DEPARTMENT OF MINES & ENERGY
SOUTH AUSTRALIA

Rept.Bk.No. 79/47

PORT LINCOLN PLANNING STUDY
ENGINEERING GEOLOGY INVESTIGATION

Client: Port Lincoln City Council

GEOLOGICAL SURVEY

By

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ENGINEERING DIVISION

G.S. No.6163
ENG. No.1979/9
D.M. No.174/79

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DEPARTMENT OF MINES & ENERGY
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ABSTRACT

The area surrounding Port Lincoln can be divided into three main physiographic regions. The aeolianite plain, the coastal plain and the highlands. Soil types range from shallow, well-drained terra rossa overlying the aeolianite to imperfectly drained duplex soils overlying the basement rocks of the highlands and the alluvial sediments of the coastal plain.

Reticulated groundwater supplies are expected to meet the demand of the Port Lincoln Water District for the next 30 to 40 years. The only potable underground water supplies can be obtained from the aeolianite aquifer.

The main foundation problems likely to be encountered are low density collapsing soils associated with soft and friable aeolianite; possible expansive soils occurring in areas subject to inundation or associated with creek alluvium; and seepage problems in hillslope excavations due to high water tables and inadequate drainage.

Sufficient reserves of aggregate and construction sand exist in the area for the forseeable future with alternative sources of coarse sand located to the northwest of the township. Proximity to the Lincoln Fault suggests that appropriate construction code requirements for earthquake resistant buildings be adopted for larger buildings.

INTRODUCTION

The City and District Councils of Port Lincoln and the Department of Housing, Urban and Regional Affairs have commissioned a study on the direction and nature of growth on the fringes of Port Lincoln. A request to the Department of Mines and Energy was received for information on soils, drainage, water resources, seismic risk and engineering geology with special reference to restraints on building construction.

PHYSIOGRAPHY

The area under study has been divided into three physiographic regions (which are closely controlled by the underlying geology) by Laut et al (1977). The topography, soils, vegetation and drainage will be discussed for each of the regions (Fig. 2).

Aeolianite plain

This region comprises an undulating plain overlying the aeolianite of the Bridgewater Formation with isolated hills (basement rocks). The dominant vegetation is mallee which blankets most of the area. Taller eucalypts are found along the drainage course of Duck Creek. Slope values average $1\text{-}3^{\circ}$. Soil cover consists of red friable loams of the terra rossa variety with some rendzinas. The soils are usually shallow (very thin or absent in some places) and are well drained although susceptible to sheet erosion when cleared and exposed.

The permeable nature of the soils and the underlying aeolianite results in very little, if any, surface runoff.

Coastal plain

This plain slopes gently from the highlands, eastwards to the coast where it is bounded by mudflats and dunes. It is totally cleared of natural vegetation and sown with pastures and cereal crops. Slopes average $1\text{-}3^{\circ}$. Soils are imperfectly drained and consist of duplex soils (i.e. soils with contrasting textural properties between the A horizon and B horizon). In this locality a sandy silty soil overlies a clay subsoil.

Fixed dunes occur on the coast and consist of a well drained whitish calcareous sand with slopes averaging $3\text{-}10^{\circ}$. Minor blowouts can result if the protective vegetation cover is removed. Mudflats which are subject to inundation occur on the landward side of the coastal dunes.

Highlands I

Rounded hills and low ranges attain a mean altitude of 170 metres. Much of the native vegetation has been cleared to provide an open parkland for grazing. Remnants of native vegetation in the form of peppermint box, sugar gums and yaccas, occur on hill crests and in some gullies. Slopes average 10-17° with a maximum of about 30°. Soils are imperfectly drained and consist of duplex soils with sandy loam over clay (podsols, red brown earth) on the hillslopes and skeletal and stony but usually well-drained soils with ironstone gravel on the ridges. Occasional well-drained weakly structured sandy soils are encountered on the slopes.

The surface soils usually set hard, but once cleared and exposed, they are susceptible to erosion. Gullying can be rapid where this erosion reaches to clay sub-soil.

Intermittent streams flow in the gullies some of which have small reservoirs constructed on them to collect runoff for stock watering.

Highlands II

This region includes low hills derived from the dissection of a lateritic plateau. This area is mostly cleared to provide an open parkland and grassland which is utilized for grazing and cereal cropping. Again the soils are imperfectly drained and consist of duplex types described above. Ironstone gravel is found on the slopes and crests with the dominant remaining vegetation being peppermint box, sugar and blue gums.

