1950/19
Copy 3

COMMONWEALTH OF AUSTRALIA.

MINISTRY OF NATIONAL DEVELOPMENT.
~~DEPARTMENT OF SUPPLY AND SHIPPING.~~

BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS.

~~REPORT NO.~~ :

RECORDS	:	1950 No. 19.
PLANS	:	N60 - 3A - 1
		N60 - 3A - 2
		N60 - 3A - 3
		N60 - 3A - 4

MINERAL DEPOSITS OF The TWEED - FINGAL AREA. NORTHERN NEW SOUTH WALES.

D. E. Gardner.	Geologists.
J. Ward.	
T.D. Dimmick	
L.M. Edhousel	Geophysicist.
L.R. Lee.	Laboratory Assistant.

SOUTHPORT, QLD. JULY 1950.

MINISTRY OF NATIONAL DEVELOPMENT.

BUREAU OF MINERAL RESOURCES.

GEOLOGY AND GEOPHYSICS.

RECORDS : 1950. No.19.

PLANS : N60 - 3A - 1
N60 - 3A - 2
N60 - 3A - 3
N60 - 3A - 4

MINERAL DEPOSITS OF THE TWEED - FINGAL AREA. NORTHERN NEW SOUTH WALES.

D.E. Gardner.
J. Ward. } Geologists.
T.D. Dimmick.

L.M. Edhouse. Geophysicist.

L.R. Lee. Laboratory Assistant.

SOUTHPORT. QUEENSLAND. JULY 1950.

MINISTRY OF NATIONAL DEVELOPMENT.

BUREAU OF MINERAL RESOURCES.

GEOLOGY AND GEOPHYSICS.

RECORDS : 1950, No.19.

PLANS : N60 - 3A - 1
N60 - 3A - 2
N60 - 3A - 3
N60 - 3A - 4

MINERAL DEPOSITS
OF
THE TWEED - FINGAL AREA.
NORTHERN NEW SOUTH WALES.

CONTENTS. **PAGE.**

ILLUSTRATIONS : At end of report.

TABLES.

MINERAL DEPOSITS OF THE TWEED - FINGAL AREA.
NORTHERN NEW SOUTH WALES.

SUMMARY.

The deposits of heavy mineral sands along the East Coast of Australia are being investigated primarily to determine their content of monazite. In the Tweed-Fingal area, a deposit beneath the dunes adjacent to the beach, has a length of 9000 feet, a width varying from 80 feet to 330 feet, and an average thickness of 2.6 feet. A second deposit in the northern third of the area, from 400 to 800 feet west of the beach, is approximately 1700 feet long, varies in width from 140 to 250 feet, and has an average thickness of 2.2 feet. These deposits contain 47,000 tons of zircon-rutile-ilmenite-monazite concentrates, with an estimated 280 tons of monazite. The average grade is 365 lbs of heavy mineral concentrate per cubic yard of sand. The average thickness of overburden is 4.3 feet. Virtually the total area of the deposits is available for mining. The thoria content of the monazite is (6.6 ± 0.3) per cent.

The distribution of the heavy minerals in the deposits adjacent to the beach suggests that the grains of higher specific gravity, viz. monazite and zircon, are transported less readily than the grains of lower specific gravity, viz. rutile and ilmenite. However, in the western deposit, within the northern third of the area, the proportion of monazite is relatively high, while the proportion of zircon is relatively low.

A. INTRODUCTION.

1. General Purpose of the Investigation. The primary aim of the "Beach Sands Investigation" is to determine the reserves and the distribution of monazite in the deposits of heavy mineral sands along the East Coast of Australia. These deposits contain most of the known world reserves of zircon and rutile (Fisher 1949 (a) and (b)) for which they are being exploited at various localities, mainly from North Stradbroke Island in Queensland to Ballina in New South Wales. The monazite forms little more than 0.5 per cent of the mixed concentrates, but can be recovered as a by-product during the separation of the other minerals. Monazite, a phosphate of cerium, lanthanum, praeseodymium and other rare earths, with thorium silicate, is utilised commercially as a source of cerium and of thorium. In this investigation, the thorium content of the monazite is being determined on the basis of its radioactivity.

