THE OVERSEAS DEVELOPMENT ADMINISTRATION

FALKLAND ISLANDS AIRPORT

FEASIBILITY STUDY

REPORT

1972

R/1171 (K.E.A.)

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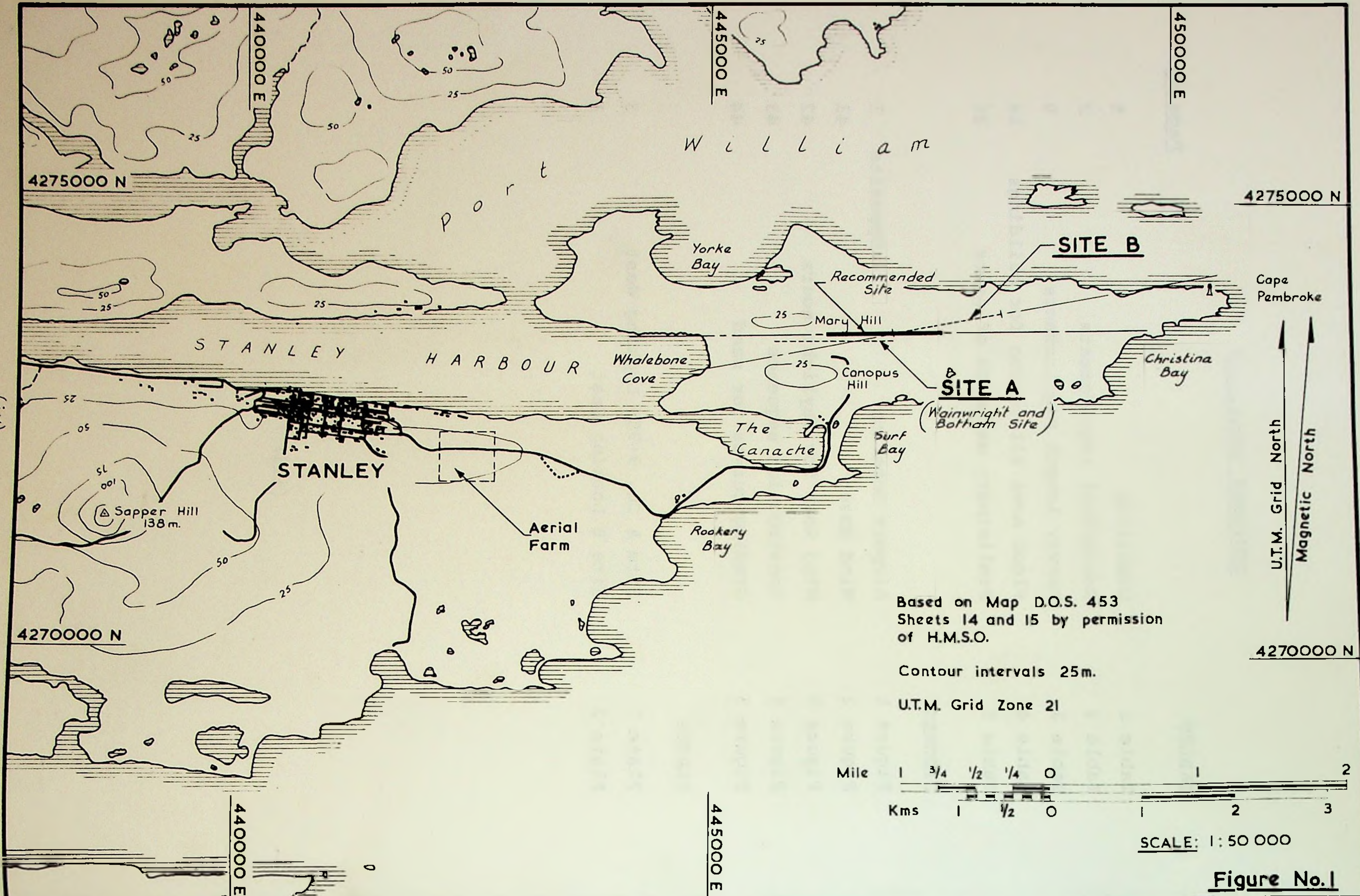

440000 E
445000 E
450000 E
4275000 N
4270000 N
Port William
STANLEY HARBOUR
STANLEY
Sapper Hill
138 m.
Aerial
Farm
Whalebone
Cove
Yorke
Bay
Recommended
Site
Mary Hill
SITE B
SITE A
(Wainwright and
Botham Site)
Canopus
Hill
The
Canache
Surf
Bay
Rookery
Bay
Christina
Bay
Cape
Pembroke
U.T.M. Grid North
Magnetic North
Based on Map D.O.S. 453
Sheets 14 and 15 by permission
of H.M.S.O.
Contour intervals 25m.
U.T.M. Grid Zone 21
Mile 1 3/4 1/2 1/4 0 1 2
Kms 1 1/2 0 1 2 3
SCALE: 1:50 000

Figure No.1

1. INTRODUCTION

In 1969 Wainwright and Botham of the Board of Trade, London, reported on the feasibility of constructing an airfield on the Cape Pembroke Peninsula and established, on site, proposed alignments for both a main and a cross runway. This report was followed in September, 1971, by an "Initial Reconnaisance Report" by Lt. Col. R. Wheatley, M.B.E., R.E., which considered eight alternative sites but discarded each of them in favour of the site proposed by Wainwright and Botham.

Terms of Reference for topographical and geotechnical surveys of a site on the Cape Pembroke Peninsula and for the preparation of a Feasibility Study for a proposed airport on this site were given under cover of a letter dated 19th November, 1971, addressed to Rendel, Palmer & Tritton by the Overseas Development Administration of the Foreign and Commonwealth Office, London.

The two sites considered by Rendel, Palmer & Tritton are shown on Figure1. Site A is that considered by Wainwright and Botham and lies in the bottom of a flat valley between Canopus and Mary Hills. On the recommendation of the Consultants the site survey was extended to cover a second site, Site B, further to the east and overlying a part of Site A and an area of precompressed peat at the east end of Site A.

This Report is based on the information collected in the Falkland Islands by the Survey team in the period from mid-November, 1971 to mid-January, 1972.

2. CRITERIA FOR AIRPORT SITE SELECTION AND DESIGN

2.1 Aircraft Types

The Consultants were asked to consider operations using the Fokker Friendship F27, the Hawker Siddeley 748, or other suitable aircraft. From an examination of operational characteristics, the following aircraft were established as being the critical aircraft in the relevant preliminary design elements:-

Runway length - Fokker F27 (See Section 3.1.1)

Pavement thickness - Hawker Siddeley Andover (See Section 3.1.1)

Fuel requirements - Hawker Siddeley 748 (See Sections 3.1.1 and 3.15)

2.2. Proposed Routes and Diversions

The proposed operators, Lineas Aereas del Estado, are planning scheduled services to the Falkland Islands out of Comodoro Rivadavia, linking with the direct service to Buenos Aires, with a main alternate of Rio Gallegos. As shown in Table 2, the proposed route length is 525 nautical miles. (See Page 5)

2.3 Topography

The site selected by Wainwright and Botham, Site A on Figure 1, lies in a valley between two hills as shown on Plate 1. The ground is generally flat, with isolated sand dunes and rock outcrops, and a high water table giving rise to ponding over much of the site.

Site B, shown in Plate 2, is again a flat area with rock outcrops on both North and South sides, and with isolated sand dunes, but no surface ponds.

A comparison of the topography of the two sites shows that Site B is the more restricted but sufficient area can be found even at this site for a Class "C" strip width without the necessity of bulk rock excavation. However, at Site B there is no suitable location for a future cross runway other than that proposed by Wainwright and Botham which is some 500 metres to the west of the main runway threshold for Site B. Also at Site B the apron and terminal area is best situated between two rock outcrops but this limits any futrue development. The terminal area at Site A can be situated at the foot of Canopus Hill but to avoid cutting into the base of the peat overlying the hill, the main runway centre line should be moved northwards by 80 metres and the cross-runway centre line moved eastwards by 30 metres from the Wainwright and Botham siting.

2.4 Geotechnical Considerations

A study of the foundation conditions pertaining at Site A shows layers of peat and sand, in places mixed to form highly compressible sandy peat, overlying clay and bedrock. The total thickness of the sand and peat layers varies from 7 metres at the west end of the site to 2 metres at the east end. The water table is high all over the site, there being several permanent surface ponds.

PLATE 1. SITE A. CH 9 + 950 LOOKING WEST

PLATE 2. SITE B. LOOKING EAST

The foundation conditions at Site B are more consistent being overconsolidated dark brown peat, of approximately 1 metre thickness, overlying clay and bedrock. At the western end of Site B the peat is overlain by wind blown sand but the peat is exposed over the majority of the Site. In general the water table over Site B is 1 metre below the ground level.

2.5 Usability

As shown on Figure 1, the centre lines of the main runway for Sites A and B have orientations of 88° 47' and 79° 18' respectively, to U.T.M. grid North. For a single runway with a maximum cross-wind component of 13 knots, the overall usability for Site A is 61 per cent compared with 64 per cent for Site B. (See Table 1 overleaf)

2.6 Obstructions

The I.C.A.O. requirements for obstruction clearances for aircarft taking-off or landing are satisfied for either site, but as shown in Figure 1, the extended centre-line for the runway on Site B passes over the Aerial farm to the East of Stanley, whereas no ground higher than 100 metres is encountered on the extended centre-line for the runway on Site A until the Two Sisters, some 14 km. from the west threshold.