GEOLOGY

The geology of the Port Lincoln area is shown in Fig. 3 and a short summary appears in Table I together with comments on hydrogeology and engineering geology.

The oldest rocks exposed are the basement rocks of early Proterozoic age which form the highlands to the immediate west and north of Port Lincoln. They consist of metasedimentary rocks of the Hutchison Group (quartzites, schists, dolomites etc) and granitic gneisses of the Lincoln Complex. These rocks are the oldest recorded in South Australia and have a probable age of 2590 million years based on radioactive isotope dating.

During the Tertiary age, fossil lateritic soils were developed on the basement rocks in some areas. These soils are usually shallow and contain variable amounts of massive ironstone gravel (buckshot). During laterization, the basement rocks underwent deep weathering, ferruginization and kaolinization (Johns, 1961). A large portion of these rocks are obscured in the highlands by the laterite which forms a continuous sheet.

The windblown calcareous sands (aeolianite) of the Bridgewater Formation blanket large areas to the south and west of Port Lincoln and in some areas, form spectacular coastal scenery.

The Semaphore Sand of Quaternary age comprizes fixed calcareous and siliceous dunes along the coastline to the north of Port Lincoln.

Recent alluvial deposits consisting of clays, sands and gravels cover large areas, in particular the eastern coastal plain and drainage lines to the west of the highlands (here, the alluvium consists largely of resorted lateritic gravel).

Geological Structure

Port Lincoln lies on the Gawler Platform which is a stable crustal zone extending from Yorke Peninsula through the Gawler Ranges to the far northwest. This area of basement rock is generally low in relief and is usually blanketed by a thin veneer of sediments. The metasedimentary rocks and granitic gneisses which comprise the basement have been highly metamorphosed and tightly folded to form a major north to northeast trending orogenic belt (Rutland et al, 1979).

Faulting of basement rocks has occurred subsequent to the major folding episodes. The major structural feature is the prominent scarp associated with the Lincoln Fault (Fig. 3). The vertical movement is estimated to be about 200 m and was associated with the formation of the gulfs (Johns, 1961). Another prominent feature is the mylonite zone which marks the boundary between the Hutchison Group and the Lincoln Complex. This zone comprizes rocks which have been pulverized and rolled during faulting or intense metamorphism.

WATER RESOURCES

Groundwater

Although the water reticulated throughout the Port Lincoln Water District (Fig. 4) is pumped from groundwater basins to the south (Lincoln and Uley South; see Fig. 4), actual groundwater quality and quantity at any location is dependent on the underlying geology and physiography. There are four main sub-divisions.

(a) Aeolianite plain - the aeolianite of the Bridgewater Formation is the most widely utilized aquifer on Eyre Peninsula, not only in the Port Lincoln area, but also further up the west coast at Polda and Streaky Bay. Good quality groundwater is nearly always intersected in this aquifer in the sandy area, except near the margins of the unit where it thins out. The permeable nature of the sediments allows rainfall to percolate freely to the water table, which varies in depth from 10-15 metres depending on the surface elevation. Water quality ranges between

300-3000 mg/1 Total Dissolved Solids but is generally less than 1500 mg/1 (see Appendix A on suitability of underground water for agricultural purposes). Total hardness is about 400 mg/1 and water softeners are required to prolong the life of domestic appliances. Supplies obtainable are variable up to about 200 kl/day (2000 gph), but south of Little Swamp, some supplies of 1000 kl/day, (10 000 gph) have been obtained. In some areas, good supplies of reasonable quality water can be found in permeable zones in the Tertiary lateritic sediments which underlie the aeolianite.

Reticulated supplies are expected to meet demands in the Port Lincoln area until well after the year 2000 (Yandell, 1976), however the aeolianite aquifer could not sustain a heavy concentration of individual domestic water supply wells.

(b) Highlands - the basement rocks are not regarded as good aquifers because of the massive nature of the gneissic and quartzite rocks and the strong tendency of the schists to weather to clayey material. These factors prevent the development of fracture systems which are necessary in hard rocks to allow downward percolation of rainfall and movement of groundwater. Consequently only small supplies of stock quality water (over 5000 mg/1) are generally developed.

(c) Valleys in highlands - most valleys contain alluvium consisting of clays, sands and sometimes gravel. Many of the creeks flowing in these valleys are fed by springs derived from runoff which has percolated down into the alluvium and flowed as groundwater slowly downstream. Wells up to 10 metres deep sunk into this shallow valley alluvium generally yield only small supplies of stock quality water.