2. Situation. The Tweed-Fingal Area comprises a beach and associated dunes separated by the Tweed River from a low lying coastal plain, and higher country a mile to three miles to the west. The beach extends northwards for 3½ miles from Fingal Point to Letitia Spit at the mouth of the Tweed River, about 600 feet south of the solid rock which forms the North Head of the river and 2000 feet south of the Queensland-New South Wales State boundary. Plans of the area, along with a locality map, are given in Plate 1 at the end of this report.

3. Access. Access to the Tweed-Fingal area is by means of the Pacific Highway, which runs southwards through the coastal plain, and a main road which runs along the eastern bank of the Tweed River from the Highway bridge to Fingal Point. The area in the vicinity of Fingal Point is closely built up, forming the township of Fingal. Northwards from the Township, dwellings in a Native Settlement extend along the western foot of the dunes to about one third of the distance to Letitia Spit. A metalled track runs through the Settlement nearly to its northern end, but further north, motor transport over the sandy surface is practicable only by means of a four wheel-drile vehicle with a low reduction gear.

4. Mining Tenements. At the time of the investigation, leases and applications for leases (Footnote) (Plate 1) were held as follows :-

G.L.3 : J.A. Foyster, Cudgen, N.S.W.

Special Lease Applications :-

No.125 : J.A. Foyster, Cudgen, N.S.W.
No.144 : J.P. Murphy, Tweed Heads, N.S.W.
No.149 : J.P. Murphy, Tweed Heads, N.S.W.

FOOTNOTE : The application numbers are registered at the Court House, Murwillumbah, N.S.W.

5. Responsibility for Sections of this Report. The several sections of this report were compiled by those whoe were most directly responsible for the conduct of the respective portions of the work. In general, however, each member of the staff assisted in several phases of the investigation. Mr. T.D. Dimmick, now an officer of the Queensland Geological Survey, carried out the preliminary field work in the area. Mr. J. Ward, assisted by Mr. L.R. Lee, was responsible for Laboratory work, including the separation and examination of minerals. Mis L.M. Edhouse conducted radiometric determinations of quantities of monazite, and investigations of the thoria content of the monazite. D.E. Gardner supervised the work.

B. TOPOGRAPHY.

The area between the beach and the Tweed River varies in width from 1000 feet to 1400 feet. On the profiles of Plate 2, it is seen that the portion adjacent to the beach, about 400 to 600 feet wide, is formed of sand dunes rising to a height of 20 to 25 feet. The remainder of the area, 600 to 800 feet wide, is low and sandy, and encloses tidal lagoons connected by channels to the river. The sand dunes adjacent to the beach are in the form of long ridges parallel to the beach. This is illustrated in the profiles of the bore lines between line 6000N and 2950N, which show two main crests at approximately 100 feet and 150 to 200 feet west of the beach. An additional pronounced dune is shown clearly in lines 4500N and 5250N, about 600 feet west of the beach, and can be traced further south. North of line 5250N this dune terminates against a lagoon, which encroaches on the edge of the main dunes, and probably represents a former channel of the Tweed River.

South of line 6000N the dunes are firmly bound by vegetation, which, on their western or landward sides consists of mixed dune scrub (trees, shrubs and vines) thick enough in places to impede progress through the area. On the eastern or seaward side, a covering of shrubs persists to within about a hundred feet of the beach, where it gives place to coarse grass and spinifex. Some distance north of the 6000N line , the vegetation becomes sparse and scattered, and the dunes have been broken up to some extent by wind erosion. The effects of this erosion may be seen in the profiles, in Plate 2, of lines 7500N to 9000N, where sharp subsidiary crests and hollows appear on the outlines of the main dunes. The ridges which occur west of the main dunes, in particular the ridge adjacent to the lagoon on lines 8250N and 9000N, are similar active dunes. The islands within the river channel are sandy, and range in height from river water level to 6 or 8 feet above water level. Their western edges are fringed by mangrove swamps. The coastal plain which ranges in level from 10 to 25 feet, (see footnote) is made up of low sandy areas covered by gum, scrub box, banksia, shrubs and bracken, with swampy tracts characterised by stands of paper-bark tea-tree and swanp sheoak, with rush-like sedges. The seamps between the Pacific Highway, and the spurs of higher country to the west have a surface level approaching 10 feet. At the edge of the river, the coastal plain is, in places, fringed by mangrove swamps. Portions of the plain are illustrated in the profiles of the scout-boring lines. (Plate 3) From about 2 miles south of Fingal Point, the Tweed River flows approximately northwards parallel to the coast, and is separated from the ocean by a comparatively narrow dune area. It is probable that the mouth of the river has been much further south that it is at present, and has been moved northwards because of the growth of sandspits from Cudgen Point to Fingal Point, and from Fingal Point to Letitia Spit.