2.7 Other Criteria

Other factors influencing the final choice of the site including runway length requirements, airspace requirements and access to the site are of equal relevance for each of the Sites A and B.

2.8 Proposed Airport Site Location

To obtain the best possible location for the airport is is recommended that Site A is adopted as recommended by previous reports, but amended as follows:-

(a) The runway centre-line be moved 80 metres north to give adequate space for the terminal area and to take advantage of the better foundation conditions on this alignment.

(b) The west threshold of the main runway be moved 550 metres to the east from the location established on site by Wainwright and Botham, to avoid the poor foundation conditions at the west end of Site A.

TABLE 1. RUNWAY USABILITY

Main Runway

Aircraft Type	Cross-wind Component in knots	Usability as %	
		Daylight Hours	24 Hours
Light Aircraft	11	51	52
	20	80	83
F-27	13	58	61
	29	97	97

Main Runway and Cross Runway

Aircraft Type	Cross-wind Component in knots		Combined Usability as %	
	Main Runway	Cross Runway	Daylight Hours	24 Hours
Light Aircraft	11	11	76	76
	20	20	94	93
F-27	13	11	80	80
	29	11	97	98

(c) The centre-line of the cross runway, as established by Wainwright and Botham, be moved 30 metres to the north-east to allow sufficient space for the Terminal area and reduce the quantity of earthworks required.

This location and orientation of the airport and runways takes advantage of the easier topography and operational characteristics of Site A whilst avoiding the worst of the foundation conditions of Site A and making partial use of the superior foundation conditions pertaining at Site B.

The orientation of the main runway will then be 88° 47' from U.T.M. grid north (83° 51' from magnetic north) and of the cross-runway will be 144° 52' to U.T.M. grid north (139° 56' from magnetic north).

3. PROPOSED FACILITIES AND DESIGN

3.1 Aircraft Movement Areas and Airfield Strip

3.1.1 Runway

In assessing the routes and related fuel requirements, as well as runway length requirements and aircraft operations, the Consultants have obtained the advice of the British Airports Authority.

Table 2 shows the route lengths considered and the fuel requirements for the HS748 over these routes. It has been assumed that, in view of the weather conditions prevailing in Patagonia and the Falkland Islands, all aircraft will operate with full fuel tanks. Under this condition all flights shown in Table 2 can be undertaken by both the F27 and HS748 aircraft.

The safety of operations in this area will be improved by the provision of good ground/air communications, which will enable early diversions to be made.

The estimated wind components shown in Table 2 were based on information received from the Meteorological Office, London, giving wind speeds at the assumed cruising level of 18,000 to 20,000 feet. The information showed that the yearly average at this altitude for westbound flights is a headwind of 38 knots with a standard deviation of 20 knots, and for northbound flights the mean is a tailwind of 4 knots with a standard deviation of 18 knots.

TABLE 2 ROUTE/FUEL REQUIREMENTS

Flight		Route Length in n.m.	Wind Component in kts.	Alternate Airfield	Distance Destination to Alternate in n.m.	Wind Component to Alternate in kts.	Fuel Requirement in lb.			
From	To						Route	Diversion	Hold	Total
Stanley	Comodoro Rivadavia	525	+50	Rio Gallegos	357	0	5200	2560	1000	8760
Stanley	Rio Gallegos	432	+50	Comodoro Rivadavia	357	0	4300	2560	1000	7860
Comodoro Rivadavia	Stanley	525	-50	Rio Gallegos	432	+50	3400	3950	1000	8350
Rio Gallegos	Stanley	432	-50	Puerto Deseado	399	+50	2950	3450	1000	7400

Notes:-

1. All route lengths are great circle distances.
2. For wind components: + indicates headwind; - indicates tailwind.
3. Fuel requirements quoted are for the critical aircraft, the Hawker Siddeley 748, at maximum take-off weight.
4. Maximum fuel loads:-
   - (a) F27 without optional tanks - 9500 lb.
   - (b) F27 with optional tanks - 13500 lb.
   - (c) HS748 without optional tanks - 11500 lb.

Runway length requirements for various payloads for the F27 are given in Table 3. As stated above, these figures are based on the assumption that a full fuel load will be carried in standard tanks and that the payload is decreased to give the relevant take-off weights. The runway length has been assessed by reducing the decision speed below the maximum to "balance" the runway length requirements such that the accelerate-stop distance becomes equal to the take-off run. This procedure ensures the minimum paved length, but requires that a "clearway" be provided, comprising an area of unpaved land over which an aircraft may fly after lift-off and while climbing to a height of 50 feet.

Reference to Table 3 shows that in order to increase the payload capability from 7,500 lbs to 8,500 lbs, 275 metres of additional full strength pavement would be required. It is therefore recommended that a runway length of 1,250 metres with a clearway length of 265 metres is selected, to give reasonable economy in paylod capability against prime cost.

The following are the payloads which can be carried from the relevant runway lengths, by the F27 with full standard tanks:-

Runway length in metres	Payload in lbs
1100 (3600 feet)	5,300
1215 (4000 feet)	7,075
1250 (4100 feet)	7,500

The wind roses for 24 hours and for daylight hours only for the Stanley area are shown in Figures 2 and 3, and the usability under various conditions shown in Table 1. The I.C.A.O. criterion for light aircraft is a maximum cross-wind component of 10 knots, while for aircraft of the size of the F27 or HS748 the comparative figure is 13 knots. The F.A.A. criterion for maximum cross-wind component for light aircraft is 11 knots. However, under British Civil Airworthiness regulations both the F27 and the HS748 are certificated to operate in cross-winds up to 29 knots and light twin aircraft, such as the Piper Navajo, are certificated up to 20 knots.

Using the I.C.A.O. and F.A.A. figures the airport overall usability with a single runway is for the F27 61% and for light aircraft 52%. With the inclusion of a cross-runway these figures become 80% and 76% respectively. However if the maximum cross-wind components as certificated under B.C.A. regulations are assumed, for a single runway the usabilities become for the F27 97% and for light aircraft 83%, and with the addition of a cross-runway 98% and 93% respectively.

TABLE 3. RUNWAY LENGTH REQUIREMENTS.

Varying payload for Fokker Friendship F27 Series 200/400.

Payload in lb.	Runway Length required in m.	Clearway required in m.	Remarks
8500	1525	350	Maximum payload with full fuel and 16.5° flap.
7500	1250	265	
6000	1140	265	
4000	1000	210	
2000 Zero	970 940	20 Zero	130 m.) of the Runway) Length may be 220 m.) Stopway.

Notes:-

1. The runway lengths are based upon the following:-

   (a) Take-off with full fuel load in standard tanks of 1130 Imperial gallons.

   (b) Zero wind, standard atmospheric pressure and airport reference temperature of 10.7°C (51.3°F) pertaining.

   (c) 16.5° flap setting with water/methanol injection take-off conditions.

   (d) Wet runway surface.

2. If optional extra tanks are fitted to the F27, the maximum fuel load is increased to 1645 Imperial gallons and the payload capabilities in the table should be reduced by 4000 lb.

3. In calculating runway lengths, the F27 is the critical aircraft.

4. The runway lengths shown were calculated using reduced decision speeds, such that the take-off run became equal to the accelerate-stop distance. For the low payloads shown the absolute minimum decision speed was used and thus stopways had to be provided.

At present no specific light aircraft operations are planned and thus it is proposed that a single runway be built with provision for future construction of a cross-runway. The I.C.A.O. recommend a minimum usability for an airport of 95% and to enable the usability of the single runway to achieve this figure it is recommended that the runway be designed such that aircraft may be operated up to their maximum certificated cross-wind components. For safe operations in 29 knot cross-winds it is recommended that the runway width be 45 metres (150 feet) with strengthened margins 7.5 metres (25 feet) wide, compared with the I.C.A.O. Class "C" recommendations of a runway width of 30 metres with 5 metre wide margins. This runway width will enable all aircraft under consideration to turn on the runway without the provision of loops.

If future development of the airport traffic includes a large number of light aircraft movements then, in order to increase the usability, a cross-runway may be required. To enable construction of the future cross-runway with the minimum of reconstruction of the main runway and strip, it is proposed that the junction between the two runways is constructed under the main runway contract as shown on the Drawings. It is also proposed that the major earthworks for the cross-strip should be undertaken during the Contract for the main runway, as the paving to the cross-strip will be of a light construction which could be undertaken by the Public Works Department, or a local contractor. Future extensions to the main runway if required will be to the west.

Since no parallel taxiway is envisaged, the runway design will take account of the higher stresses induced by slow moving aircraft, and will be of 320 millimetre (12½ inches) total thickness, with a 20 millimetre asphalt surfacing on a crushed stone base, and a stabilised sub-base, giving an L.C.N. of 15-20. The theoretical minimum total pavement thickness is 250 mm with a 50 mm asphalt surfacing. The increase in pavement thickness from the minimum of 250 millimetres will be achieved, with no increase in cost, by reduction of the asphalt thickness to 20 millimetres and thickening the cheaper sub-base. The thicker pavement will be more economically strengthened if higher L.C.N's are required at any future date.

3.1.2 Strip

A strip width of 150 metres, as recommended for an I.C.A.O. Class "C" runway, is proposed. During construction the turf and any top soil will be removed from the strips and replaced on adjoining sections after grading to finished levels. A general feature of the soil in the Falkland Islands is the high acidity (pH 4.5) coupled with a deficiency in phosphate. In addition the soil may suffer from surface drought for part of the year. Under these conditions it is unlikely that the native grasses present in the replaced turf will re-seed with sufficient vigour to cover any 'bare' patches of top soil. Accordingly a seeding operation with possible fertilization will be necessary to bring the strips up to standard.

