Management Plan for Antarctic Specially Protected Area No. 119

DAVIS VALLEY AND FORLIDAS POND, DUFEK MASSIF

1. Description of Values to be Protected

Forlidas Pond (82°27'28"S, 51°16'48"W) and several ponds along the northern ice margin of the Davis Valley (82°27'30"S, 51°05'W), in the Dufek Massif, Pensacola Mountains, were originally designated as a Specially Protected Area through Recommendation XVI-9 (1991, SPA No. 23) after a proposal by the United States of America. The Area was designated on the grounds that it "contains some of the most southerly freshwater ponds known in Antarctica containing plant life" which "should be protected as examples of unique near-pristine freshwater ecosystems and their catchments". The original Area comprised two sections approximately 500 metres apart with a combined total area of around 6 km^2. It included Forlidas Pond and the meltwater ponds along the ice margin at the northern limit of the Davis Valley. The site has been rarely visited and until recently there has been little information available on the ecosystems within the Area.

This Management Plan reaffirms the original reason for designation of the Area, recognizing the ponds and their associated plant life as pristine examples of a southerly freshwater habitat. However, following a field visit made in December 2003 (Hodgson and Convey, 2004) the values identified for special protection and the boundaries for the Area have been expanded as described below.

The Davis Valley and the adjacent ice-free valleys is one of the most southerly 'dry valley' systems in Antarctica and, as of May 2005, is the most southerly protected area in Antarctica. While occupying an area of only 53 km^2, which is less than 1% of the area of the McMurdo Dry Valleys, the Area nevertheless contains the largest ice-free valley system found south of 80°S in the 90ºW-0º-90ºE half of Antarctica. Moreover, it is the only area known in this part of Antarctica where the geomorphology preserves such a detailed record of past glacial history. Some ice-free areas around the Weddell Sea region have scattered erratics and sometimes moraines, but the assemblage of drift limits, moraines, and abundant quartz-bearing erratics in the Davis Valley and associated valleys is unique and rare. The location of the Dufek Massif close to the junction between the western and the eastern Antarctic ice sheets also makes this site particularly valuable for the collection of data that can be used to constrain parameters such as the past thickness and dynamics of this sector of the Antarctic ice sheet. Such data are potentially extremely valuable for understanding the response of the Antarctic ice sheet to climate change. The Area therefore has exceptional and unique scientific value for the interpretation of past glacial events and climate in this part of Antarctica and it is important that this value is maintained.

The terrestrial ecology of the Area is impoverished but is also highly unusual, with lake and meltwater stream environments and their associated biota being rare this far south in Antarctica. As such, they provide unique opportunities for the scientific study of biological communities near the extreme limit of the occurrence of these environments. Vegetation appears to be limited to cyanobacterial mats and a very sparse occurrence of small crustose lichens. The cyanobacterial mat growth in the terrestrial locations is surprisingly extensive, and represents the best examples of this community type known this far south. The cyanobacterial community appears to survive in at least three distinct environments:

- in the permanent water bodies;
- in exposed terrestrial locations, particularly at the boundaries of sorted polygons; and
- in a series of former or seasonally dry pond beds on ice-free ground in the Davis Valley.

No arthropods or nematodes have thus far been detected in samples taken from within the Area, and the invertebrate fauna in the Area is unusually sparse. This characteristic distinguishes the

Area from more northerly ice-free valley systems such as those at the Ablation Valley – Ganymede Heights (ASPA No. 147), Alexander Island, or at the McMurdo Dry Valleys (ASMA No. 2), where such communities are present. Rotifers and tardigrades have been extracted from samples taken within the Area, with the greatest numbers occurring within the former pond beds in the Davis Valley, although their diversity and abundance is also extremely limited compared with more northerly Antarctic sites (Hodgson and Convey, 2004). Further analyses of the samples obtained and identification of all taxa present are in progress, and are expected to make an important contribution to the understanding of biogeographical relationships between the different regions of Antarctica.

The Area is extremely isolated and difficult to access, and as a result has been visited by only a small number of people. Reports indicate that small field parties visited the Area in December 1957, in the 1965-66 and 1973-74 austral summer seasons, in December 1978 and in December 2003. The total number of people having visited probably numbers less than 50, with visits generally limited to a period of a few weeks or days. No structures or installations have been built within the Area, and as far as is known all equipment brought into the Area has subsequently been removed. While Hodgson and Convey (2004) reported evidence of a very limited number of human footprints and several old soil pit excavations, the Area has been exposed to few opportunities for direct human impact. The Area is believed to be one of the most pristine ice-free valley systems in Antarctica, and is therefore considered to possess outstanding potential as a reference area for microbiological studies, and it is important that these values receive long-term protection.

The site possesses outstanding wilderness and aesthetic values. The dry and weathered brown valleys of the Area are surrounded by extensive ice-fields, the margins of which fringe the valleys with dry based glacial ice of a deep blue hue. This abrupt and dramatic blue-ice margin stands in stark contrast to the stony and barren ice-free landscape of the valleys, and aesthetically is extremely striking in appearance. One of the original explorers of this area in 1957 recalled “the excitement we felt at being the first people to view and enter this magnificently scenic, pristine area.” (Behrendt, 1998: 354). Further examples of descriptions of the Area by visitors are: “[the blue ice] was towering over us ~ 150 feet – a large wave of blue. It was like being in a tidal wave that was held in suspension as we walked under it…” (Reynolds, field notes, 1978), and “I still cannot find adequate superlatives to describe the features, whether large or small, biologic or physical… [Of the] many settings that stretch the imagination…in my experience none match the northern side of the Dufek Massif, with Davis Valley as its crown jewel.” (Reynolds, pers. comm., 2000); “the most unusual [landscape] I have ever seen on any of the seven continents.” (Boyer, pers. comm., 2000); “Probably the single most remarkable environment I've been, either in Antarctica or elsewhere” (Convey, pers. comm., 2004). Burt (2004) described the region simply as “inspiringly awesome”.

The boundaries of the Area have been revised to include the entire ice-free region centered on the Davis Valley, including the adjacent valleys and Forlidas Pond. In general, the margins of the surrounding ice sheets form the new boundary of the Area, resulting in special protection of the region as an integrated ice-free unit that more closely approximates the valley catchments. The full catchments of the surrounding glaciers that flow into these valleys extend considerable distances from the ice-free area and do not possess many of the values related to the purpose of special protection, and are therefore excluded from the Area.