TABLE I
SUMMARY OF HYDROGEOLOGY AND ENGINEERING GEOLOGY

Age/Formation	Geology	Soils	Hydrogeology	Engineering Geology
Recent/Quaternary				
-Alluvium	Clays, sands and gravels	Imperfectly drained duplex soils on coastal plain. Variable in creeks	Variable in supply and salinity. Better quality in gravels e.g. old river courses	Creeks subject to flooding, uncertain distribution of weak materials near creek valleys. Areas subject to inundation on plain
-Semaphore sand	Calcareous and Siliceous dunes	Well drained sand	Insufficient information	Subject to blowouts
Pleistocene				
-Bridgewater	Aeolianite - may be consolidated or loose. Usually with surface capping of calcrete	Well drained, shallow loams (terra rossas, some rendzinas)	Very good aquifer. Supplies up to 250 kl/day of good quality water - usually less than 1500 mg/l	Collapsing soils with soft material. Surface calcrete may require blasting
Tertiary	Lateritic soils on bedrock with ironstone gravel	Imperfectly drained sandy loam over clay	Only forms aquifer when overlain by aeolianite. Moderate supplies of good quality from permeable zones	Susceptible to sheet erosion
Early Proterozoic				
-Hutchison Group	Quartzites, schists, dolomites. May be weathered at surface	Imperfectly drained duplex soils (podsols, red-brown earth). Gullying can be if cleared	Poor aquifer. Stock quality water only	May have non uniform foundation conditions. Excavations should have adequate drainage. Service trenches may require blasting
-Lincoln Complex	Granitic gneiss. May be weathered at surface	As above	As above	As above

Sites located higher up the gullies provide better quality water than further downstream. Supplies and salinities are highly variable.

(d) Coastal plain - clays, sands and gravels overlie the basement rocks at shallow depth. Again groundwater supplies from shallow wells are very variable, but some have obtained water of less than 1000 mg/l from ancient buried stream channels.

Surface Water

Where groundwater salinities are too high, dams are sometimes used for stock supplies where suitable catchments exist. Most streams in the study area drain to the east towards the coast and flow intermittently, usually after heavy rain. To the northeast, sand dunes prevent the streams from entering the sea. Instead they terminate in mudflats.

The Little Swamp-Duck Ponds system contains surface water only after very wet years, and it is only in exceptionally heavy rainfall years that Duck Creek actually flows south to Tulka. This lack of runoff is probably due to the permeable nature of the underlying aeolianite.

Pollution Potential

Potential for contamination of the unconfined aquifer in the aeolianite is high due to the permeable nature of the soils and sediments. Possible sources in the study area include stormwater and septic tank drainage, stock wastes and waste disposal. The long-term effect of agricultural fertilizers (which can yield nitrates and phosphates) on groundwater quality is not known with certainty. Fortunately, there are few sources at the present time. The groundwater basins which supply reticulated water have a very low pollution potential as the E & W S Department have taken ownership over the basin areas (Fig. 4) and consequently, land use is strictly controlled.

In other areas, contamination of surface water could occur where septic effluent may not drain away due to the impermeable nature of the bedrock, and lateral subflow into drainage lines or out onto the land surface may occur. Recticulated sewerage is therefore recommended.

ENGINEERING GEOLOGY

Problems associated with engineering geology can also conveniently be described in terms of physiographic region. See also Table I.

(a) aeolianite plain - a surface capping of calcrete may present problems with excavations. Although usually consolidated, the aeolianite may be soft and friable beneath a thin calcrete crust. Settlement under load may occur, expecially when the soil is damp. This problem is particularly apparent in the shopping area of the township where the aeolianite overlies the basement at variable depth. To overcome this, wide footings should be used and the soil near the footing should be kept free from moisture.

(b) highlands - shallow fresh bedrock will make sound building foundations provided unstable bedrock is removed. However, bedrock between fresh outcrops may be weathered and overlain by a clay soil of high plasticity, thus providing non-uniform foundation conditions.

Building should not be permitted on the alluvium in or near creekbeds because of the danger of flooding and the uncertain distribution of weak materials in the alluvial sand, gravel and clay sediments. Slope stability should not present problems due to the very low landslide potential which results from strong bedrock at shallow depths and the low slope gradients.

Care must be taken to provide adequate drainage for any excavations cut into the hillside. Although conditions may be dry at the time of excavation, shallow groundwater seepages can develop in very wet years.

In some areas of the highlands, large areas of outcrop of near surface bedrock (up to 30% of land area) may make development for agricultural purposes (farmlets) unsuitable.