The strips, once established as outlined above, will need only occasional mowing or alternatively some form of chemical growth retarder might be used.

3.1.3 Link Taxiway and Apron

The centre line of the link taxiway is located one hundred and twenty metres east of the west Threshold. At this location the terminal area is clear of the future cross-runway strip and the terminal buildings are located in an area of good foundation conditions.

The proposed taxiway width of 15 metres is as recommended for I.C.A.O. Class "C" runways. The construction type and thickness will be as for the main runway.

It is proposed to provide an apron of 4,800 square metres with a stand capacity suitable for two aircraft of the size of the F27 and with a flexible pavement of the same thickness as the main runway pavement, but with a fuel resistant surfacing.

3.2 Airport Drainage

The drainage system will comprise open side drains outside the strip, culverted under the taxiway link on the south side, leading to one outfall on each side of the runway.

Two subsoil drains one under each edge of the runway pavement will be constructed with piped outfalls into the side drains at 200 metre intervals, and with facilities for flushing out the drains. French drains joining the side drains at either end of the strip will also be constructed to maintain a low water table within the strip.

With the cross-runway construction, the north side drains will be diverted to their respective outfalls along the sides of the cross-runway strip and the south side drain culverted under the cross-runway strip.

3.3. Road Access and Car Parks

The existing road from Stanley to Cape Pembroke is a gravel track of uneven surface and a width varying from 4 metres to 2 metres. The major part of the road has a satisfactory horizontal alignment but the realignment of three sections and the construction of a new length of road from the Canache to the terminal area is recommended.

The total length of road from the outskirts of Stanley to the proposed site is 6.5 kilometres (4 miles). A road consisting of a surfaced pavement 3.5 metres (11.5 feet) wide with shoulders 1.5 metres wide on each side, is recommended. The pavement proposed will consist of surface dressing over 150 millimetres (6 inches) of crushed rock base on a sub-base varying in thickness dependant on sub-grade conditions. Side drains will be provided as necessary to accommodate surface run-off and to maintain the local water table at a reduced level.

It is proposed that the first 4 km from Stanley will utilize the existing track apart from two sections where the lengths of horizontal realignment total 1 km, firstly realigning the road to the east of the Transmitting Station and secondly realigning the road by Rookery Bay. Where the horizontal alignment of the existing road is satisfactory the sub-base course will be used to regulate the road profile. From Rookery Bay to the Canache, the road will follow approximately the line of the existing track but will be reconstructed on the sand sub-soil.

For the next 1.5 km along the south and east sides of the Canache, the existing ground conditions are surface layers of peat over sub-soils varying from bedrock through weathered rock zones to sand. On this section it is proposed to remove any peat and to construct the road on the exposed sub-soil. Short lengths of embankment are also proposed to maintain the vertical alignment.

The final section of the proposed road, from the east end of the Canache, along the east side of Canopus Hill and to the proposed terminal area, has a maximum gradient of 5%, the steepest on any section of the proposed road. The soil conditions are peat over clay with some rock outcrops. It is recommended that shallow deposits of peat should be excavated to expose the clay sub-soil, and that deeper deposits of peat should be partially excavated and replaced with sand fill on which the road should be constructed, thus avoiding excessive settlement due to consolidation of the peat. Where outcrops occur the road profile should be designed to avoid large excavations through rock.

At the airport, surfaced car parking space will be provided for twenty-five cars with provision made for other vehicles to run off the road to park on unpaved ground. Provision will also be made for possible future construction of additional car parks.

3.4 Fencing

A post and wire fence is proposed, as shown on the Drawings, to keep the runway strip clear of cattle and unauthorised personnel. The construction of a hare proof fence would be possible but the cost would be prohibitive. Gates in the fence will be provided in the terminal area and at either end of each runway. Access both to Yorke Bay and the lighthouse will be provided outside the fence by unsurfaced tracks and all runway drainage outfalls will be culverted adjacent to the fence.

3.5 Buildings

3.5.1 Terminal Building

A single storey reinforced concrete framed structure with non-load bearing walls and a total floor area of 275 square metres (3,000 square feet) is proposed for the terminal building. Table 4 shows the proposed allocation of floor space to individual purposes.

3.5.2 Operations Building

The operations building is proposed as either a reinforced concrete or a steel framed two storey building, with the first floor being a steel framed visual control cabin. The floor areas proposed are shown in Table 4.

3.5.3 Ancillary Buildings

Substation:- The Substation will be a reinforced concrete framed building housing, the transformer, high and medium voltage switchgear, the stand-by generator, and an equipment store.

Fire Service Building:- It is proposed to provide a steel framed shelter to protect the fire and rescue vehicles whilst they are stationed at the airport. A fire-crew room has been proposed in the operations building. During periods when no flights are expected and the fire fighting vehicles are in Stanley, the apron ground equipment may be kept in the shelter.

TABLE 4. FLOOR AREA ALLOCATION FOR BUILDINGS

Terminal Building	Area in sq.m.
Arriving passengers waiting area	29.0
Baggage collection area	18.0
Surgery & Health	14.0
Baggage Handling area	39.5
Immigration	10.0
Customs office and Search room	13.5
Airline office	7.5
Corridors	11.0
Toilets	22.5
Stores	8.0
Snack Bar	7.5
Waiting Area	92.5
Telephone	2.0
	275.0
Operations Building	
Fire and Airport Staff	19.0
Stores	11.5
Kitchen	7.0
Toilet	7.0
Crew room	21.0
Communications centre	15.0
Signals Officer - office and workshop	22.5
Communications Equipment	18.0
Stairway	9.0
Corridors	26.5
Control room	17.5
Briefing area	12.5
A.T.C./Airport Manager's office	17.5
	204.0
Substation	
Stand-by Generator	25.0
Switch gear	15.0
Transformer	10.0
Store	30.0
	80.0

3.6 Water Supply

An 80 mm (3 inch) diameter water main will be provided from the town to the terminal area feeding a storage tank at ground level, of sufficient capacity to fight any building fires, and a tank on the roof of the Operations Building for potable water supply. The water main from the town will generally follow the line of the access road.

3.7 Airfield Lighting

It is understood that the anticipated operational schedules would not include for landing or take off other than in daylight hours; accordingly, no provision has been made for permanent runway, taxi-way and apron edge lighting but the design will include for ducting and other service provisions to enable these facilities to be added if required in the future.

However, provision should be made for occasional unscheduled, or emergency, operations at night and it is proposed that portable lighting units with rechargeable batteries be provided for such eventualities. White lights will be provided for edge lighting on both sides of the runway at 60 metre intervals with green threshold and runway end lights. Mobile trolley mounted, extensible towers with battery or diesel powered floodlights will be provided for the apron.

The portable and mobile equipment will be stored within the substation; battery charging facilities will be provided.

For the approach and landing aids at the east end of the runway, a permanent VASI system and permanent simple approach lighting in accordance with Annexe 14 of the I.C.A.O. Recommendations are recommended. The simple approach system will comprise high intensity, unidirectional white lights arranged on the extended centre line over a distance of 420 metres from the threshold, with a 30 metres cross bar at a distance of 300 metres from the threshold. Staged brilliance control will be provided from the control desk in the operations building.

As the existing light house at Cape Pembroke can be seen for many miles, the Consulting Engineers do not propose the installation of an additional visual beacon for the initial stages of operation. Should a beacon be found to be necessary it would be sited adjacent to the terminal complex.

3.8 Navigational Aids

The following facilities are proposed as being the minimum aids required for approach and landing:-

1. High-powered NDB, say, 750 watt, sited on high ground adjacent to the terminal complex on Canopus Hill.

2. Low-powered NDB on the extended centre line of the runway as far from the 26 threshold as practical at a distance of, say, 2 km.

Each unit would be provided with dual operation and monitoring facilities.

The provision of VOR has been considered and it would appear from preliminary investigations that siting on Canopus Hill could be feasible but a site survey by specialists would be required to determine this. However, the Consultants are of the opinion that a decision regarding the provision of VOR and DME should be held pending operational experience of approach and landings at Stanley and the availability of staff for maintenance.

3.9 Telecommunications

The following facilities are proposed:-

a. HF RT link with Comodoro Rivadavia with capability of extension to other airports on the Mainland.

b. HF RT ground/air en-route.

c. HF RT ground/air area control.

d. VHF RT ground/air approach and aerodrome control.

e. VHF RT local services and surface movements.

f. Land line telephone link with Stanley exchange.

Items a, b and c will be multi-channel SSB units of, say, 1 kW; main and stand-by units will be provided. Also it is recommended that an additional watch keeping receiver should be installed in a town office to provide a monitoring facility during non-scheduled times of operation.

50 watt units will be provided for Item d with battery powered stand-by; low-power units will be provided for Item e.

For Item f a 30 pair cable is proposed with catenary suspension from the poles carrying the overhead power line from the town to the airport; the cable will be buried within the airport boundary and town precincts.

The transmitter and receiver aerials will be located in a compound situated south of the terminal complex; the masts will be provided with obstruction lights.

It should be noted that the European Space Research Organisation have expressed concern as to the possible adverse effect of the telecommunications and navigational aid equipment on their satellite tracking installation west of Stanley and they have asked that they be advised of the locations of the equipment and aerials and its characteristics before it is finalised.

3.10 Power Supply

It is understood that new 3.3kV generating plant will be commissioned in Stanley in 1972 and that adequate reserve will be available to meet the airport demand of approximately 60 kW. An overhead line operating at 3.3 kV is proposed from the town Generating Station to the Substation adjacent to the terminal building; the connection will be taken through buried cables within the airport boundary. The Substation will be equipped with a 3.3 kV/400 volt transformer and switchgear.