C. GENERAL GEOLOGY.

1. The Beach and Coastal Dune Area. The sand dunes and the coastal plain are recent in age, and are composed of unconsolidated quartz sand. The dunes adjacent to the beach contain small quantities of heavy minerals, and overlie "seams" of heavy minerals.

FOOTNOTE. Mean low water has been adopted as the datum for levels in this report. Mean seal level is approximately 3 feet, and mean high water level approximately 6 feet.

These seams were deposited by the surf on the upper part of the beach during stormy weather in periods when the beach was a little to the west of its present position. The deposits of heavy minerals in Block 2 Plate 1 near the northern end of the area, viz., from 7500N to 9000N, owe their origin in part to wind concentration. It appears probable that in this locality former beach deposits have been exposed and carried by the wind along with quartz sand into recent small active dunes.

The dune which occurs at the top of the beach - the foredune- continually receives additional sand blown from the beach by the prevailing winds. During stormy periods, the foredune may be eroded away. The vegetated sand ridges behind the present foredune appear to represent former foredunes, developed during periods when the top of the beach was some distance west of its present position. The dune strip which appears typically on line 6000N from 110W to 55E can be traced unbroken from the northern end of Letitia Spit to, approximately, the 00 bore line, and apparently has been formed from sand blown up from the present beach. During the period of its development, the top of the beach advanced in an easterly direction from approximately 110W to 55E. The crest seen at 6000N / 190W represents a prominent dune easily recognised in the field from some distance south of the 5250N bore line up to about the 6750N line. This apparently was a foredune formed when the position of the beach remained stationary for some considerable time, viz. on the 6000N lines, at approximately 140W. The dune strip which includes this old foredune, i.e. 6000N/325W to 6000N/160W, is readily recognised from about the 5250N line northwards to the southern boundary of G.L.3, where it terminates abruptly near the edge of a lagoon. During the period when this dune strip was developing, the top of the beach, recognised by the deposits of heavy minerals below the dunes, advanced in an easterly direction from about 6000N/260W to 6000N/160W. It is probable that this dune strip, with the underlying deposits of heavy minerals formerly continued further northwards, but that its northern end has been eroded by the Tweed River. The south-eastern boundary of the lagoon in this locality may mark the supposed river channel. The deposits of heavy minerals in Block 2 from 7500N to 9000N, now subject to re-sorting by wind action, were probably originally beach deposits continuous with the deposits in line 6000N, 260W to 160W, but were later re-sorted during the encroachment of the river.

In the southern portion of the area, the prominent dune at 00/ 400W trends north-westerly and terminates abruptly at about 300 feet south of the 750N bore line. At the northern end of the south-eastern margin of the lagoon, which is close to the termination of the dune, numerous basalt boulders appear. A bed of basalt boulders is exposed on the beach during stormy weather, approximately 300 ft. south of the 750N line. On the 16th December 1949, the boulder bed appeared from about 300 feet south to 450 feet south of the bore line, and extended seawards towards Cook Island. It is possible that the boulders approximately represent an old river channel which breached a former dune spit. The heavy mineral intersected in bore line 750N as far westerly as 570W may represent concentrations formed at that time.

2. <u>Adjacent Areas.</u> Pliocene basalt outcrops at Fingal Point and Cook Island, and continues downwards below sea level. This basalt appears as cliffs at the northern and western edges of the Tweed River near the Highway Bridge, where it continues below river water level. Inliers or "islands" of Lower Palaeozoic sediments separate the western edge of the coastal plain from the Terranora Broadwater, form the higher land on which is built the greater part of the Town of Tweed Heads, and form the headland at Point Danger. In places, these sediments are capped by Pliocene Basalt.

3. <u>Evidence of Recent Emergence.</u> The present beach and coastal dunes, and the coastal plain, appear to be a result of a comparatively recent emergence of this portion of the coast. Evidence of emergence is seen in the following :-

(a) A platform, presumably wave cut, surrounds Cook Island at a height of approximately 10 feet above high water level.