(c) coastal plain - the potential problems in this area are the dangers associated with proximity to creeks (as described above) and areas which are subject to inundation.

(d) other - in addition to the swampy areas near the coast, the area to the northwest of Little Swamp is also subject to inundation. Soils in these areas are also probably expansive i.e. are subject to marked changes in volume with changes in moisture content.

In the township area and environs, stability and drainage problems may be associated with infilled drainage lines (e.g. seepage problems downstream of the dam on Normandy Place) and possibly old rubbish dumps. In these situations, high water tables are promoted by imported material of low permeability. In other areas, a shallow water table may be established on the weathered bedrock surface which may be impermeable. This results in 'springs' on the ground surface and seepage problems for any excavations and buildings therein (e.g. Kent Place). Adequate drainage facilities constructed at the time of excavation would help solve this problem. Occasional patches of expansive clays associated with weathered amphibolite rocks (intruded into granitic gneiss) require special footing design (e.g. Rosslyn St.)

It must be stressed that these comments are general in nature and that it is strongly recommended that potential building sites be inspected individually to ensure adequate footing design.

EXTRACTIVE INDUSTRY

Table II lists details of quarries within the area of interest, and locations are given in Figure 3. The two main materials currently extracted are construction sand and quartzite aggregate.

Stranded beach deposits at Louth Bay, Poonindie and North Shields provide the bulk of the current production of construction sand for Port Lincoln. Under the Mining Act 1971-1972, additional mining within 800 metres of the coast is prohibited, however more than adequate reserves of medium and fine grained sand are available from the current tenements. Adequate reserves of coarse sand do not exist in the area, but Nichol (1977) has located several alternative sources to the northwest of Port Lincoln.

Adequate reserves of quartzite and granite aggregate also appear to be located in existing quarries near Port Lincoln. If these were to be exhausted, the local geology appears quite favourable for the development of new quarries to the north of Port Lincoln. There may be a possible conflict between the Port Lincoln Quarry and any western expansion of the township due to the noise nuisance of blasting.

SEISMICITY

Based on the geographical distribution of earthquake epicentres, Eyre Peninsula is classified as an active zone. The largest earthquake recorded was located near Cleve on 2nd November, 1959, with a magnitude of 5.1 - large enough to be detected by all Australian seismic stations. In the early

TABLE II

CONSTRUCTION RESOURCES - PORT LINCOLN AREA

Site No. (Fig.3)	Quarry Owner (Operator)	Location (section)	Status	Mineral Mined	Usage	Production (tonnes) Dec 77-Dec 78	Reserves	Comments
HD. LINCOLN								
1	L. Robertson (D.K. Quarries Pty. Ltd.)	402	Operating	Granite	Road constn.	44790	Not known	
2	P. Constantinopoulos (W. Murphy)	438	Operating	Sand	Filling Road constn.	1525	32 000 tonnes	Lease expires Dec. 1979
3	K. Harris	50	Operating	Sand	Filling	22055	Expected 10 yrs.	Access difficult in winter months
4	P. Whillas	163, 256	Not yet worked	Quartzite	Road constn.			Lease under applicn.
HD. LOUTH								
5	M. Murray (B. Hage)	159	Operating	Quartzite	Aggregate	2050	At least 10 yrs.	
6	M. Bascombe (Poonindie Brickworks)	123	Operating intermittent-ly	Clay	Bricks	1000	Expected 15 yrs.	Pit used for last 20 yrs.
7	K. Harris	110, 111	Operating	Sand	Construc-tion	1800	45 000 tonnes	Drilling recom-mended for reser ves calculation
8	Pearce Transport Pty. Ltd.	124	Operating	Sand	Fertilizer filler	9350	120 000 tonnes	
9	K. Seeman	277	Operating	Sand	Construc-tion	11580	140 000 tonnes	Worked out portion used as rubbish dump

1960's several earthquakes of magnitude 4.0-4.5 were detected regularly each year, but over the last eight years or so, none have been recorded. The damage threshold is thought to be magnitude 4.75 (McCue, 1975). Several earthquakes swarms have been felt but have been localized in their influence and of low magnitude.

The epicentres recorded since 1963 are associated with the basement rocks but unfortunately, due to the distance and widespread nature of the station network, accurate locations could not be determined. Recent geological mapping in the highlands has revealed a number of north-south faults which could well be associated with seismic activity.

