds a diverse lichen and invertebrate fauna. A total of 73 species of invertebrate were recorded with 12 of these being endemic (16.4%). Of the ten species of invertebrate that would be adversely affected by both alignments it has been assessed that only two (the beetle *Tarphiophasis leleupi* and the silverfish *Ctenolepisma sanctaehelenae*) may suffer significant impact.

Six of the island's nine endemic species of lichen were recorded during the survey. However, only two of these (*Roccella sanctae-helenae* and *Dimelaena triseptata*) would suffer significant impact as a result of the proposed works.

The landscape elements of the site are unusual for the island, this being one of very few areas that consists of low, periodically rain-washed terraces of hard rock that step gently down slope. The presence of a south-facing cliff with damp caves at its base is also highly unusual.

The population of *Roccella sanctae-helenae* on Pig Hill Cliff is holds a significant portion of the world population of this species and this would be lost were alignment A to go ahead. The main unique landscape feature would also be lost and this would be difficult, time consuming and expensive to mitigate. Alignment D avoids the removal of the cliff, thus retaining this lichen population and the damp caves. While the second lichen (*Dimelaena triseptata*) is widespread at the site it is still a nationally scarce species. However, remediation for this species is simpler and the construction of the near-flat terraces planned recreates suitable habitat for recolonisation on the upper terraces at least.

It is not expected that the diversion of periodic flow from Dry Gut into Little Dry Gut will have any significant impact on the valley and its fauna.

If either of the two proposals is to go ahead alignment D is preferable to alignment A as it retains more of the unique landscape elements including the single most important habitat element on site – Pig Hill Cliff.

I would finally suggest that, whichever alignment is adopted, serious consideration be given to the potential mitigation measures outlined above.

7 REFERENCES

APTROOT, A. 2013. *Lichens of St Helena*. Pisces Publications, Newbury. ISBN 978 1 874357 7.

ASHMOLE, P. & ASHMOLE, M. 2000. *St Helena and Ascension Island: a natural history*. Anthony Nelson Publishers, Oswestry.

ASHMOLE, P. & ASHMOLE, M. 2004. *Guide to Invertebrates of Prosperous Bay Plain Plain, St Helena and Illustrated account of species found on the Eastern Arid Area (EAA), including Prosperous Bay Plain, Holdfast Tom and Horse Point Plain*. Privately published.

BASILEWSKY, P (ed.). 1970. *La faune terrestre de l'Île de Sainte-Hélène. Première Partie*. [Introduction, non-invertebrates, Collembola, Diplura, Thysanura, Odonata, Blattariae, Isoptera, Orthoptera and Dermaptera.]

BASILEWSKY, P (ed.). 1972. *La faune terrestre de l'Île de Sainte-Hélène. Deuxième Partie*. [Coleoptera].

BASILEWSKY, P (ed.). 1976. *La faune terrestre de l'Île de Sainte-Hélène. Troisième Partie*. [Embioptera, Neuroptera, Diptera, Siphonaptera, Hymenoptera, Psocoptera, Mallophaga, Thysanoptera and Hemiptera].

BASILEWSKY, P (ed.). 1977. *La faune terrestre de l'Île de Sainte-Hélène. Quatrième Partie*. [Non-insect invertebrates].

CAIRNS-WICKS, R. & LAMBDON, P. 2012. *Habitat Survey Report: Dry Gut and the Southern Ridge of Prosperous Bay Plain*. Commissioned report to SHG.

COLWELL R.K. (2009). *EstimateS: statistical estimation of species richness and shared species from samples*. Version 8.2.0. (http://viceroy.eeb.uconn.edu/EstimateS).

KARISCH, T. 2007. Zur Schmetterlingsfauna von St. Helena 3. Teil: Kleinschmetterlinge (2) (Insecta: Lepidoptera: Pyraloidea). *Linzer Biologische Beitrage*. 39(1):405-414.

LIENHARD, C. & ASHMOLE, P. 2011. The Psocoptera (Insecta: Psocodea) of St Helena and Ascension Island (South Atlantic) with a new record from South Africa. *Revue Suisse de Zoologie*. 118(3):423-449.

SABROSKY, C.W. 1987. *78. Asteiidae*. In: MCALPINE, J.F., PETERSON, B.V., SHEWELL, G.E., TESKEY, H.J., VOCKEROTH, J.R. & WOOD, D.M. (eds.): *Manual of Nearctic Diptera, Vol. 2, Research Branch, Agriculture Canada Monograph 27*. Can. Com. Group-Publ., Ottawa, pp. 899-902.

ACKNOWLEDGEMENTS

I would like to thank Phil Lambdon, Chris Hillman, Annalea Beard and Alan Gray who assisted with fieldwork. I would also like to thank Annina van Neel of Basil Read and Rob Kleinjan of Halcrow who assisted with site access and logistics. I am grateful to all other Basil Read and Halcrow staff who assisted me on site.