2. Aims and Objectives

Management at Forlidas Pond and Davis Valley ponds aims to:

- avoid degradation of, or substantial risk to, the values of the Area by preventing unnecessary human disturbance and sampling in the Area;
- preserve the ecosystem as an area largely undisturbed by human activities;
- preserve the almost pristine ecosystem for its potential as a biological reference area;

- allow scientific research on the natural ecosystem and physical environment within the Area provided it is for compelling reasons which cannot be served elsewhere;
- minimize the possibility of introduction of alien plants, animals and microbes to the Area; and
- allow visits for management purposes in support of the aims of the Management Plan.

3. Management Activities

The following management activities shall be undertaken to protect the values of the Area:

- Markers, signs or other structures erected within the Area for scientific or management purposes shall be secured and maintained in good condition and removed when no longer necessary.
- Visits shall be made as necessary to assess whether the Area continues to serve the purposes for which it was designated and to ensure management and maintenance measures are adequate.

4. Period of Designation

Designated for an indefinite period of time.

5. Maps

- Map 1: Davis Valley and Forlidas Pond, ASPA No. 119, Dufek Massif, Pensacola Mountains: Location Map.

  Map Specifications: Projection: Lambert Conformal Conic; Standard parallels: 1st 82°S; 2nd 83°S; Central Meridian: 51°W; Latitude of Origin: 81°S; Spheroid: WGS84.

  Inset: the location of the Pensacola Mountains and Map 1 in Antarctica.
- Map 2: Davis Valley and Forlidas Pond, ASPA No. 119: Topographic map and protected area boundary.

  Map Specifications: Projection: Lambert Conformal Conic; Standard parallels: 1st 82°S; 2nd 83°S; Central Meridian: 51°W; Latitude of Origin: 81°S; Spheroid: WGS84; Vertical datum: WGS84. EGM96 MSL height differential –21 m. Contour interval 25 m. Topographic data generated by digital orthophoto and photogrammetric techniques from USGS aerial photography (TMA400, TMA908, TMA909 (1958) and TMA1498 (1964)) by the Mapping and Geographic Information Centre, British Antarctic Survey (Cziferszky *et al*. 2004). Accuracy estimates: horizontal: ±1 m; vertical: ±2 m, declining towards the south away from available ground control points. Area beyond orthophoto coverage northwest of Forlidas Pond is mapped from a georectified Terra ASTER satellite image acquired 9 November 2002. Elevation data are unavailable in this region and it is therefore of reduced spatial accuracy.

6. Description of the Area

6(i) Geographical coordinates, boundary markers and natural features

General description

Davis Valley (82°28'30"S, 51°05'W) and Forlidas Pond (82°27'28"S, 51°16'48"W) are situated in the north-eastern Dufek Massif, Pensacola Mountains, part of the Transantarctic Mountain range. The Dufek Massif is situated approximately mid-way between the Support Force Glacier and the Foundation Ice Stream, two of the major glaciers draining northwards from the Polar Plateau into the Ronne and Filchner Ice Shelves. Approximately 60 km to the southeast is the Forrestal Range (also part of the Pensacola Mountains), which is separated from the Dufek Massif by the Sallee Snowfield. The Ford Ice Piedmont separates the Dufek Massif from the Ronne and Filchner Ice Shelves, about 50 km to the northwest and 70 km to the northeast respectively.

The Davis Valley is approximately five kilometers wide and seven kilometers long, with its northern extent defined by the blue ice lobes that form part of the southern margin of the Ford Ice Piedmont. It is bounded in the east by Wujek Ridge and Mount Pavlovskogo (1074 m), flanked on the outer side by a glacier draining north from the Sallee Snowfield to the Ford Ice Piedmont. The western extent of the valley is defined by Clemons Spur, Angels Peak (964 m) and Forlidas Ridge. The Edge Glacier extends approximately 4 km into the Davis Valley from the Sallee Snowfield. The southern Davis Valley is dominated by Mount Beljakova (1240 m), on the northwestern margin of the Sallee Snowfield. Several smaller valleys exist in the west of the Area, adjacent to the prominent Preslik Spur and Forlidas Ridge. Almost 75% of the region enclosed by the large surrounding ice fields is ice-free, comprising 39 km^2 of ice-free ground in total, with the remainder of the area covered by the Edge Glacier, other permanent bodies of snow / ice and several small ponds.

Forlidas Pond occupies a small unnamed dry valley separated from the Davis Valley by a tributary ridge extending north from Forlidas Ridge. Other ponds within the Area occur at various locations along the blue ice margin of the Ford Ice Piedmont, at the snout of the Edge Glacier, and at the foot of an ice lobe in the west below Angels Peak.

Boundary

The Area comprises all of the Davis Valley and the immediately adjacent ice-free valleys, including several of the valley glaciers within these catchments. The boundary predominantly follows the margins of the surrounding ice fields of the Ford Ice Piedmont and Sallee Snowfield, which enclose the ice-free area that is considered to be of outstanding value. The northern boundary extends parallel to and 500 metres north from the southern margin of the Ford Ice Piedmont in the Davis Valley and in the adjacent valley containing Forlidas Pond. This is in order to provide an additional buffer of protection around the freshwater bodies of value along this glacier margin. The eastern boundary follows the ice margin east of Wujek Ridge from the Ford Ice Piedmont to Mount Pavlovskogo. The southeastern boundary extends from Mount Pavlovskogo across the Sallee Snowfield and the upper slopes of the Edge Glacier, following areas of outcrop where they exist, and again across the Sallee Snowfield to Mount Beljakova. The southern and western boundaries of the Area follow the margins of the permanent ice. The boundary encompasses a total area of 57.2 km^2.

Boundary markers have not been installed in the Area because of its remoteness, the limited opportunities for visits and the practical difficulties of maintenance. Moreover, the margins of the permanent ice fields are generally sharply defined and form a visually obvious boundary around most of the Area.