In the Port Lincoln area, the Lincoln Fault (Fig. 3) is the obvious location for seismic activity which would result from any future movement along the scarp. The township is situated in Zone 1 of the preliminary risk map prepared by the Standards Association of Australia (1976) which incidentally, also includes Adelaide. See Appendix B for comments on building damage during earthquakes.

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SRB:NK

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APPENDIX A

SUITABILITY OF UNDERGROUND WATER FOR AGRICULTURAL PURPOSES

APPENDIX B

DAMAGE TO BUILDINGS DURING EARTHQUAKES

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DAMAGE TO BUILDINGS DURING EARTHQUAKES

It is quite possible that during an earthquake a structure several hundred metres from the fault on which movement occurred could suffer similar damage to a structure immediately above it.

Detailed observations in those parts of the world where earthquakes are common have shown that there are three main factors which influence the amount of damage sustained by buildings during earthquakes, namely:

(a) Distance from the epi-central zone. In some cases, there is visible dislocation of ground surface along the fault trace during earthquakes (eg. Meckering Earthquake. Western Australia). The zone in which ground dislocations occur is commonly termed the "complete destruction" zone.

(b) The type of foundation material upon which buildings are located. In the majority of cases the greatest damage occurs to buildings located on unconsolidated fills and alluvial soils. Buildings located on rock usually sustain the least damage.

(c) The type of construction. It has been found that structures can be designed and built so as to minimise, but not eliminate entirely, the damage due to earthquakes. Special building codes have been developed in countries or regions which have frequent earthquakes. However, even where structural collapse of buildings is prevented, there is still a relatively high danger of fire, and damage to services - water, gas and electricity. Proposed buildings codes for Australia (Standards Association of Australia, 1976) suggest that regulations to cover the design of buildings with relation to resistance to earthquakes should be the responsibility of Local Council bodies, and would depend on the likely seismicity in any areas.