Particular thanks go to the St Helena National Trust and BugLife without whom I would have been unable to undertake this work.

Appendix 1: Lichen transects

Number	Start point	End point
Initial Survey		
1	15°58.078'S 005°38.840'W 277m	15°58.078'S 005°38.840'W 280m
2	15°58.086'S 005°38.866'W 281m	15°58.067'S 005°38.887'W 282m
3	15°58.077'S 005°38.868'W 282m	15°58.054'S 005°38.876'W 285m
Extended survey		
4	15°58.015'S 005°38.933'W 297m	15°58.029'S 005°38.957'W 301m
5	15°58.018'S 005°38.962'W 299m	15°58.019'S 005°38.992'W 303m
6	15°58.041'S 005°38.987'W 302m	15°58.055'S 005°38.994'W 301m

Note: As it was necessary to sample areas of exposed rock only, and the topography of the ridge is random it was not possible to keep the transects perfectly straight so when plotted in a GIS several may be less than 50m long (Transect 6, for example was L-shaped as there was no suitable habitat if it were continued in the same direction).

The maximum diameters (mm) of each colony located within each $1m^2$ transect point are listed below:

Initial survey

Transect 1
- A 63, 20, 21, 5, 27, 11, 81
- B 21, 32, 46
- C –
- D 37, 40, 11, 21, 27, 30, 32, 19, 80
- E 36, 21, 48, 52, 5

Transect 2
- A 53, 60, 42, 21
- B 36
- C –
- D –
- E 30

Transect 3
- A 36, 9, 27, 33, 22, 31, 43, 43, 46, 23, 31, 22, 20, 44, 74, 40, 65, 32, 32, 42, 36, 27, 48, 36, 37, 23, 12, 6, 27
- B –
- C –
- D –
- E 26

Extended survey

Transect 4

A	37, 22, 62, 40, 31, 72, 26, 17, 14, 13, 28, 11, 8, 42, 6, 12, 12, 8, 9, 15, 40, 36, 24, 12, 29
B	–
C	47
D	42, 12, 32, 33, 47, 22, 20, 16, 11, 8, 32, 12, 14, 17, 18, 36, 10, 9
E	18, 47

Transect 5

A	32, 22, 14
B	–
C	–
D	29, 26
E	14

Transect 6

A	–
B	–
C	46, 43, 26, 23
D	5, 35, 36, 91, 61, 6, 5
E	25

APPENDIX 2: PITFALL TRAP LOCATIONS

Crest of Pig Hill

Pitfall 1:	15°58.075'S 005°38.859'W 287m	Sandy area with Creeper
Pitfall 2:	15°58.084'S 005°38.865'W 288m	Rocky outcrop
Pitfall 3:	15°58.076'S 005°38.840'W 285m	Scattered fist-sized rocks
Pitfall 4:	15°58.062'S 005°38.852'W 291m	Rocky outcrop
Pitfall 5:	15°58.048'S 005°38.877'W 295m	Sandy area with Creeper

Caves at the base of Pig Hill Cliff

Pitfall 6:	15°58.142'S 005°38.837'W 270m	Dry cave
Pitfall 7:	15°58.143'S 005°38.836'W 270m	Dry cave
Pitfall 8:	15°58.151'S 005°38.827'W 271m	Damp cave

APPENDIX 3: INVERTEBRATE SPECIES LIST

A total of 20 individual samples were collected, these were:

Sample no.	Date	Methodology and location
1	28/04	Suction sampling on top of ridge
2	28/04	Hand searching on top of ridge
3	29/04	Hand searching on top of ridge
4	02/05	Suction sampling on top of ridge
5	02/05	Hand searching on top of ridge
6	02/05	Hand searching on the far slope and in caves
7	05/05	Hand searching on top of ridge
8	05/05	Hand searching on the far slope and in caves
9	05/05	Light trapping on the far slope
10	10/05	Berlese extraction of vegetation deposit on cliff ledge
11	10/05	Pitfall traps on top of ridge
12	10/05	Pitfall traps in caves
13	19/05	Suction sampling west of potential works
14	19/05	Hand searching west of potential works
15	19/05	Berlese extraction of vegetation deposit – upper Little Dry Gut
16	20/05	Suction sampling in upper Little Dry Gut
17	20/05	Hand searching in upper Little Dry Gut
18	20/05	Suction sampling in lower Little Dry Gut
19	20/05	Hand searching in lower Little Dry Gut
20	20/05	Berlese extraction of vegetation deposit – lower Little Dry Gut

Notes on the species list

For each species the up-to-date taxonomic name is given along with the species authority and common name where appropriate.