A spur will be taken from the overhead line terminating in a pole mounted transformer adjacent to the low-power NDB As the runway construction will require the diversion of the existing telephone line to the lighthouse at Cape Pembroke, it is proposed to support the new telephone cable from the poles supporting the power line to the beacon. Failures at the source of generation and of transmission lines must be anticipated, and it is proposed that a stand-by generator should be provided at the Substation to cater for essential power loads at the airport. The estimates include the cost for new plant but it is understood that serviceable plant of adequate capacity may be available in Stanley by the time the Airport is commissioned. The stand-by for the low-powered NDB would be obtained from float charged batteries.

3.11 Operation of the Airport

It is understood that the airport will have an operational staff of two people, one acting as air traffic controller and airport manager, the other being a radio officer. It is also understood that the air traffic controller will undertake control of the Beaver flights from the harbour.

Inter-communication between the Airport and the Meteorological Station in Stanley will be provided through the land line telephone link proposed in 3.9.f. Minimal instrumentation and recording equipment will be provided at the Airport.

The Consulting Engineers propose that the Meteorological Office at the Airport be designated as a Supplemenatry Meteorological Office - SMO - and that it should be manned during the hours of scheduled operation. The Airport SMO should be responsible for advising the mainland F.I.C. and aircraft en-route of weather conditions in Stanley via the HF RT links proposed in 3.9.a, b, and c.

For return flights the Airport SMO would receive information direct from the mainland and pilots would be so briefed in the Operations Building.

3.12 Fire and Rescue Service

3.12.1 Aircraft Fire Fighting

The provision of the following minimum scale of extinguishing agents is proposed in accordance with the recommendations of the Board of Trade publication CAP 168 for this category (IV) of airport:-

Water for foam production	- 600 galls
Foam liquid	- 30 galls
Pumping rate for foam/water solution	- 150 gall/min
Either Dry Chemicals	- 100 lb
or CO_2	- 200 lb

Dry powder is the normally recommended complementary agent but this requires the provision of a small quantity of CO_2 for aircraft engine fires. This can most conveniently be provided by means of a small hand propelled fire extinguisher on wheels which can be positioned adjacent to the aircraft during engine starting operations.

Storage of the following is also required at the airport:-

Foam liquid	- 60 galls
Either Dry Chemicals	- 100 lb
or CO_2	- 200 lb

The following equipment is at present available in Stanley:-

2 No. Firefly Land Rover Fire Engines (one equipped for foam)

4 No. Trailer pumps

1 No. 150 gallon capacity trailer

One Firefly equipped for foam will be required to remain in town for emergencies. Hence it is recommended that the following new equipment be provided:-

1 No. Firefly Land Rover equipped for foam production.

1 No. Set of equipment for conversion of existing Firefly to foam production.

2 No. Trailers 250 gallons capacity each.

1 No. Trailer complete with dry powder and rescue equipment.

1 No. Hand Trolley for fighting engine fires (CO_2).

With the exception of the last two items of equipment, it is envisaged that all equipment would normally be kept in Stanley to augment the existing town facilities, but that all the above equipment, plus one extra Firefly equipped for foam, should be available with four crew at the airport for each operation using the F27. For operations of light aircraft under 12,500 lb gross weight, the attendance of a single Firefly equipped for foam and two crew should be provided.

3.12.2 Domestic Fire Protection

As stated in Section 3.6 it is proposed that a storage tank be provided adjacent to the terminal area with sufficient capacity for fighting fires in buildings. Fire extinguishers will be provided in all buildings for fighting minor fires.

3.12.3 Rescue

It is proposed that a minimum scale of rescue equipment (axes, crowbars, hammers, ladders etc.) be provided as recommended in the Board of Trade publication CAP 168, for this category (IV) of airport.

It is also recommended that this equipment be kept permanently, on the trailer provided for the dry powder fire extinguishing agent, at the airport. When flights are expected the trailer should be attached to the Land Rover provided for the Airport Manager in order to be readily available for emergencies. This vehicle should carry the duty fire officer and should be on stand-by at the airport for all flights.

For sea rescue it is recommended that a large sea-going dinghy be provided, complete with an outboard motor and a suitable trailer on which the deflated dinghy can be transported.

The trailer should be kept at the airport and be towed to the most convenient launching site in an emergency. At the time of construction, tracks should be provided to Whalebone Cove, Christina Bay and a suitable location on the north side of Cape Pembroke adjacent to the lighthouse.

Inter-communication with established rescue services throughout the Islands will be provided through the HF & VHF R T equipment and telephone line proposed in 3.9.

3.13 Maintenance

It is assumed that all routine civil maintenance of the airport and access road will be undertaken by the Public Works Department, and it is proposed that various suitable items of contractors plant be taken over for this purpose, after completion of the construction. It is also understood that the P.W.D. will be able to maintain all airport vehicles and that the Power and Electrical Department could maintain the airfield lighting, stand-by generator and electrical systems and services.

It is proposed that the Radio Officer will be responsible for all maintenance of the radio and navigational-aid equipment, and will be based at the airport where there is provision for both a workshop and store.

No aircraft maintenance facilities are envisaged at the airport. It is assumed that all flights will carry an engineer and that in the event of a major breakdown any necessary spares would be flown out to Stanley on a second aircraft. If required by the operators a store could be made available at the airport for a limited quantity of spares.

3.14 Fuel Storage and Fuelling

It is understood that it is proposed to construct a fuel storage farm in the vicinity of Stanley in the near future, and that separate tankage will be provided for commercial petrol, avgas for the Beaver operations and kerosene. Accordingly it is proposed that no fuel storage facilities be constructed at the airport, but that an articulated vehicle be provided for transporting the fuel from the tank-farm to the airport. It is further proposed that the vehicle provided should comprise a single prime mover and three trailers, one each for avgas, diesel oil and kerosene. By attaching the relevant trailer to the prime mover avgas deliveries can be made to the Beaver Hangar and to the airport for any light aircraft movements, diesel oil deliveries can be made for domestic heating, and kerosene deliveries can be made to the airport. Provision should be made for towing the trailers by an alternative vehicle in the event of any breakdown of the prime mover.

The estimated fuel requirements for the flight from Comodoro Rivadavia are, from Table 2, 3500 lb per trip. On the basis of one trip per week and allowing for occasional diversions and holding, the total fuel requirement per annum will be approximately 100 tons.

3.15 Customs and Cargo Handling

Provision has been made in the terminal building for customs checks on passengers in the normal way, and baggage can be handled from a central area in the building. It is recommended that the Agent appointed for handling cargo should transport the cargo directly between the aircraft and his bonded warehouse in Stanley.

3.16 Future Developments

The following provisions have been made for possible future developments of the airport:-

- extensions to the main runway will be to the west, and in order to improve the foundation conditions a surcharge will be deposited in the initial construction over the full runway width for a length of 500 metres;
- similarly surcharges will be deposited on the future cross-runway and to the west of the proposed apron to preconsolidate any peat lying in areas reserved for future extensions;
- the perimeter fence will be constructed initially to accommodate the future cross-runway and main runway and apron extensions;
- future extensions of the terminal building will be to the east, and a doubling of the area of the building will be possible with the layout proposed on the Drawings;
- any future buildings which may be required in the terminal area can be located in the area between the future apron extension and the road;
- provision has been made for a possible future increase in total car park capacity to 75 vehicles.
- ducts will be provided under the runway and other surfaced areas, at suitable spacings, for cables and controls to future visual and navigational aids.

4. CONSTRUCTION

4.1 Geotechnical Factors

Geotechnical factors affecting construction include the high water table and the compressible nature of some of the foundation materials. The drainage of the site is discussed in paragraph 4.3 below. The geotechnical long sections in Drawings 13 and 14 indicate the location of soil strata observed in trial borings and pits on the site.

In areas where overconsolidated peat is above ground water level, in relatively shallow deposits of less than say 2 metres with little or no overburden, it should be removed, in preference to having fill material placed on top of it. In areas where it is uneconomical to remove the overconsolidated peat because of a high water table or excessive overburden, engineering difficulties should be minimised in ensuring that at least 1.3 metres of sand or construction material exists between the pavement surface and the peat.

Drawings 13 and 14 indicate that from the eastern end of the site to approximately chainage 10+250 deposits of soft to firm overconsolidated peat (see Appendix 1) occur at depths of less than 1.3 metres. These deposits are in general less than 1 metre thick and could probably be excavated economically, thus eliminating any possible future settlement of the pavement due to consolidation of the peat. West of chainage 10+250 the over-consolidated peat deposits occur at depths in excess of 2 metres and should not prove to be a significant geotechincal hazard during or after construction.

A significant construction problem is the presence of sandy peat deposits west of chainage 10+200. These deposits occur as discontinuous lenses with generally more than 2 metres of sand overburden. These deposits of sandy peat become thicker and occur with greater frequency west of chainage 10+700. Due to the thickness of these strata, and the depths at which they occur, it is not an economic proposition to excavate them. Therefore it is necessary to adopt some other method of reducing post-construction settlements to an acceptable minimum. An economic method of achieving this is to preload the construction area with a surcharge calculated to cause settlements greater than the sum of the calculated settlement due to construction and the calculated rebound which will occur following the removal of the surcharge. The surcharge should be applied over the whole area likely to be affected by sandy peat deposits and should be designed to eliminate post construction settlement in the worst conditions likely to be encountered. This is recommended to reduce the possibility of differential settlements taking place after construction, due to the possible variation in the thickness of sandy peat deposits between boreholes.