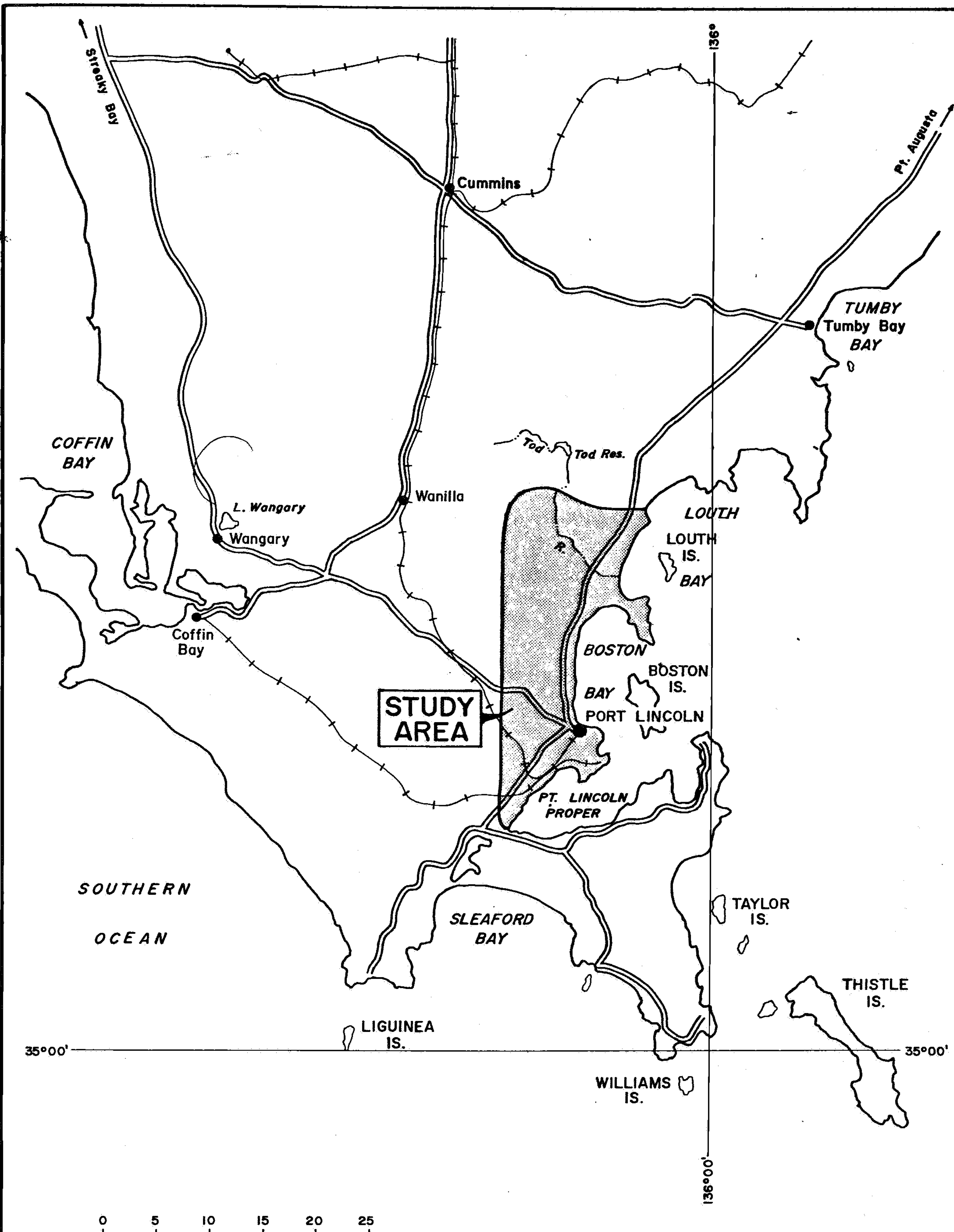


FIG. 1

	DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	SCALE 1:500000
COMPILED S. Barnett	PORT LINCOLN PLANNING STUDY	DATE 22nd March 1979
DRN TE / CKD		PLAN NUMBER
	LOCALITY PLAN	S 13949