Meteorology

Several estimates of mean annual surface air temperature have been made in the Dufek Massif region from measurements taken in ice bores or crevasses at around 10 metres depth. A measurement of –24.96°C was obtained 32 km due north of Forlidas Pond on the Ford Ice Piedmont in December 1957 (Pit 12, Map 1) (Aughenbaugh *et al*., 1958). Another estimate of -9°C was made in December 1978 in the Enchanted Valley (Map 1), measured in a crevasse at 8 metres depth (Boyer, pers. comm., 2000).

Detailed meteorological data for the Area itself are limited to records collected over two weeks in 2003. Hodgson and Convey (2004) measured temperature and relative humidity over snow and rock surfaces at their sampling sites within the Area from 3-15 December 2003, with data recorded at 30-minute intervals. Temperatures over snow ranged from a maximum of +12.8ºC to a minimum of –14.5ºC, with an average over the period of –0.56ºC. Temperatures over rock ranged from a maximum of +16.0ºC to a minimum of –8.6ºC, with an average over the period of +0.93ºC (data over rock were only recorded from 3-11 December 2003). Relative humidity recorded over snow ranged from a maximum of 80.4% to a minimum of 10.8%, with an average over the period of 42.6%. Over rock surfaces (from 3-11 December 2003), relative humidity ranged from a maximum of 80.9% to a minimum of 5.6%, with an average over the period of 38.7%.

Data on windspeeds and directions within the Area are not available. While the ice-free area possesses many features related to wind erosion, there is some evidence to suggest that windspeeds in the locality are currently not especially high. For example, ice and snow surfaces were observed as largely free of wind-blown debris, and terrestrial cyanobacterial mats exist intact in exposed locations in the dry valleys (Hodgson and Convey, 2004). No precipitation data are available, although the bare ice and rock surfaces and low average relative humidity recorded by Hodgson and Convey (2004) attest to a dry environment of low precipitation.

Geology, geomorphology and Soils

The Dufek Massif is characterized by layered bands of cumulate rock belonging to the Dufek intrusion, thought to be one of the largest layered gabbro intrusions in the world (Behrendt *et al*., 1974; 1980; Ferris *et al.*, 1998). This is exposed in the Davis Valley as the light- to medium-gray, medium-grained Aughenbaugh gabbro, which is the lowest exposed part of the Middle Jurassic Dufek intrusion (Ford *et al.*, 1978).

The Davis Valley primarily consists of minimally weathered talus and glacial till of both local and exotic origin. In particular there appears to be an abundance of erratics of Dover Sandstone, one of several metasedimentary layers disrupted by the Dufek intrusion. An extensive glacial geomorphological record is evident, showing at least three major glacial and two major interglacial events (Boyer, 1979). Features include overlapping valley-glacier moraines, ice sheet moraines, lake shorelines, lateral glacial channels, ice eroded surfaces, well-developed patterned ground and erratics. The complex glacial, glaciofluvial and lacustrine history provides evidence for very old sub-polar or temperate-type valley glaciation, a former ice sheet level as much as 400 metres higher than today, and the multiple advance and retreat of local alpine ice since the last major ice advance (Boyer, 1979; Hodgson and Convey, 2004). Measurements made of the geomorphology and samples taken by Hodgson and Convey (2004) will be used to establish a glacial chronology for the region and to constrain past ice sheet thickness. This research aims to establish how the chronology in this region correlates with that for other parts of Antarctica, and in particular whether it matches that for the McMurdo Dry Valleys (million-year time-scales) or whether the record is entirely Late Quaternary (millennial time-scales). As such, the site is considered to be extremely important for climate and ice-sheet history research, since it is the only site known where such an extensive and well-developed suite of geomorphological features is present in this part of Antarctica and this far south.

Soils are not well-developed in the Area and generally lack a significant organic component. Parker *et al*. (1982) collected a soil that was light brown in color, resulting from gravel weathering predominantly to muscovite. The soil comprised sand (81%) with silt (14%) and clay (5%), a composition different from other sites in the Pensacola Mountains where the clay proportions of six samples ranges from 0.4% to 1.6%. The soil sample from the Davis Valley had a pH of 6.4 (Parker, *et al*., 1982).

Lakes, ponds and streams

Forlidas Pond is a perennially frozen, shallow, round lake that was estimated to be approximately 100 metres in diameter in 1957 (Behrendt, 1998). In December 2003 the lake was measured by Hodgson and Convey (2004) as 90.3 metres in diameter from shoreline to shoreline on a transect azimuth of 306º (magnetic). At this time it was frozen almost completely to its base, with a thin layer of hypersaline slush at the lake bottom, and a freshwater meltwater moat that was partly ice free and partly covered by 10-15 cm of ice (Hodgson and Convey, 2004). Depth was measured as between 1.63 to 1.83 metres, and average conductivity and temperature was 142.02 mS cm-1 and -7.67ºC respectively. The salinity of the bottom-water in Forlidas Pond is thus around four times greater than seawater. Hodgson and Convey (2004) data report a remnant pro-glacial lake near the margin of the Ford Ice Piedmont, 900 metres from Forlidas Pond. Their data also show evidence of a series of former shorelines up to 144 metres from and 17 metres higher than the present level of Forlidas Pond. Boyer (pers. comm., 2000) reported that a second pond was visible in this valley in 1978 from the vantage of Forlidas

Ridge, which probably refers to an ephemeral meltwater pond that occurs where the valley meets the Ford Ice Piedmont.

A series of small meltwater ponds occurs along the blue-ice margin of the northern Davis Valley. Two were observed at 82º 27.4'S, 50º 58'W and 82º 27.5'S, 51º 02'W in 1978, although their exact size, depth and other physical characteristics are unknown (Boyer, pers. comm. 2000). Two further ponds were described and mapped in this vicinity in December 2003, located at 82º 27.5' S, 51º 05.5'W and, 82º 27.55' S, 51º 07' W (Map 2) (Hodgson and Convey, 2004). A pro-glacial pond was also observed in 1978 at the margin of the ice sheet in the west of the Area below Angels Peak (Map 1: 82º29.6'S, 51º14'W), although its physical characteristics are unknown (Boyer, pers. comm., 2000). The pro-glacial lake at the snout of the Edge Glacier is the largest within the Area, but it differs from the others in that, apart from at the margins where moats form seasonally, it is permanently frozen to the bottom. Cyanobacterial mat development in this lake is therefore limited to the perimeter and adjacent shoreline.