The species status is defined as follows:

-	Non-endemic species (non-native or indigenous)
*	Endemic species
**	Endemic genus and species
?	Indicates uncertainty

The scarcity status is defined as follows:

Common	Widespread on the island (5 or more sites in different areas)
Scarce	Either less than 5 sites, or all sites restricted to the Eastern Arid Area
Rare	Only known from one or two sites
?	Indicates uncertainty

	Species	Author	Common name	Status	Scarcity	Initial survey total	Extended survey total	Relevant alignment
Mollusca								
Gastropoda								
Helicidae	*Helix aspersa*	Müller, 1774	Garden Snail	-	Common	0	6	-
Succineidae	*Succinea sanctaehelenae*	(Lesson, 1830)	Blushing Snail	*	Common	0	1	-
Crustacea								
Isopoda								
Porcellionidae	*Porcellio laevis*	Latreille, 1804	Smooth Slater	-	Common	8	4	AD
Chilopoda								
Scolopendromorpha								
Scolopendridae	*Scolopendra morsitans*	Linnaeus, 1758	Red-headed Centipede	-	Common	2	0	AD
Diplopoda								
Julida								
Blaniulidae	*Proteroiulus fuscus*	(Am Stein, 1847)	Snake Millipede	-	Common	0	1	
Julidae	*Ommatoiulus moreletii*	(Lucas, 1860)	Black Portugese Millipede	-	Common	2	7	AD
Arachnida								
Scorpiones								
Buthidae	*Isometrus maculatus*	(de Geer, 1778)	Lesser Brown Scorpion	-	Common	0	1	AD
Araneae								
Clubionidae	*Clubiona dubia*	Pickard-Cambridge, 1869	-	*	Common	1	0	AD
Corinnidae	*Xeropigo tridentiger*	(Pickard-Cambridge, 1869)	-	-	Common	7	8	AD
Dictynidae	*Archaeodictyna condocta*	(Pickard-Cambridge, 1876)	-	-	Scarce	1	3	A
Dictynidae	*Dysdera crocata*	Koch, 1838	Woodlouse Spider	-	Common	1	0	AD
Linyphiidae	*Meioneta affinis*	(Kulczyn'ski, 1898)	-	-	Scarce	0	1	-
Oecobiidae	*Oecobius* sp.	-	-	?*	?	6	6	AD
Oonopidae	*Gamasomorpha insularis*	Simon, 1907	-	-	Scarce	5	4	AD
Salticidae	*Hasarius adansoni*	(Audouin, 1826)	Adanson's House Jumper	-	Common	6	15	AD
Sicariidae	*Loxosceles rufescens*	(Dufour, 1820)	Mediterranean Recluse Spider	-	Rare	1	0	A
Theridiidae	*Latrodectus geometricus*	Koch, 1841	Brown Widow	-	Scarce	2	0	A
Thomisidae	*Philodromus signatus*	Pickard-Cambridge, 1869	-	*	Common	1	0	AD

Arachnida (contd.)								
Acari								
Scheloribatidae	*Scheloribates* sp.	-	-	?	?	2	29	AD
Bdellidae	Bdellidae indet.	-	-	?	?	58	0	A
Acari Indet. (small red)	Acari Indet.	-	-	?	?	2	3	A
Acari Indet. (grey square)	Acari Indet.	-	-	?	?	12	9	AD
Acari indet. (dark)	Acari Indet.	-	-	?	?	0	1	-
Acari indet. (small brown)	Acari Indet.	-	-	?	?	0	1	-
Acari indet. (flat orange)	Acari Indet.	-	-	?	?	0	1	-
Insecta								
Blattodea								
Euthyrrhaphidae	*Euthyrrhapha pacifica*	(Coquebert, 1804)	Pacific Cockroach	-	Common	1	0	A
Blattellidae	*Balta longicercata*	(Bolívar, 1924)	Ghost Cockroach	-	Common	1	6	AD
Blattidae	*Periplaneta australasiae*	(Fabricius, 1775)	Australian Cockroach	-	Common	3	2	AD
Coleoptera								
Anobiidae	*Sphaericus gibboides*	(Boieldieu, 1854)	-	-	Scarce	4	4	A
Coccinellidae	*Cheilomenes lunata*	(Fabricius, 1775)	Lunate Ladybird	-	Common	0	1	-
Coccinellidae	*Exochomus flavipes*	(Thunberg, 1781)	Black Mealybug Predator	-	Common	0	7	D
Coccinellidae	*Nephus binaevatus*	(Mulsant, 1850)	-	-	Common	0	2	D
Curculionidae	*Phlyctinus callosus*	Schönherr, 1826	Banded Fruit Weevil	-	Common	0	3	D
Lathridiidae	Lathridiidae indet.	-	-	?	?	1	0	A
Tenebrionidae	*Tarphiophasis leleupi*	Ardoin, 1972	-	**	Scarce	5	7	AD
Collembola								
Entomobryidae	*Entomobrya multifasciata*	(Tullberg, 1871)	-	?	?	0	95	D
Entomobryidae	*Lepidocyrtus* sp. b	-	-	?	?	2	0	AD
Katiannidae	Katiannidae indet.	-	-	?	?	1	0	AD
Poduridae	*Xenyella yucatana*	Mills, 1938	-	-	Scarce	2	0	A
Collembola indet.	Collembola indet. (small grey)	-	-	?	?	1	136	AD
Collembola indet.	Collembola indet. (blind)	-	-	?	?	6	0	A
Diptera								
Asteiidae	*Anarista vittata*	Sabrosky, 1976	-	*	Rare	0	1	-
Chyromyiidae	*Aphaniosoma approximatum*	Becker, 1903	-	-	Scarce	0	1	D
Phoridae	*Megaselia pleuralis*	(Wood, 1909)	-	-	Scarce	1	0	A
Sarcophagidae	*Sarcophaga haemorrhoidalis*	Fallén, 1817	Red-tailed Flesh Fly	-	Common	1	3	AD
Syrphidae	*Eristalinus aeneus*	(Scopoli, 1763)	-	-	Common	0	7	D
Syrphidae	*Syritta stigmatica*	Loew, 1857	-	-	Common	1	1	AD