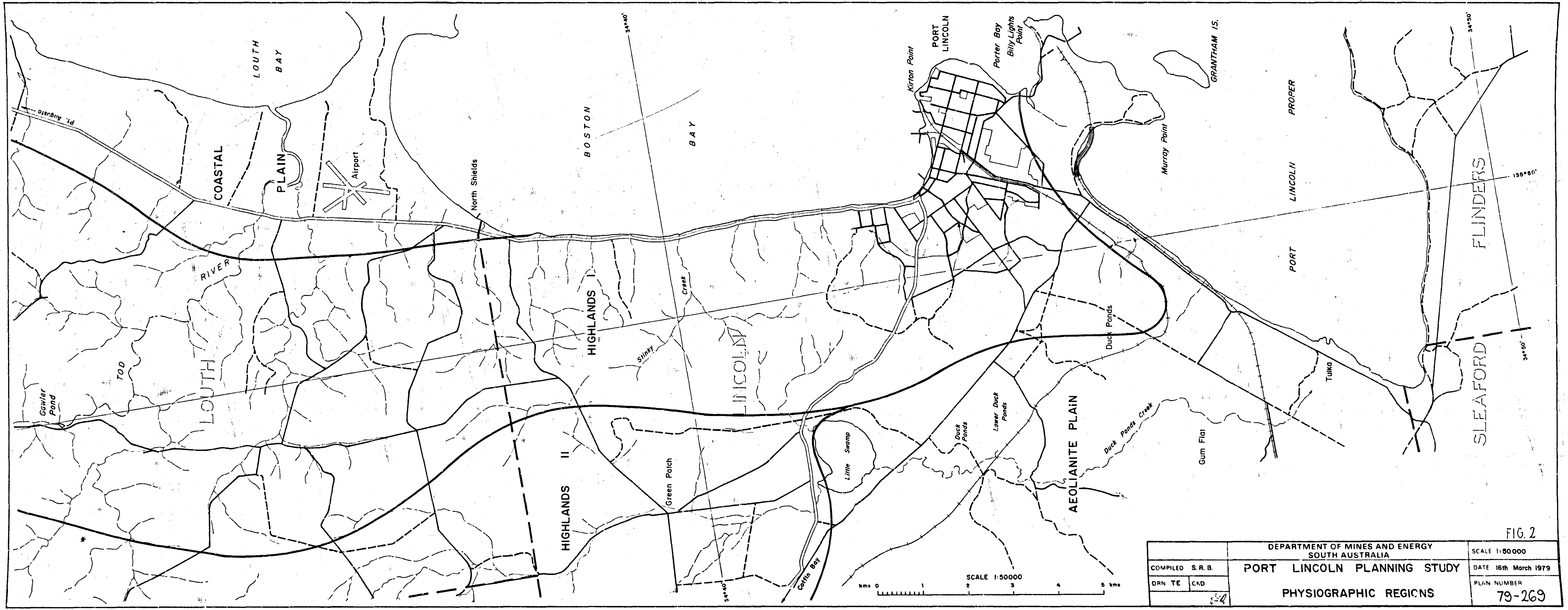
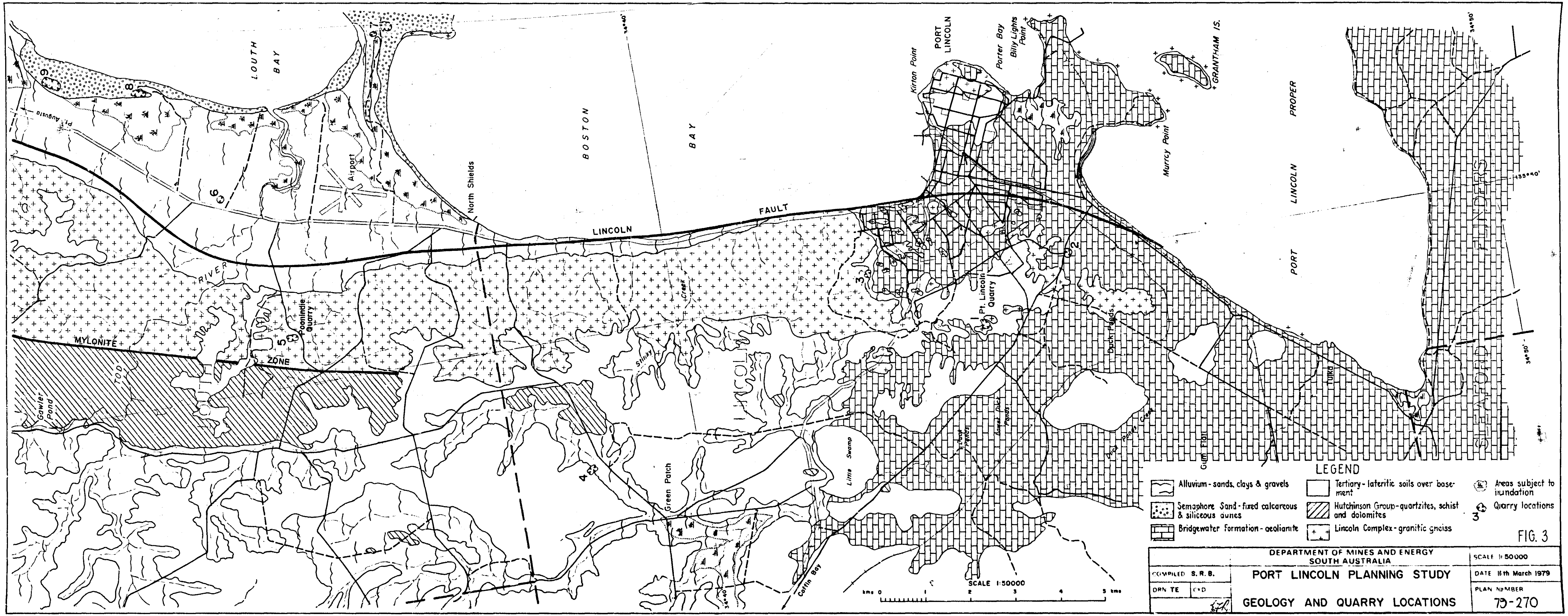
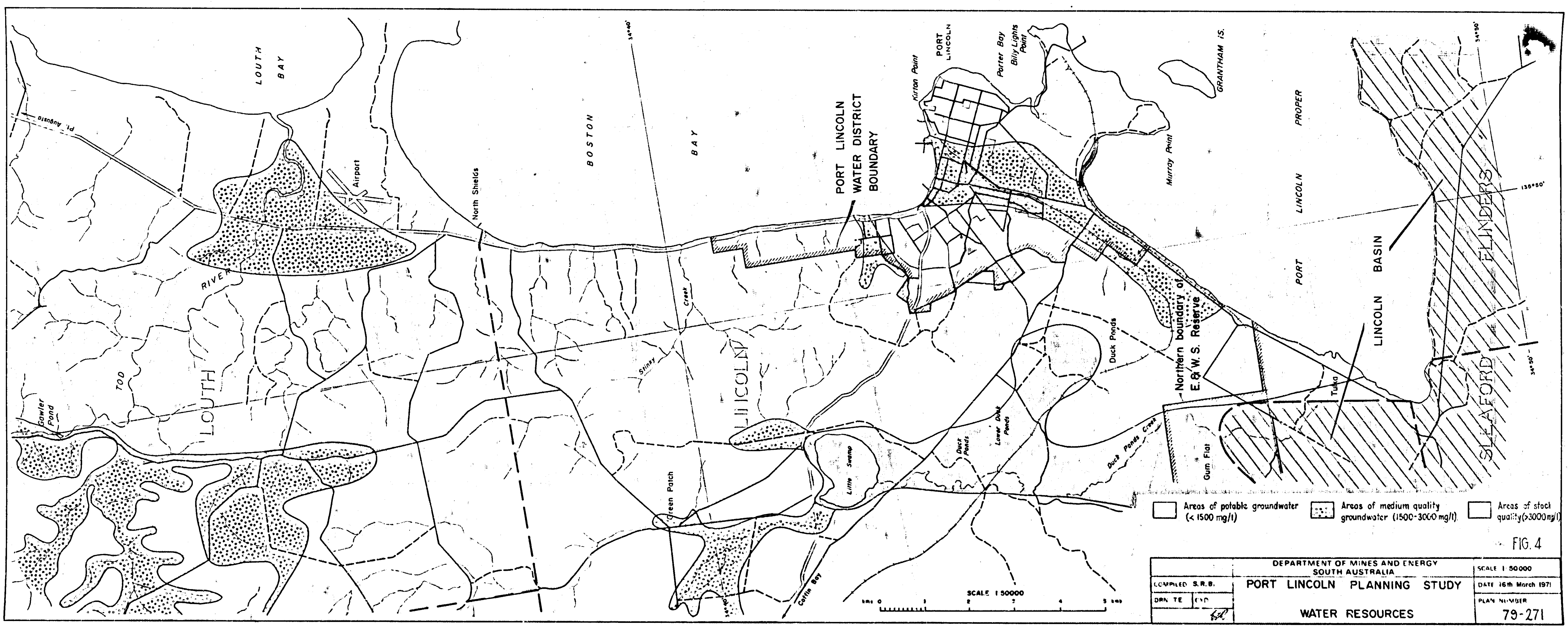