Little information exists on streams within the Area. Dry stream channels and water erosion features are evident within the ice-free area, although only small glacial melt streams on the Edge Glacier have thus far been reported as flowing in December (Hodgson and Convey, 2004). The apparent lack of melt streams may be because all visits to date have been made in the month of December, possibly before streams become more active. The presence of sizeable lake moats, the temperatures recorded by Hodgson and Convey (2004), as well as the biological and the geomorphological evidence, suggest that it is probable that at least some streams become active later in the season from melting snow, although perhaps not on an annual basis.

Biology

Visible biota is extremely limited within the Area, and vegetation appears to be restricted to cyanobacterial mats, found both in lakes and in patches on the surface of ice-free ground, and a very sparse occurrence of small crustose lichens. Previous anecdotal reports of the possible occurrence of mosses within the Area could not be substantiated by Hodgson and Convey (2004), and it is probable that the rich cyanobacterial mat growth was earlier mistaken for bryophytes by non-specialists. Neuburg *et al.* (1959) observed yellow and black lichens growing sparsely in sheltered places in the Davis Valley, while Hodgson and Convey (2004) observed several lichen forms growing deep within the crevices of boulders, although species observed have not yet been identified.

The cyanobacterial community appears to survive in at least three distinct environments:

a. in the permanent water bodies, particularly at the bottom and moat of Forlidas Pond and at the bottom and edges of the shallow ponds near the northern ice margin in the Davis Valley, which are extensively covered by a red-brown cyanobacterial mat. Cyanobacterial mat growth is also evident in the moat and seasonally wetted perimeter of the proglacial lake at the snout of the Edge Glacier;

b. in exposed terrestrial locations, particularly at the edge of larger rocks forming the boundary of sorted polygons, where a foliose mid-brown form has developed to depths of at least 10-15 cm;

c. in a series of former dry pond beds in the Davis Valley, which have extensive areas of almost continuous cyanobacterial mat on the former pool floors (two of up to c. 50 metres in diameter). These depressions tend to accumulate winter snow which later ablates, providing a protected and moist environment where the cyanobacterial community can grow in relatively greater abundance than elsewhere.

Of the cyanobacterial community growing in permanent water bodies, Neuburg *et al.* (1959) identified cyanobacteria growing on the bottom of Forlidas Pond as *Phormidium incrustatum* and *P. retzii*. Hodgson and Convey (2004) characterized the mat at Forlidas Pond as red-brown in color, and noted that sheets of mat regularly become detached from the bottom and gradually move up through the ice, both here and at other ponds. Sometimes meltwater forms around the fragments within the ice as they move upwards, also carrying faunal (tardigrade, rotifer)

communities with them. The aquatic cyanobacterial mats in the permanent ponds were actively photosynthesising, as evidenced by gas bubbles trapped against the lower ice surfaces. On reaching the surface, mat material is blown into moats or onto the local shoreline, or further afield. Cyanobacterial mats have formed and survive on the shoreline above the lake ice level, and may become flooded as lake water levels vary over the season and meltwater seeps into the ponds. Fossil examples of this type of mat were also found buried under boulders and flat stones between the present and previous (higher) shorelines of several of the ponds (Hodgson and Convey, 2004).

The second form of cyanobacterial community was particularly well-developed at a proglacial lake bed and in the mid-valley floor in the valley containing Forlidas Pond, and in Davis Valley near a large snow gully (path of the ephemeral meltwater stream) descending into the lake at the snout of the Edge Glacier (Hodgson and Convey, 2004). Nearly all of these mats observed were dry, although those near to melting snow were damp and lower thalli were often deep green in color. Sporadic snow melt was considered the most likely main source of water for these mats, at least in Forlidas Valley.

The third growth form of cyanobacterial mat occurs in the Davis Valley in a series of at least four former or dry pond beds between the Ford Ice Piedmont margin and the most recent retreat moraine crossing the valley, and a further pond bed is present on top of a large moraine on the eastern side of the valley. Extensive areas of dried cyanobacterial mat occur on the former pool beds, with two being almost continuous and of up to c. 50 metres in diameter. The growth form also occurs in many of the adjacent small gullies between polygons or other cryoturbation features, which often have the appearance of temporary drainage features. Extractions from samples taken from within these areas were found to yield the greatest numbers of rotifers and tardigrades of any taken within the Area, showing these areas to be biologically productive, which necessitates a source of liquid water. In December 2003 very little snow was evident on the valley floor, prompting Hodgson and Convey (2004) to reason that the source of moisture may be from a considerable increase in melt later in the season flowing off the local ice sheet in the upper valley, or from local ice-cored moraines. Although this process was not occurring during their visit, footprints and shallow soil survey pits remaining from one of the previous parties (i.e. 25-46 years old) indicated that some ground was moist or waterlogged at the time of the earlier visit. Seasonal inundation by liquid water would explain the extensiveness and integrity of this cyanobacterial community, and its apparent resilience to the potential ravages of polar winds, as well as the relative abundance of invertebrates extracted from samples taken from within these areas.

The invertebrate fauna within the Area is impoverished, with both the diversity and abundance of organisms being extremely limited compared to more northerly Antarctic sites (Hodgson and Convey, 2004). The invertebrate communities consist of rotifers and tardigrades, with a complete absence of nematodes or arthropods from samples taken, even from the most biologically productive sites within the Area. Extractions generated predominantly rotifers, with more limited number of tardigrades, and numbers for both were very low in comparison with similar extractions from other Antarctic locations. Surprisingly, the most productive sites for these organisms were not the aquatic environments of the permanent lakes, but the former pond beds in the Davis Valley as noted above. Research on the microbial biology of the Area is continuing, with samples collected being examined by a team of microbiologists, protozoologists and molecular biologists at the British Antarctic Survey (Hodgson and Convey, 2004). These studies are expected to provide an integrated overview of the microbial ecology of this site near the extreme limit of terrestrial habitats in the world.