Slight consolidation will be caused by the drainage of the site, but because the soft deposits are in general deeper than 2 metres and therefore deeper than the level to which water table will be lowered, any consolidation settlement will be due to an increase in effective stress in the soft strata.

4.2 Construction materials

Two Road Research Reports (LN/404/M.P.O'R, and LN/452/M.P.O'R. both 1963) give a general review of construction materials in the Falkland Islands. The following notes refer to materials reasonably easily obtainable adjacent to the site.

4.2.1 Rock materials

The principal rock type in the region is fine grained quartzite occuring in steeply dipping moderately jointed beds adjacent to the site. No holes were drilled in this area to asses the depth of weathering, since no suitable drill bit was available, but a quarry in similar material west of Stanley indicates that up to 5 metres of slightly weathered rock may be encountered. Similar rock types occur in small deposits in the coves and bays of the Cape Pembroke Peninsula.

Preliminary tests carried out on aggregate prepared from surface samples collected from Mary Hill (located 1 km north west of the site) and from the cobble deposits at Surf Bay (1½ km south of site) indicate that neither is susceptible to bitumen stripping, when subjected to the test described in M.P.B.W. General Specification for Airfield Pavements No. 201, Clause 1004, using both distilled and lime water. There was minimal stripping when water with a pH of 4.5 was used.

The polished stone value from preliminary tests of aggregate from both sources is over 59 and is therefore considered suitable for use as a wearing course material. Magnesium sulphate soundness tests on these materials give values of less than 4% after five cycles. An aggregate crushing test on a sample prepared from Surf Bay cobbles gave a value of 19% which is less than the 23% normally specified and is therefore considered suitable. Los Angeles Abrasion tests carried out on the same material gave results of 25% and it is therefore suitable. It is likely that material from Mary Hill will also be suitable in these respects.

It is the opinion of the Consultant Engineering Geologist and materials testing Consultant Engineers retained by Rendel, Palmer & Tritton that well maintained plant of a suitable type will crush the material to give aggregate with elongation and flakiness indices within the accepted limits. Recirculatory crushing may have to be adopted to obtain acceptable aggregate.

The material should be suitable for Marshall asphalt and concrete aggregate and when graded to within the required limits it should be suitable for compacted stone base-course.

4.2.2 Sand

Sand deposits occur on the surface of a large part of the airport site, and in addition along the foreshore of the Cape and in sand dunes both north and east of the site. These deposits all consist of a fine uniform quartz sand which is clean in the dunes and along the foreshore but slightly contaminated with organic material on the surface of the site. The deposits on the foreshore are contaminated with salt and would require washing if used for anything other than general fill. Small deposits of well graded sand and fine gravel with cobbles were proved on a small islet to the eastern end of the Canache inlet and also on the isthmus connecting the Cape Pembroke Peninsula to the mainland. These deposits may be of use in preparing and maintaining an access road but should only be exploited with due regard to the effects of erosion of the isthmus. Unproved deposits of fine to medium sand occur below low water level in the eastern part of the Canache.

The principal deposits of sand likely to be used during construction occur in the sub-grade and as sand dunes north of the site. In-situ California Bearing Ratio (C.B.R.) tests indicate the sub-grade has a C.B.R. of 5.5% whilst compacted laboratory tests indicate that a C.B.R. of 10% can be expected if the material is compacted to B.S. Heavy Compaction standard at natural moisture content. In situ plate bearing tests indicate that the material has a modulus of sub-grade reaction of approximately 32.5 MN/m^2 per m (120 lb/in^2 per in.).

Stabilisation tests carried out using Shell Road Oil (S.R.O.) on samples of sub-grade sand indicate that wet sand mixes with:- sand: lime: water: S.R.O. proportions of 100: 3:6:7; 100:2:6:5:5 and 100:3:6:6 all have adequate stability to carry normal traffic after 14 days curing. A sample with the mix proportions 100:5:6:9 was found to be unstable. Mixes using the nearest grade of bitumen to S.R.O. which is available in Argentina, namely Shell Mex R.C.2, proved unsatisfactory as it became unstable when brought into contact with wet sand.

Stabilisation tests using cement are being carried out at the time of writing this Report.

A recommendation for the stabilisation of sub-base material will be made on completion of testing.

4.2.3 Other Materials

(i) Weathered quartzite. Samples of blue-grey sandy clayey silt, which forms the most weathered horizon of weathered quartzite, were obtained but have not been tested, as it is not included in materials required for construction.

(ii) Water. Samples of water from the airfield site which were tested were shown to be unsuitable for human consumption or for the preparation of concrete.

4.3 Airport Site Drainage and Consolidation

As stated in Section 4.1 it is recommended that, in order to minimise the effects of the settlement occuring in areas of normally consolidated sandy peat, a surcharge be placed over the runway and apron areas from chainage 10+100 westwards. A system of four longitudinal drains, two each side of the runway centre line, is proposed to lower the water table over the site. The outer drain will be excavated outside the strip and will be the permanent strip drainage. The inner drain on each side of the runway will be excavated at the foot of the surcharge embankment and will be backfilled after removal of the surcharge and construction of the longitudinal sub-soil drains under each edge of the pavement.

4.4 Construction Sequence

A suggested construction sequence is shown in Figure 4. It must be emphasized that the construction period shown assumes that the plant capacity provided will not be inhibited by distance from the mainland.

5. PRELIMINARY COST ESTIMATES

The preliminary estimate of cost of the works, excluding engineering fees, is shown in Table 5. There is no experience of major civil engineering construction work by contract in the Falkland Islands to serve as a guide to the level of pricing to be expected from South American or other contractors. In the light of their recent experience of tenders received for a major project on a remote site in the Pacific area, the Consultants consider that the estimate of costs should include an allowance for incentive to contractors to carry out work in the Falkland Islands, where conditions will be unfamiliar to them and where continuity of work is unlikely. Such an allowance is shown in the estimate, additional to the estimated costs of shipping plant and materials and importing labour.

TABLE 5 PRELIMINARY COST ESTIMATES

Section No.	Description	Cost in £
1	Airfield Earthworks	456,000
2	Airfield Paving	172,000
3	Road Earthworks	64,000
4	Road Paving	107,000
5	Drainage Works	53,000
6	Fencing and Gates	11,000
7	Water Supply and Distribution	52,000
8	Power Supply	50,000
9	Airfield Lighting	30,000
10	Navigational Aids and Tele-communications	70,000
11	Terminal Building	18,000
12	Operations Building	13,000
13	Substation	6,000
14	Fire Station	3,000
15	Sewage Disposal	12,000
16	Airfield Markings	8,000
	Sub-Total	1,125,000
	Add for incentive loading (see text) 15%	169,000
17	Supply Fire and Rescue Equipment	8,000
18	Supply Maintenance Equipment	10,000
	Add for Labour Camp	60,000
	Imported Labour	100,000
	Shipping	150,000
	Sub-Total	1,622,000
	Add for Contingencies 10%	162,000
	GRAND TOTAL	1,784,000

The estimated cost in Table 5 is for a runway length of 1250 metres (4100 ft). The total estimated cost for a runway length of 1100 metres (3600 ft) is £1,676,000 and for a runway length of 1215 metres (4000 ft) is £1,761,000. All estimates include for the cost of the cross-runway earthworks. To exclude this work would reduce each of the estimates by £38,000.

6. ACKNOWLEDGEMENTS

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RENDEL, PALMER & TRITTON

April, 1972.

APPENDIX I

Geotechnical Description of the Cape Pembroke Peninsula

A1.1 Introduction

Stanley Harbour is the principal physical feature in the Stanley region, and is bounded to the north-east and east by the Cape Pembroke Peninsula. A narrow sandy isthmus between the Canache and the South Atlantic Ocean forms the peninsula's only link with the rest of East Falkland, and is protected on the eastward and seaward side (leeward to the prevailing wind) by a rocky reef.

The bedrock of the area is composed mainly of the Lower Carboniferous to Mid-Devonian Port Stanley Beds. This formation, together with the Port Philomel Beds, forms the upper section of the Devono-Carboniferous sediments in the Falkland Islands and consists mainly of unfossiliferous quartzites and quartzitic sandstones with some intercalated shales (Photogeology of the Falkland Islands, Univ. of Birmingham, Unpublished report 1971). The Port Stanley Beds are intensely folded in the area with the fold axes trending east-west. The sites under consideration lie along the eroded axis of an anticline with two steeply dipping limbs on either side. Drift deposits include wind-blown sand, peat and a relatively thin zone of residual soil derived from quartizite bedrock. Small deposits of coarse sand and gravel occur in the bays and coves of the peninsula.

A1.2 Bedrock

The Port Stanley beds in the region of the Cape Pembroke Peninsula are quartzitic in nature, being fine to medium grained, with the formation of fine quartz crystals. In the region of the proposed airport site they are steeply dipping and moderately jointed. To the extreme west of the Cape shallow dipping formations are visible in the trough of a syncline. The formation of weathered bedrock and residual soil, which was observed at a number of sites, indicates that the material does weather at a rate faster than erosion takes place, the residual soil formed being a sandy clayey silt with a moisture content of approximately 30% in its most weathered state. It is not expected that this material, which underlies most drift deposits, should pose any geotechnical problems during the construction of the airport. The properties of the quartzite bedrock are outlined in greater detail in Section 4.2.1.