(b) Conglomerate, consisting of rounded and sub-rounded boulders of basalt, and rounded quartz pebbles, appears in a cutting near the Fingal Post Office, from the road level up to approximately 12 feet above present high water level.

(c) A shingle bed, composed of sub-angular boulders of basalt, 12 to 15 feet above present high water level, fringes the sand and indurated sand which joins the basalt outcrop of Fingal Point to the larger outcrop of basalt at Fingal Township.

The emergence suggested by the conglomerate and boulder beds appears to be of the order of at least 15 feet. Apart from this evidence, numerous kitchen middens appear on the spurs of higher land at the western edge of the coastal plain. These middens are now separated from river and beach by wide tracts of swamp and tangled vegetation. The middens seem to indicate an eastward recession and the coast line, with the development of a swampy coastal plain. However the emergence suggested by the occurrence of the middens may be of small magnitude.

D. METHOD OF TESTING.

1. Mapping. The positions of the bores in Letitia Spit were mapped in a plane table survey, which related them to the lease pegs of G.L.4, and to the eastern training wall of the Tweed River. Bores south of G.L.3 were related to the eastern training wall, and to the surveyed western boundary of the allotments in the Native Settlement. The bore sites in the coastal plain were marked out by chaining from fences shown in the New South Wales Lands Dept. Plan of the Parish of Terranora, County of Rous (Scale : 1 inch equals 40 chains. Date : January, 1947). A plan showing the bores in the Tweed-Fingal area on a scale of 500 feet to the inch is given in Plate 1. The boundaries of Palaeozoic sediments and Tertiary basalt were sketched on to Military Maps and Lands Department Parish and Town Plans. These boundaries are approximate only.

2. Boring. Boring to ground water was by means of a post hole digger or auger, lengthened as required with 5 foot lengths of piping, coupled by screw joints. Below ground water level, or below the depth to which sampling of loose sand could conveniently be done with a post hole digger, about 20 feet, the bore hole was cased with light 3 - inch boiler tubing, and a sand pump used. Before boring was started, the bore sites were levelled, using a telescopic alidade set up on a plan table. The datum for levels was high water mark, which was assumed to have the level given in the Tide Tables of the Queensland Department of Harbours and Marine, plus one to two feet added for the wash of the surf. The levels of the bores were determined to within about 3 inches, and checked by back levelling.

Preliminary boring and sampling of the beach and adjacent dunes was carried out during August 1948, when bores were put down to ground water level. Additional boring in June 1949, to ground water level, defined the boundaries of the heavy mineral deposits. In November 1949 some of the earlier bores were deepened and sampled below water level. At the same time scout bores were put down in Greenbank Island and in the coastal plain.

3. Sampling. During the preliminary boring, samples were taken of any sand which appeared to contain appreciable quantities of heavy minerals, and a single sample was made up from the overburden. During the later boring, the bores were sampled in sections from top to bottom, whether mineral appeared to be present or not. The reason for this complete sampling is that concentrates with a comparatively high zircon content tend to be grey rather than black, and are liable to be left unsampled. Samples taken from the bore holes were reduced by quartering to a convenient size, about 700 to 1000 cubic centimetres, and bagged for despatch to the field laboratory.

4. Laboratory Work.

(a) Estimation of Quantities of Heavy Minerals. The bore samples were dried, and 700 ccs. of each sample was weighed. The heavy mineral concentrates were then separated from the 700 ccs. of sample by means of a laboratory Wilfley Table, and the weights and volumes of the dry concentrates were measured. The quantities of heavy minerals in the samples were then expressed as weight per cent and "lbs/per cu.yd" (pounds weight of heavy mineral concentrate per cubic yard of sand) and are given in Table 7 at the end of this report.

(b) Determination of Compositions of Concentrates. The average percentage composition of the heavy mineral concentrates in the area was obtained from a composite sample from each bore line. The composition of the composite sample was determined by separating the sample into a magnetic and a non-magnetic fraction on a Frantz Isodynamic Separator, and separating the non-magnetic fraction into a zircon and a rutile concentrate electrostatically. The magnetic fraction and the zircon and rutile concentrates were weighed and the composition of the magnetic fraction determined by grain-counting. The monazite content of the sample was determined radiometrically. The average composition of the heavy mineral concentrate in the area is given in Table 3, Page 11.