Viable yeast species have been recorded in the soil, along with the algae *Oscillatoria* sp., *Trebouxia* sp. and *Heterococcus* sp. (Parker *et al.*, 1982). Chasmoendolithic microorganisms have been recorded in rocks in the Dufek Massif (Friedmann, 1977), although Hodgson and Convey (2004) found no evidence of their presence within the Area and noted that rock-types most favorable for the occurrence of endolithic organisms are not widespread.

Human activities and impact

There have been few visits to the Area and human impacts are believed to be minimal (Table 1). Because of its remoteness and the infrequency of visits, it is one of the few ice-free areas of Antarctica where the compiled record of past human activity at the site is almost complete. The almost pristine condition of the environment contributes to the extremely high value of the Area and is an important reason for its special protection.

The key characteristics of visits recorded to the Area are summarized in Table 1, which should be updated as required (see Section 7(x)). Past camps have generally been on the ice sheet outside of the Area. Previous parties removed all wastes from the Area, with the possible exception of small quantities of human wastes. In 2003 all wastes including all human wastes were removed, both from within the Area and from the party's adjacent campsite on the Ford Ice Piedmont (Map 2). Hodgson and Convey (2004) noted that in December 2003 the evidence of previous visits was limited to a number of footprints and several shallow soil excavations in the Davis Valley.

Table 1. Known visits to the Davis Valley and adjacent ice-free valleys within the Area.

Party	**No. pers**	**Org**	**Purpose**	**Dates**	**Duration (days)**	**Locations visited**	**Camp**	**Transport**
Aughenbaugh Behrendt Neuburg Thiel Walker	5	IGY (US)	Geology Geophysics	Dec 1957	?	FIP,DV,FP, FR	FIP west of FR	Sno-Cat traverse to FIP, thence on foot
Ford ?	?	USGS	Geology	Dec 1965 – Jan 1966	?	?	?	Numerous helicopter landings in Dufek Massif
Ford ?	?	USGS	Geology	Summer 1973-74	?	?	?	?
Ford ?	?	USGS	Geology	Summer 1976-77	?	?	?	?
Russian ?	?	?	Geology?	Summer 1976-77	?	?	?	?
Boyer Reynolds	2	USGS	Geology	12 Dec 1978	2	FIP, DV	EV	Toboggan from EV to ice margin, thence on foot

Ford Boyer Reynolds Carl?	4	USGS	Geology	14 Dec 1978	4	FIP, DV, FR, AP	EV	Toboggan from EV to ice margin, thence on foot
Hodgson Convey Burt	3	BAS (UK)	Biology Liminology Glacial geo-morphology	3-15 Dec 2003	13	FIP, DV, FP, FR, AP	FIP 1.9km north of FP	Twin Otter to FIP, thence on foot.
TOTALS	**?**				**?**			

Key:

FIP – Ford Ice Piedmont	DV – Davis Valley	FP – Forlidas Pond	FR– Forlidas Ridge	AP – Angels Peak
CS – Clemons Spur	PS – Preslik Spur	MB– Mt Beljakova	MP–Mt Pavlovskogo	EV–Enchanted Valley

6(ii) Restricted and managed zones within the Area

None.

6(iii) Structures within and near the Area

No structures, installations or caches are known to exist within the Area.

6(iv) Location of other protected areas within close proximity of the Area

There are no other protected areas nearby, with the nearest being Ablation Valley – Ganymede Heights (ASPA No. 147), Alexander Island, which is approximately 1300 km to the north-west.

7. Permit conditions

Entry into the Area is prohibited except in accordance with a Permit issued by an appropriate national authority. Conditions for issuing a Permit to enter the Area are that:

- it is issued only for compelling scientific reasons that cannot be served elsewhere, or for essential management purposes consistent with plan objectives such as inspection or review;
- the actions permitted will not jeopardize the physical, ecological, scientific or aesthetic and wilderness values of the Area, nor the pristine value of the Area and its potential as a largely undisturbed biological reference site;
- any management activities are in support of the objectives of the Management Plan;
- the actions permitted are in accordance with the Management Plan;
- the Permit, or a copy, shall be carried within the Area;
- a visit report shall be supplied to the authority, or authorities, named in the Permit;

- permits shall be issued for a stated period.

7(i) Access to and movement within the Area

- Landing of aircraft is prohibited within the Area and overflight below 100 metres above ground level is prohibited.
- Vehicles are prohibited within the Area.
- Access into and movement within the Area shall be on foot.
- No special restrictions apply to the means of access, or air or land routes used, to move to and from the icefields surrounding the boundaries of the Area.
- Access into the Area should be at a practicable point close to sites of study to minimize the amount of the Area that needs to be traversed. The terrain and crevassing generally makes such access most practical from the Ford Ice Piedmont in the north.
- Pedestrian routes should avoid lakes, ponds, former pond beds, stream beds, areas of damp ground and areas of soft sediments or sedimentary features. Care should be exercised to avoid damage to any areas of cyanobacterial mat growth, in particular to the extensive areas found in former pond beds in Davis Valley.
- Pedestrian traffic should be kept to the minimum necessary consistent with the objectives of any permitted activities and every reasonable effort should be made to minimize effects.

7(ii) Activities that are or may be conducted in the Area, including restrictions on time or place

- Research that will not jeopardize the scientific or ecosystem values of the Area, or its pristine value and potential as a reference site, and which cannot be served elsewhere;
- Essential management activities, including monitoring;
- The appropriate authority should be notified of any activities/measures undertaken that were not included in the authorized Permit.

7(iii) Installation, modification or removal of structures

- Structures shall not be erected within the Area except as specified in a Permit.
- Permanent structures are prohibited.
- All scientific equipment installed in the Area must be approved by Permit.
- Should equipment be intended to remain within the Area for a duration of more than one season it shall clearly be identified by country, name of the principal investigator and year of installation. All such items should be made of materials that pose minimal risk of contamination of the Area.
- Removal of structures, equipment or markers for which the period specified in the Permit has expired shall be a condition of the Permit.

7(iv) Location of field camps

- Camping within the Area is prohibited.
- Suitable camp sites have been proven to the north and west of the Area on the Ford Ice Piedmont (Map 2), and also in the Enchanted Valley (Map 1).