A1.3 Sand

Sand deposits on the Cape Pembroke Peninsula consist mainly of fine uniform quartz grains. Figure 5 indicates typical grading curves of sand from the airport sites, and from the sand dunes on the north side of the Peninsula. Site B shown on Figure 1 is largely devoid of sand with the exception of some small isolated eroded sand dunes. The sand is more widespread as a sub-grade material to the west of this site where shallow deposits approximately 1 m deep occur. From there it becomes progressively deeper towards the west and covers the whole of Site A where deposits of up to 7 m occur intermingled with soft peat (see Drawings 13 and 14 showing borehole logs). The in situ C.B.R. value of this material is approximately 5.5% with a value of approximatley 10% when compacted at natural moisture content (19%-22%). The modulus of sub-grade reaction of the sand as determined by platebearing tests using an 18 in. dia. plate and corrected to the standard 30 in. dia. plate is approximately 32.5 MN/m^2 per m (120 $lb./in.^2$ per in.) and the in-situ permeability as determined by a pumping test is of the order of 1×10^{-2} cm/sec. to 3×10^{-2} cm/sec. The ground water level is at, or close to, the surface of the sand and has a neutral pH.

A1.4 Peat

Peat deposits on the Peninsula are essentially of two distinct types:

a) normally consolidated soft light brown fibrous sandy peat

and b) overconsolidated soft to firm dark brown peat.

The latter deposit covers the entire site, being overlain in the west of the eastern site surveyed and the entire western site by sand referred to in A1.3 above and in places by sandy peat described in (a) above. The normally consolidated soft light brown fibrous sandy peat is a highly compressible material with a natural moisture content of approximately 250%. In general this material is covered by at least 1 m of sand and has been observed to be interbedded with sand layers in places.

The normally consolidated sandy peat is highly compressible with values of coefficient of compressibility (m_v) ranging from 1.2 m^2/MN to 7.79 m^2/MN when measured in a triaxial dissipation test. Values of the coefficient of consolidation (C_V) range from 465 to 6771 m^2/yr for the stress ranges under consideration when measured in a triaxial dissipation test, and from 10 to 95 m^2/yr. when measured in the oedometer test. The former type of test is likely to produce the more realistic results of the two. It must be emphasized that these tests were carried out on specimens of one undisturbed sample which was thought to be representative of the sandy peat taken from one of the trial pits dug on the site. The results quoted therefore, while being very useful in providing an estimate of magnitude and rates of settlement in order that a construction method incorporating surcharging may be evaluated, should not be used for the detailed calculation of settlements in regions of the site other than that area immediately adjacent to where the sample was taken.

A1.5 Geotechnical Survey of the Proposed Airport Sites

It must be emphasized that due to soil conditions existing on the sites trial borings were carried out using a continuous flight mechanical auger and two wash-boring units made up on site. Neither of these methods is ideally suited to producing an exact record of soil conditions existing at the site even with the regular soil sampling that was carried out in the boreholes. Check boreholes were dug at some wash-borehole locations using four inch diameter hand augers, casing the holes with six inch piping. This allows a continuous record of soil strata to be made to check the accuracy of the wash-boreholes. In all cases these boreholes very largely confirmed the findings of wash-boreholes. The slow nature of this form of operation, the limited depth to which it could be carried out, and the high wastage of six inch casing precluded its use on a more general scale. The continuity of the weathered bedrock and clayey silt was checked every twenty-five metres between boreholes 1 and 22 by carrying out a resistivity survey. No major discontinuity was observed in the bedrock profile.

APPENDIX 2

METEOROLOGY

All the meteorological data contained in this report relates to Stanley. The location of the present meteorological station is at Latitude 51° 42'S Longitude 57° 52'W at an elevation of 166 ft above mean sea level (barometer), being situated on a ridge above the town. In relation to Cape Pembroke the meteorological station is approximately 3¼ miles (5 km) west of the proposed airfield site and is approximately 100 ft higher in elevation. The standard of time used is the Zone Time of meridian 60°W. Thus all records are related to GMT-4. Unless otherwise acknowledged the sources of the meteorological data are the Annual Meteorological Tables of the Falkland Islands and Dependencies Meteorological Service and its successor the British Antartic Meteorological Service.

A2.1 Temperature

A2.1.1 Air Temperature. The following table shows the mean and extreme air temperatures recorded for the different months of the year.

Mean and Extreme Temperatures in Degrees Fahrenheit.
(After Pepper, 1954)

Month	Monthly mean temperature	Mean daily maximum temperature	Highest maximum recorded 1944-53	Mean daily minimum temperature	Lowest mininum recorded 1944-53	Mean diurnal range
Jan	49.0	56	72	42	32	14
Feb	48.0	55	73	41	31	14
March	46.5	53	75	40	28	13
April	43.0	49	61	37	26	12
May	39.0	44	57	34	21	10
June	36.0	41	48	31	20	10
July	35.5	40	46	31	22	9
Aug	36.0	41	51	31	22	10
Sept	39.0	45	57	33	24	12
Oct	41.5	48	64	35	25	13
Nov	44.5	52	70	37	27	15
Dec	46.5	54	70	39	30	15
Year	42.7	48	75	36	20	12
Range	13.5	16	-	11	-	-

Source: Cawkell, Maling and Cawkell. The Falkland Islands. MacMillan & Co. Ltd. London. 1960.

The average monthly mean temperature is 43°F while the maximum and minimum temperatures rarely exceed 70°F and 20°F respectively. The air temperature has never been known to exceed 76°F or fall below 12°F. The number of days when the average daily air temperature fell below 32°F for 1959, the year with the coldest winter in 20 years (1951-70), is given in the following table together with the distribution of freezing degree days for that year.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	TOTAL
No. of days when av. daily air temp. was below 32°F	0	0	0	1	4	4	9	6	1	0	0	0	25
No. of freezing degree days	0	0	0	1	9.5	11.5	13	21	2.5	0	0	0	58.5

Note: The freezing degree-days for any one day equals the difference between 32°F and the average daily air temperature when below 32°F.

A2.1.2 Ground Surface Temperature. As may be seen from the following table no month is free from ground frost.

Annual, average monthly distribution of days of ground frost.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	TOTAL
1.4	1.5	5.1	12.0	15.6	20.4	20.2	20.5	18.3	13.1	6.3	4.3	138.5

Notes: Observation period 1951-61.
A day of ground frost is a day when the night time grass minimum temperature (read at 1200 GMT) is less than 30.4°F.

A2.1.3 Soil Temperatures. An analysis of the mean monthly soil temperatures for 18 years (1948-65) for depths 4 inches, 8 inches, 1 ft and 4 ft showed that no month experiences freezing temperatures at or below a depth of 4 inches. A more detailed analysis of daily soil temperatures for 1959 for depths 4 inches, 8 inches, 1 ft and 4 ft showed that on no day of that year had freezing temperatures been recorded at or below a depth of 4 inches.

A2.2 Winds

The prevailing wind is westerly. Sixty-five per cent of the winds blow from the quadrant between south-west and north-west. The percentage frequency of winds blowing from different directions throughout the year is shown in the following table.

N	NE	E	SE	S	SW	W	NW	Calm
13	4	3	2	9	18	20	27	4

There is little seasonal variation in wind direction; SW winds appear to be more common during summer than winter, while NE winds have a maximum frequency in spring and a minimum in autumn. Winds from the SE and E on the other hand are rare, their occurrence being usually during the summer.

An analysis of the frequency of wind directions and speed at Stanley is shown by the "24 hour" wind rose diagram in Figure 2. An additional wind rose for "daylight" hours is shown in Figure 3.

It was stated locally that there is no significant difference in the speed and direction of the winds at the proposed airport site compared with those recorded at the meteorological station.

An analysis of the average hourly wind speed (1951-70) for each month of the year revealed that winds were less strong during the evening, night and early morning, blowing at 14-16 knots, but increased during the morning, reaching a peak of 18-20 knots around midday, becoming less strong in the afternoon. Calm conditions are rare with about 20 days in each month experiencing "strong breeze" winds of force 6 on the Beaufort Scale (22-27 knots) and an average of 4 days when "gale" force 8 winds (34-40 knots) are blowing. The annual, average monthly distribution of force 6 and force 8 winds are shown in the following tables.

Annual, average monthly distribution of days of force 6 winds.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Av.
20.0	20.1	21.7	17.9	21.0	18.8	20.5	19.6	17.7	22.4	21.4	20.8	20.2

Notes: Observation period 1951-61.
A day of force 6 winds is a day on which the mean wind (not the extreme wind in gusts) reached or exceeded this figure at any of the eight hours of observation.

Annual, average monthly distribution of days of force 8 winds.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Av.
3.1	3.8	4.5	4.6	4.8	3.9	4.5	5.1	3.7	4.9	4.8	4.1	4.3

Notes: Observation period 1951-61.
A day of force 8 winds is a day on which the mean wind (not the extreme wind in gusts) reached or exceeded this figure at any of the eight hours of observation.

A2.3 Precipitation

A2.3.1 Rainfall. The average annual rainfall at Stanley is about 26 inches and thunderstorms are rare. As may be seen from the following table this rainfall is spread fairly evenly throughout the year with a slight maximum in the summer months of December and January, the wettest month being December, and a minimum in early spring (September and October).

Average rainfall and number of days with rain at Stanley.
(After Pepper, 1954)

Month	Average rainfall in inches	Number of days with more than 0.01 in. of rain
January	2.7	18
February	2.2	17
March	2.4	19
April	2.3	20
May	2.5	21
June	2.1	21
July	2.0	21

Table Cont/....

Average rainfall and number of days with rain at Stanley Cont/....

Month	Average rainfall in inches	Number of days with more than 0.01 in. of rain
August	1.9	20
September	1.4	16
October	1.5	16
November	1.9	17
December	2.8	20
Totals	25.7	226

Source: Cawkell. The Falkland Islands.