FIG. 2

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	SCALE 1:50000
PORT LINCOLN PLANNING STUDY	DATE 16th March 1979
PHYSIOGRAPHIC REGIONS	PLAN NUMBER 79-269
COMPILED S.R.B. / DRN TE / CKD	



LOUTH BAY
BOSTON BAY
PORT LINCOLN
Kirton Point
Porter Bay
Billy Lights Point
GRANTHAM IS.
Murray Point
PORT LINCOLN PROPER
North Shields
Airport
LINCOLN FAULT
RIVER
MYLONITE ZONE
Poonindie Quarry
Pt. Lincoln Quarry
Duck Ponds
Stinky Creek
Gawler Pond
Green Patch
Little Swamp
Coffin Bay
Tulka
Gum Flat
LEGEND
Alluvium - sands, clays & gravels
Semaphore Sand - fixed calcareous & siliceous dunes
Bridgewater Formation - aeolianite
Tertiary - lateritic soils over basement
Hutchinson Group - quartzites, schist and dolomites
Lincoln Complex - granitic gneiss
Areas subject to inundation
Quarry locations
SCALE 1:50000
kms 0 1 2 3 4 5 kms
FIG. 3
DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA
COMPILED S.R.B.
DRN TE
PORT LINCOLN PLANNING STUDY
GEOLOGY AND QUARRY LOCATIONS
SCALE 1:50000
DATE 16th March 1979
PLAN NUMBER
79-270



LOUTH BAY
Pt. Augusta
Airport
North Shields
BOSTON BAY
PORT LINCOLN WATER DISTRICT BOUNDARY
Kirton Point
PORT LINCOLN
Porter Bay
Billy Lights Point
GRANTHAM IS.
Murray Point
PROPER
PORT LINCOLN
LINCOLN BASIN
FLINDERS
SLEAFORD
Northern boundary of E.&W.S. Reserve
Duck Ponds
Lower Duck Ponds
Duck Ponds Creek
Tulka
Gum Flat
Little Swamp
Green Patch
Cattle Bay
Stinky Creek
LINCOLN
LOUTH
TOD RIVER
Gawler Pond
34°40'
34°50'
135°50'
Areas of potable groundwater (< 1500 mg/l)
Areas of medium quality groundwater (1500-3000 mg/l)
Areas of stock quality (>3000 mg/l)
SCALE 1:50000
FIG. 4
DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA
PORT LINCOLN PLANNING STUDY
WATER RESOURCES
COMPILED S.R.B.
DRN TE
SCALE 1:50000
DATE 16th March 1971
PLAN NUMBER
79-271