7(v) Restrictions on materials and organisms which can be brought into the Area

- No living animals, plant material or microorganisms shall be deliberately introduced into the Area and the precautions listed in 7(ix) below shall be taken against accidental introductions.
- No herbicides or pesticides shall be brought into the Area.
- Any other chemicals, including radio-nuclides or stable isotopes, which may be introduced for scientific or management purposes specified in the Permit, shall be removed from the Area at or before the conclusion of the activity for which the Permit was granted.

- Fuel is not to be stored in the Area, unless specifically authorized by Permit for scientific or management purposes.
- Anything introduced shall be for a stated period only, shall be removed at or before the conclusion of that stated period, and shall be stored and handled so that risk of their introduction into the environment is minimized.
- If release occurs which is likely to compromise the values of the Area, removal is encouraged only where the impact of removal is not likely to be greater than that of leaving the material *in situ*.
- The appropriate authority should be notified of any materials released and not removed that were not included in the authorized Permit.

7(vi) Taking or harmful interference with native flora or fauna

- Taking or harmful interference with native flora or fauna is prohibited, except in accordance with a separate permit issued under Article 3 of Annex II to the Madrid Protocol by the appropriate national authority specifically for that purpose. Where animal taking or harmful interference is involved this should, as a minimum standard, be in accordance with the SCAR Code of Conduct for the Use of Animals for Scientific Purposes in Antarctica.

7(vii) Collection or removal of anything not brought into the Area by the Permit Holder

- Material may be collected or removed from the Area only in accordance with a Permit and should be limited to the minimum necessary to meet scientific or management needs. Permits shall not be granted if there is a reasonable concern that the sampling proposed would take, remove or damage such quantities of soil, native flora or fauna that their distribution or abundance within the Area would be significantly affected.
- Material of human origin likely to compromise the values of the Area, which was not brought into the Area by the Permit Holder or otherwise authorized, may be removed unless the impact of removal is likely to be greater than leaving the material *in situ*: if this is the case the appropriate authority should be notified.

7(viii) Disposal of waste

- All wastes, including water used for any human purpose and including all human wastes, shall be removed from the Area. Individuals or groups shall carry appropriate containers for human waste and gray water so that they may be safely transported and removed from the Area.

7(ix) Measures that are necessary to ensure that the aims and objectives of the Management Plan can continue to be met

- Permits may be granted to enter the Area to carry out biological monitoring and site inspection activities, which may involve the collection of limited samples for analysis or review, or for protective measures.
- Any specific sites of long-term monitoring shall be appropriately marked.
- To help maintain the ecological and scientific values derived from the relatively low level of human impact at Davis Valley and Forlidas Pond, visitors shall take special precautions against introductions. Of concern are microbial, invertebrate or plant introductions sourced from other Antarctic sites, including stations, or from regions outside Antarctica. To minimize the risk of introductions, visitors shall thoroughly clean footwear and any equipment to be used in the area – particularly sampling equipment and markers – before entering the Area.
- To reduce the risk of microbial contamination, the exposed surfaces of footwear, sampling equipment and markers should be sterilized before use within the Area. Sterilization should be by an acceptable method, such as by washing in 70% ethanol solution in water or in a commercially available solution such as ‘Virkon’.

- A comprehensive Code of Conduct and *Guidelines for Conduct of Scientific Research* have been developed for use within the McMurdo Dry Valleys (ASMA No. 2), much of which is relevant as guidance for activities within the dry valley system in this region. Visitors shall consult these guidelines and should apply them where appropriate to the conduct of scientific research and other activities within the Area.

7(x) Requirements for reports

- Parties should ensure that the principal holder for each Permit issued submits to the appropriate authority a report describing the activities undertaken. Such reports should include, as appropriate, the information identified in the Visit Report form suggested by SCAR.
- Parties should maintain a record of such activities and, in the Annual Exchange of Information, should provide summary descriptions of activities conducted by persons subject to their jurisdiction, which should be in sufficient detail to allow evaluation of the effectiveness of the Management Plan.
- Parties should, wherever possible, deposit originals or copies of such original reports in a publicly accessible archive to maintain a record of usage, to be used both in any review of the Management Plan and in organizing the scientific use of the Area.

8. Supporting Documentation

Aughenbaugh, N., Neuburg, H. and Walker P. (1958): Report 825-1-Part I, October 1958, USNC-IGY Antarctic Glaciological Data Field Work 1957 and 1958. *Ohio State University Research Foundation. Source: World Data Center for Glaciology at Boulder, Colorado.*

(ftp://sidads.colorado.edu/pub/DATASETS/AGDC/antarctic_10m_temps/ells-filchner_57.txt).

Behrendt, J.C., Henderson, J.R., Meister, L. and Rambo, W.K. (1974): Geophysical investigations of the Pensacola Mountains and Adjacent Glacierized areas of Antarctica. *U.S. Geological Survey Professional Paper 844.*

Behrendt, J.C., Drewry, D.J., Jankowski, E., and Grim, M.S. (1980): Aeromagnetic and radio echo ice-sounding measurements show much greater area of the Dufek intrusion, Antarctica. *Science 209: 1014-1017.*

Behrendt, J.C. (1998): Innocents on the Ice; a memoir of Antarctic Exploration, 1957. *University Press of Colorado, Boulder.*

Boyer, S.J. (1979): Glacial geologic observations in the Dufek Massif and Forrestal Range, 1978-79. *Antarctic Journal of the United States 14 (5): 46-48.*

Burt, R. (2004). Travel Report - Sledge Bravo 2003-2004. SAGES-10K & BIRESA: Field trip to the lakes and dry valleys in the Dufek Massif and the Shackleton Mountains. *Unpublished BAS Internal Report Ref. R/2003/K1. British Antarctic Survey, Cambridge.*

Cziferszky, A., Fox, A., Hodgson, D. and Convey, P. (2004): Unpublished topographic base map for Davis Valley, Dufek Massif, Pensacola Mountains. *Mapping and Geographic Information Centre, British Antarctic Survey, Cambridge.*

Ferris, J., Johnson, A. and Storey, B. (1998): Form and extent of the Dufek intrusion, Antarctica, from newly compiled aeromagnetic data. *Earth and Planetary Science Letters 154: 185-202.*