The number of days when the rainfall exceeds 0.01 in. is high throughout the year, being on average 226. Since rain falls "a little and often" the intensity of rainfall is low and daily falls exceeding 0.5 in. are rare. During one note-worthy storm on 31st December, 1951 it is reported that 0.4 in. of rain fell in 15 minutes and 0.6 in. in 22 minutes.

A2.3.2 Showers and drizzle. Showers occur on about 50 per cent of the days of the year and drizzle on about 30 per cent. The annual, average monthly distribution of these weather elements is shown in the following tables.

Annual, average monthly distribution of days of showers.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Av.
18.3	15.2	11.0	14.6	15.3	15.6	14.7	15.4	11.7	10.8	14.1	17.2	14.5

Notes: Observation period 1953-61.
A day of showers is a day on which an occurrence was observed at the station at any time of that day.

Annual, average monthly distribution of days of drizzle.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Av.
6.7	7.0	7.5	9.1	9.8	11.4	12.5	11.6	9.5	6.4	5.5	7.7	8.7

Notes: Observation period 1951-61.
A day of drizzle is a day on which an occurrence was observed at the station at any time of that day.

A2.3.3 Hail, sleet and snow. Hail falls on about 66 days of each year and is fairly evenly spread through all months as shown by the following table.

Annual, average monthly distribution of days of hail.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Av.
6.1	3.8	4.5	4.9	7.1	5.9	5.5	4.8	5.1	5.4	5.5	7.2	5.5

Notes: Observation period 1951-61.
A day of hail is a day on which an occurrence was observed at the station at any time of that day.

Sleet falls on about 62 days of each year and occurs in all months. June is the "worst" month with approximately 8 days of sleet while January experiences only about 2 days.

Annual, average monthly distribution of days of sleet.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Av.
1.7	2.1	2.1	4.6	7.3	7.8	6.9	7.2	7.4	6.2	4.1	4.0	5.1

Notes: Observation period 1951-61.
A day of sleet is a day on which an occurrence was observed at the station at any time of that day.

Snow occurs on about 53 days of each year. It has been recorded in all months but only occasionally falls in January; July on the other hand has, on average, 10 days when snow falls.

Annual, average monthly distribution of days of snow.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
0.1	0.5	0.8	3.9	6.8	9.6	10.0	9.0	5.7	4.5	0.9	1.1	53.1

Notes: Observation period 1951-61.
A day of snow is a day on which an occurrence was observed at the station at any time of that day.

Snow falls are usually light and melt quickly.

Annual, average monthly distribution of days of snow lying.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
0	0.3	0.1	1.0	4.6	7.8	7.9	6.1	2.8	1.3	0.4	0.3	32.5

Notes: Observation period 1951-61.
A day of snow lying is a day on which at 1200 GMT, a half or more of the ground in the vicinity of the station is covered with snow.

Drifting snow is rare as is shown by the following table.

Annual, average monthly distribution of days of drifting snow.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
0	0	0	0	0.9	1.1	2.1	1.7	0.5	0.1	0.1	0	6.5

Notes: Observation period 1951-61.
A day of drift is a day when drifitng snow occurs at any time of the day, regardless of the intensity or height of the drift.

A2.4 Cloud and visibility

A2.4.1 Cloud. The incidence of cloud at Stanley is high with a large proportion of overcast days. There are, on average, 163 days of each year which can be classified as being "cloudy" while only 6 can be classified as being "clear". The reason for this is the high average values of relative humidity which vary from a mean of 75 per cent in November to 90 per cent in July. The annual, average monthly distribution of cloudy and clear days is shown by the following tables.

Annual, average monthly distribution of cloudy days.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Av.
15.6	13.4	10.8	11.7	14.2	14.7	14.0	15.2	13.5	12.1	12.1	15.3	13.5

Notes: Observation period 1951-61.
A "cloudy day" is a day on which the total amount of cloud for the 1200, 1800 and midnight GMT observations added together exceeds 20 oktas.

Annual, average monthly distribution of clear days.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Av.
0	0.4	0.5	0.5	0.8	0.7	0.5	0.6	0.8	0.7	0.5	0.1	0.5

Notes: Observation period 1951-61.
A "clear day" is a day on which the total cloud amount for the 1200, 1800 and midnight GMT observations added together is less than 4 oktas.

The analyses made of cloud amount and cloud heights for the period 1951-61 for Stanley are shown in the following series of tables.

Average annual distribution of low cloud.

Low cloud amounts - oktas	0	1-2	3-5	6-7	8	9
%'age occurrence	13.5	21.3	19.6	23.8	20.1	1.7

Notes: Low cloud is defined as cloud with a base below 2400 m (8000 ft).
0 = No clouds with a base below 2400 m.
8 = Sky is completely overcast.
9 = Sky is invisible owing to fog, smoke etc.

Average annual distribution of cloud heights (all amounts).

Height of cloud base greater than: metres	ft. (approx)	%'age occasions
30	100	97.9
60	200	96.4
120	400	91.7
300	1000	76.2
600	2000	49.5
1200	4000	15.0
2400	8000	11.0
6000	20000	2.6

Average annual distribution of cloud heights (7-8 oktas)

Height of cloud base greater than: Metres	ft. (approx)	%'age occasions
30	100	92.9
60	200	89.1
120	400	78.3
300	1000	55.7
600	2000	32.2
1200	4000	10.5
2400	8000	7.6
6000	20000	1.6

The table above shows that, on average, the base of $^7/_8$ - $^8/_8$ cloud layer is higher than 300 m (1000 ft) on 55.7 per cent occasions and higher than 600 m (2000 ft) on 32.2 per cent occasions.

A2.4.2 Visibility. The visibility recorded at Stanley is shown in the following table.

Average annual visibility.

Visibility better than	%'age occasions
40 m	100.0
200 m	99.3
400 m	98.7
1 km	97.6
2 km	96.2
4 km	94.1
10 km	83.5
20 km	61.8
40 km	37.2

Notes: Observation period 1951-61.

As maybe seen, visibility less than 1 km occurs, on average, on 2.4 per cent of occasions, while visibility better than 2 km occurs on 96.2 per cent of occasions.

Fog occurs on about 50 days of the year and is recorded in all months.

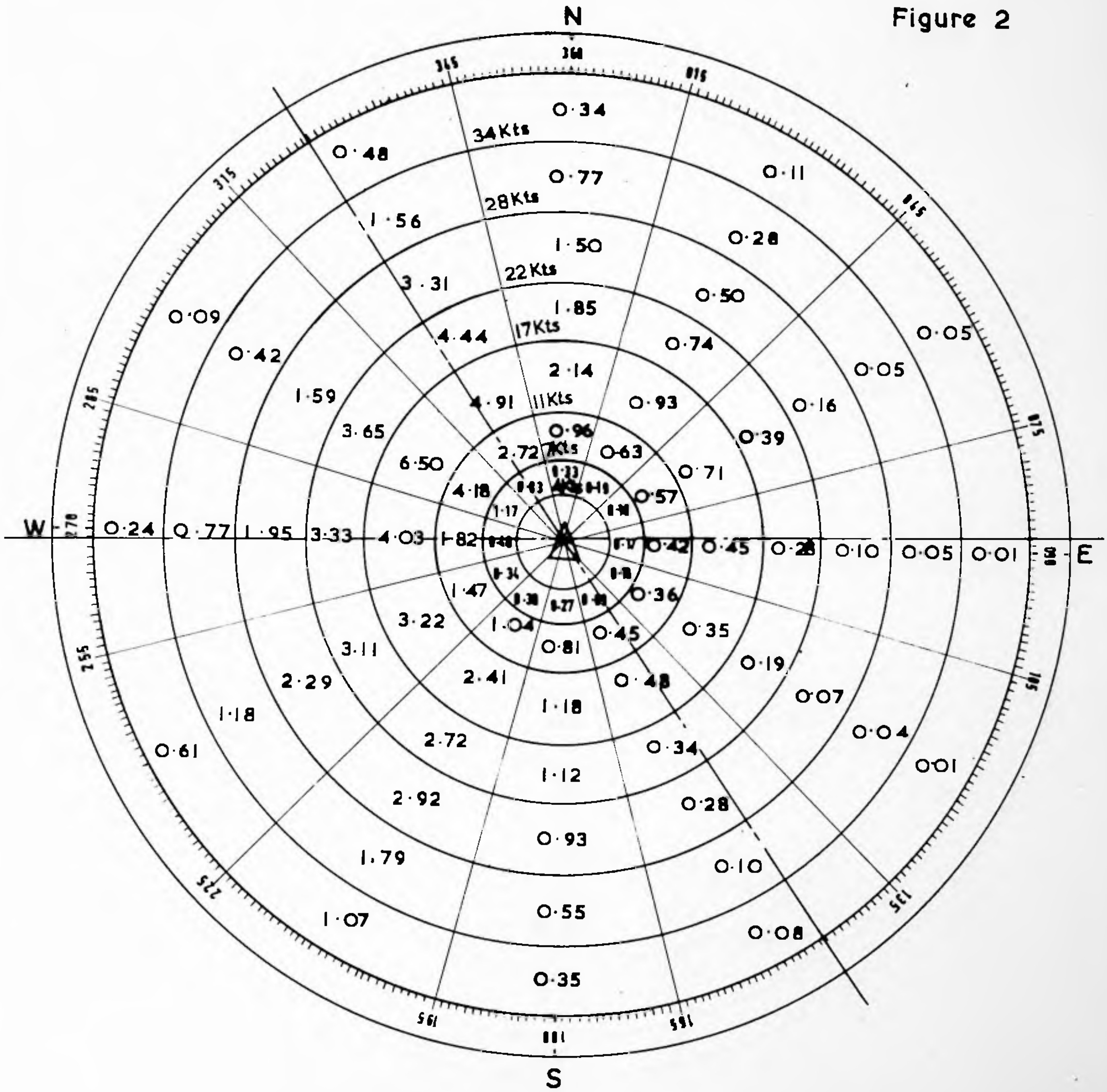
Annual, average monthly distribution of daysof fog.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
3.1	2.2	3.0	4.9	5.5	6.6	6.2	6.1	4.0	4.4	1.8	1.0	48.7

Notes: Observation period 1951-61.
A day of fog is a day on which an ocurrence was observed at the station at any time of that day. Fog is recorded when the visibility falls to less than 1100 yds. (1000 m), whatever the cause.