Insecta (contd.)								
Hemiptera								
Lygaeidae	*Sweetocoris minutus*	(Scudder, 1962)	Minute Ground Bug	-	Scarce	0	1	D
Miridae	Miridae indet. (larva)	-	-	?	?	0	4	-
Tingidae	*Teleonemia scrupulosa*	Stål, 1873	Lantana Lace Bug	-	Common	0	2	-
Hymenoptera								
Apidae	*Apis mellifera*	Linnaeus, 1758	Honey Bee	-	Common	7	2	AD
Braconidae	*Aphaereta minuta*	(Nees, 1811)	-	-	Common	1	0	A
Formicidae	*Cardiocondyla emeryi*	Forel, 1881	Emery's Sneaking Ant	-	Common	82	13	AD
Formicidae	*Paratrechina bourbonica*	(Forel, 1886)	Robust Crazy Ant	-	Common	5	28	AD
Formicidae	*Solenopsis globularia*	(Smith, 1858)	-	-	Common	5	3	AD
Formicidae	*Tapinoma melanocephalum*	(Fabricius, 1793)	Ghost Ant	-	Scarce	0	2	D
Formicidae	*Tetramorium caldarium*	(Roger, 1857)	-	-	Common	3	0	AD
Sphecidae	*Ampulex compressa*	Jurine, 1807	Cockroach Killer	-	Common	0	1	-
Lepidoptera								
Crambidae	*Helenoscoparia nigritalis*	(Walker, 1875)	-	**	Common	2	0	AD
Noctuiidae	*Agrotis ipsilon*	(Hufnagel, 1766)	Dark Sword-grass	-	Common	1	0	AD
Pyralidae	*Homeosoma privata*	(Walker, 1875)	-	*	Rare	1	0	AD
Sphingidae	*Acherontia atropos*	(Linnaeus, 1758)	Death's-head Hawkmoth	-	Scarce	3	0	AD
Tineidae	*Opogona* sp. 1 (seed)	-	-	**	Scarce	24	15	AD
Tineidae	*Opogona* sp. 2 (sock)	-	-	**	Scarce	3	1	AD
Tineidae	*Opogona* sp. 1 (wider seed)	-	-	**	Scarce	0	1	AD
Orthoptera								
Acrididae	*Primnia sanctaehelenae*	(Stål, 1861)	-	**	Common	3	2	AD
Gryllidae	*Gryllus bimaculatus*	De Geer, 1773	African Field Cricket	-	Common	2	0	AD
Phthiraptera								
Phthiraptera indet.	Phthiraptera indet.	-	-	?	?	0	1	-
Psocoptera								
Ectopsocidae	*Ectopsocus strauchi*	Enderlein, 1906	Strauch's Barkfly	-	Common	3	1	A
Liposcelidae	*Liposcelis bostrichophilus*	Badonnel, 1931	-	-	Common	7	1	AD
Trogiidae	*Cerobasis annulata*	(Hagen, 1865)	-	-	Common	4	15	AD
Thysanura								
Lepismatidae	*Ctenolepisma longicaudata*	Escherich, 1905	Gray Silverfish	-	Common	0	2	-
Lepismatidae	*Ctenolepisma sanctaehelenae*	Wygodzinsky, 1970	Violet-marked Silverfish	*	Scarce	12	1	AD