Ford, A.B. (1976): Stratigraphy of the layered gabbroic Dufek intrusion, Antarctica. *Contributions to stratigraphy: Geological Survey Bulletin 1405-D.*

Ford, A.B., Schmidt, D.L. and Boyd, W.W. (1978): Geologic map of the Davis Valley quadrangle and part of the Cordiner Peaks quadrangle, Pensacola Mountains, Antarctica. *U.S Geologic Survey Antarctic Geological Map A-10.*

Ford, A.B. (1990): The Dufek intrusion of Antarctica. Antarctic Research Series 51. *American Geophysical Union, Washington, DC.: 15-32.*

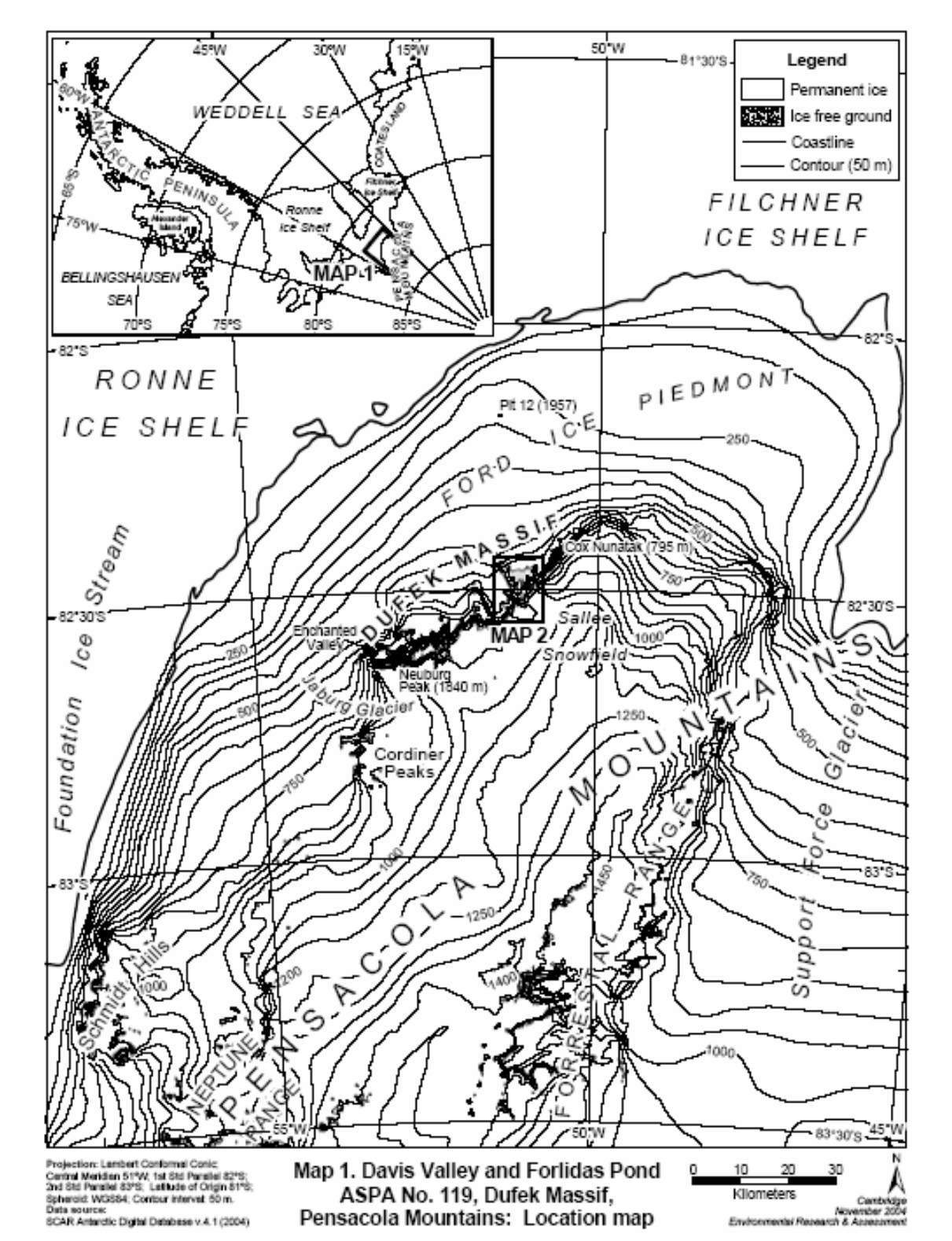
Friedmann, E.I. (1977): Microorganisms in Antarctic desert rocks from dry valleys and Dufek Massif. *Antarctic Journal of the United States 12 (5): 26-29.*

Hodgson, D. and Convey, P. 2004. Scientific Report - Sledge Bravo (2003-2004): BAS Signals in Antarctica of Past Global Changes: Dufek Massif – Pensacola Mountains; Mount Gass – Shackleton Mountains. DRAFT. *Unpublished BAS Internal Report Ref. R/2003/NT1. British Antarctic Survey, Cambridge.*

Neuburg, H., Theil, E., Walker, P.T., Behrendt, J.C and Aughenbaugh, N.B. (1959): The Filchner Ice Shelf. *Annals of the Association of American Geographers 49: 110-119.*

Parker, B.C., Boyer, S., Allnutt, F.C.T., Seaburg, K.G., Wharton, R.A. and Simmons, G.M. (1982): Soils from the Pensacola Mountains, Antarctica: physical, chemical and biological characteristics. *Soil Biology and Biochemistry 14: 265-271.*

Parker, B.C., Ford, A.B., Allnutt, T., Bishop, B. and Wendt, S. (1977): Baseline microbiological data for soils of the Dufek Massif. *Antarctic Journal of the United States 12 (5): 24-26.*