It was stated locally that the visibility at the proposed airport would be very similar to that recorded at the meteorological station.

Figure 2



WIND ROSE

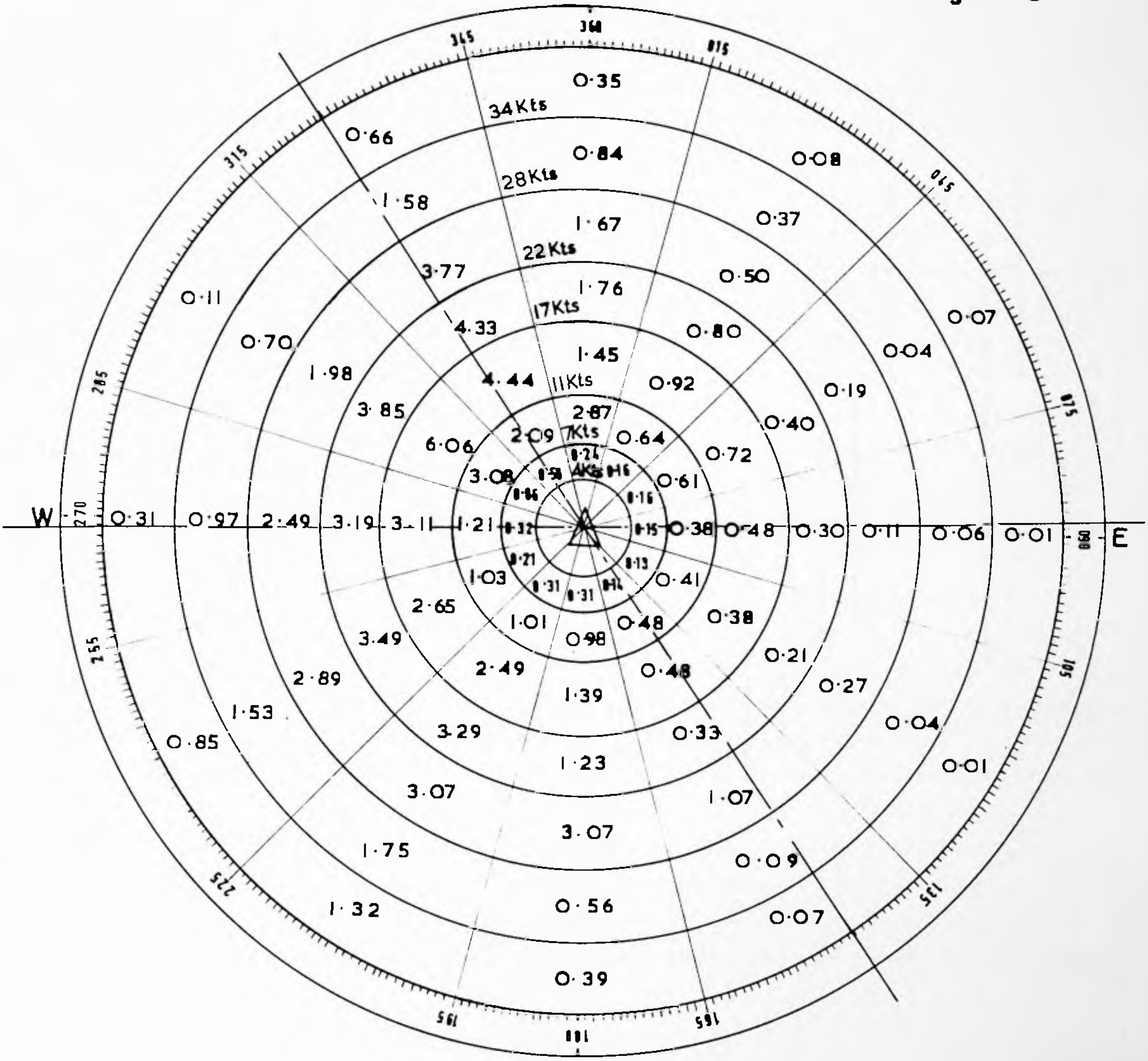
24 HOURS

NOTES

1. All observations related to True North.
2. Wind Rose based on 36,803 observations over 13 year period (1951 - 1963)
3. Figures within Wind Rose are percentage of observations.

Calms △ = 3·87%
Scale 10mm = 5knots

Figure 3



WIND ROSE

DAYLIGHT HOURS
05 to 17

Calms Δ = 3·39%
Scale 10mm = 5knots

NOTES

1. All observations related to True North.
2. Wind Rose based on 18,250 observations over 10year period (1954-1963)
3. Figures within Wind Rose are percentage of observations.

CONSTRUCTION SEQUENCE

Figure 4

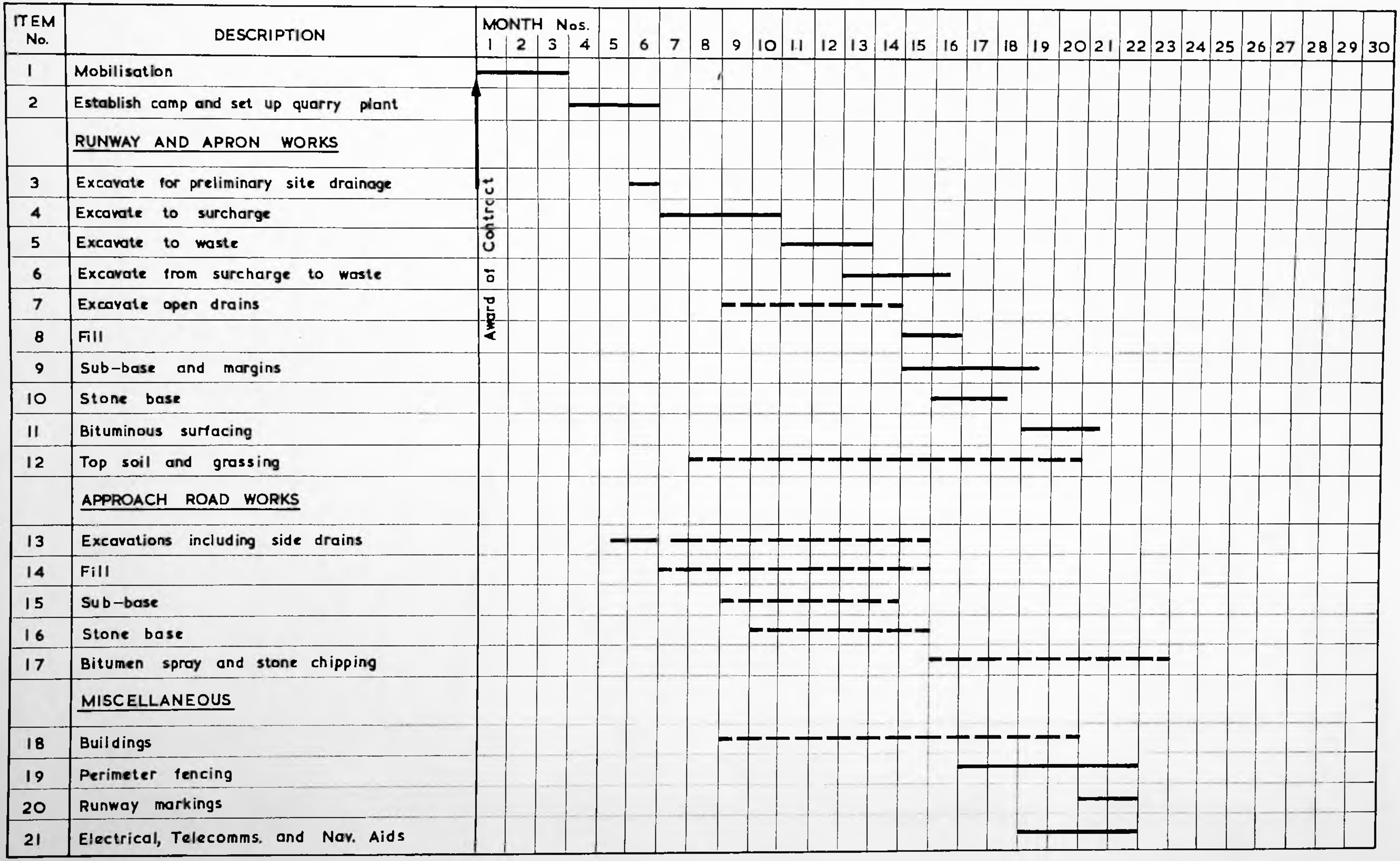


Figure No 5

PARTICLE SIZE DISTRIBUTION

Location Yorke Bay and Borehole 8 — Sample Reference No. —

Visual Description Light grey uniform fine to medium sand — Depth —