Legend
Permanent ice
Ice free ground
Coastline
Contour (50 m)
WEDDELL SEA
ANTARCTIC PENINSULA
BELLINGSHAUSEN SEA
Ronne Ice Shelf
MAP 1
FILCHNER ICE SHELF
RONNE ICE SHELF
PIEDMONT ICE
FORD
DUFEK MASSIF
Pit 12 (1957)
Cox Nunatak (795 m)
MAP 2
Sallee Snowfield
Enchanted Valley
Neuburg Peak (1640 m)
Jaeburg Glacier
Cordiner Peaks
Foundation Ice Stream
Support Force Glacier
PENSACOLA MOUNTAINS
FORRESTAL RANGE
NEPTUNE RANGE
Schmidt Hills
Projection: Lambert Conformal Conic
Central Meridian 51°W, 1st Std Parallel 82°S;
2nd Std Parallel 83°S; Latitude of Origin 81°S;
Spheroid: WGS84; Contour interval: 50 m.
Data source:
SCAR Antarctic Digital Database v.4.1 (2004)
Map 1. Davis Valley and Forlidas Pond
ASPA No. 119, Dufek Massif,
Pensacola Mountains: Location map
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Kilometers
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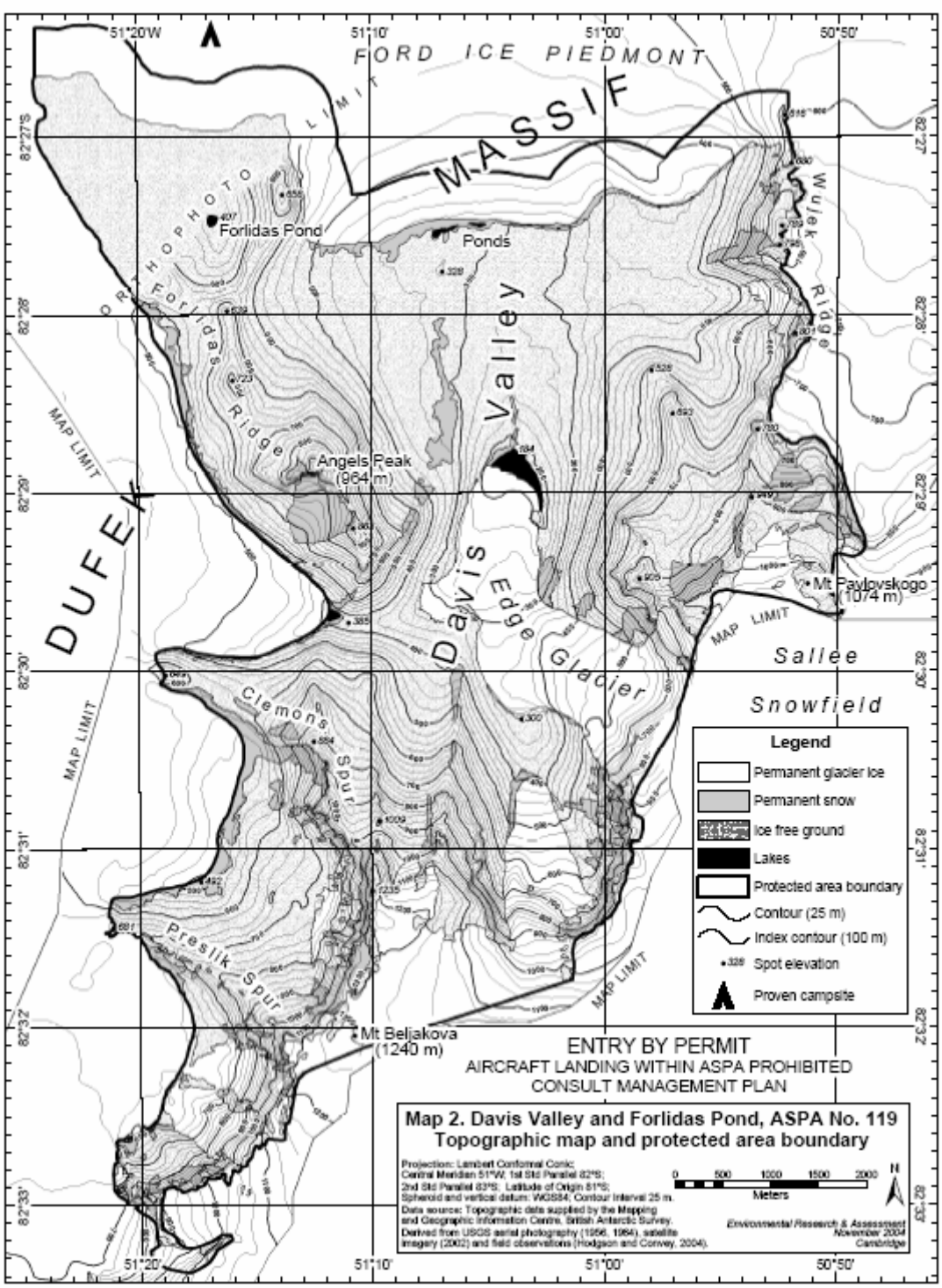
Cambridge
November 2004
Environmental Research & Assessment


51°20'W
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FORD ICE PIEDMONT
MASSIF
LIMIT
ORTHOPHOTO
Forlidas Pond
Ponds
Wilek Ridge
Forlidas Ridge
Davis Valley
Angels Peak (964 m)
DUFEK
MAP LIMIT
Edge Glacier
Mt Pavlovskogo (1074 m)
Sallee Snowfield
Clemons Spur
Preslik Spur
Mt Beljakova (1240 m)
82°27'S
82°28'
82°29'
82°30'
82°31'
82°32'
82°33'
Legend
Permanent glacier ice
Permanent snow
Ice free ground
Lakes
Protected area boundary
Contour (25 m)
Index contour (100 m)
Spot elevation
Proven campsite
ENTRY BY PERMIT
AIRCRAFT LANDING WITHIN ASPA PROHIBITED
CONSULT MANAGEMENT PLAN
Map 2. Davis Valley and Forlidas Pond, ASPA No. 119
Topographic map and protected area boundary
Projection: Lambert Conformal Conic;
Central Meridian 51°W, 1st Std Parallel 82°S;
2nd Std Parallel 83°S; Latitude of Origin 51°S;
Spheroid and vertical datum: WGS84; Contour Interval 25 m.
Data source: Topographic data supplied by the Mapping and Geographic Information Centre, British Antarctic Survey.
Derived from USGS aerial photography (1956, 1964), satellite imagery (2002) and field observations (Hodgson and Convey, 2004).
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N
Environmental Research & Assessment
November 2004
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