(c) Variation in the Composition of the Heavy Mineral Concentrates and in the Thoria Content of the Monazite. In order to detect any variation which might occur in the compositions of the concentrates from east to west, portions of the concentrates of the area were grouped into composite samples representative of the heavy mineral in Block 1 and Block 2 (Shown in Plate 1). To detect any variation from south to north, additional portions of the concentrates obtained from Block 1 were grouped into three composite samples C1, C2, and C3, representing blocks of mineral from south to north. The bores from which concentrates were taken to make up the composite samples are shown in Table 1.

TABLE 1. Tweed Fingal Area : Preparation of composite samples to examine distribution of Heavy Minerals.

COMPOSITE	BORES FROM WHICH CONCENTRATES MAKING UP COMPOSITE WERE TAKEN	LINES ALONG WHICH BORES ARE SITUATED	DIRECTION IN WHICH VARIATION INVESTIGATED
BLOCK 1.	15W - 40W	00	EAST-WEST
	36W - 510W	750N	
	50W - 200W	1500N	
	36E - 180W	3750N	
	00 - 110W	4500N	
	72W - 280W	5250N	
	110W - 260W	6000N	
	36W - 180W	6750N	
	00 - 280W	7500N	
	00 - 150W	8250N	
	24W - 54W	9000N	
BLOCK 2.	340W - 420W	3750N	
	612W - 682W	4500N	
	252W	6750N	
	415W - 670W	7500N	
	444W - 486W	8250N	
	427W - 472W	9000N	
C.1.	36W - 510W	750N	SOUTH-NORTH
	50W - 200W	1500N	
C.2.	00 - 110W	4500N	
	72W - 280W	5250N	
C.3.	00 - 280W	7500N	
	00 - 150W	8250N	
	24W - 54W	9000N	

Each composite sample was divided into two portions - one portion for the determination of the percentage of zircon, rutile and ilmenite, and the other portion for the determination of percentage monazite.

(i) Zircon,Rutile and Ilmenite. The sample was separated magnetically on a Frantz Isodynamic Separator giving a magnetic fraction made up mostly of ilmenite with a little monazite, garnet and tourmaline, and a non-magnetic fraction of zircon and rutile. The zircon and rutile were separated electrostatically. The magnetic fraction and the zircon and rutile concentrates were weighed ; the composition of the magnetic fraction was determined by grain-counting.

(ii) Monazite: The percentage monazite in concentrates was determined by means of Geiger-Muller gamma-ray counting equipment. In the determination of percentage monazite by this method, allowance has to be made for the radioactivity due to zircon,rutile and ilmenite. A quantity of high-grade monazite (Footnote) was prepared from concentrates of the area. The counting rate given on the Geiger Muller equipment by the monazite was recorded, and the number of counts per gram per minute due to this monazite was calculated. Similarly, the second portion of each of the composite samples which had been set apart for the radiometric determination of monazite was tested. Allowance was made for the radioactivity of the zircon,rutile and ilmenite and the number of counts per gram per minute due to the monazite in the sample was calculated. From comparison of the sounts/gram/minute of the high-grade monazite and the monazite in the sample being tested, the percentage monazite in this sample was calculated.

(iii) The Thoria Content of Monazite. A monazite concentrate was separated from a composite sample representing the whole area. The thoria content of this monazite was tested radiometrically by comparison with a standard monazite sample containing 6.6% thoria. Monazite concentrates were also separated from composite samples representing Block 1, and Block 2. As the quantity of monazite obtained from these composites was too small to fill the smallest of the sample containers for which the Geiger-Muller equipment has been calibrated, zircon was added to the monazite to make up the required volume. The standard monazite was then mixed with some of the same zircon, such that the proportions of monazite and zircon approximated to those in the sample to be determined. The thoria content of the monazite in the two samples was then compared radiometrically with the thoria content of the standard monazite.

E. RESULTS OF THE INVESTIGATION.

1. Distribution of the Mineral Deposits.

(a) Extent. The plans given in Plate 1 show that the deposits of heavy mineral occur from about 2,000 feet south of the northern end of Letitia Spit to the southern end of the beach, near Fingal Point. The principal deposit, continuous over this distance, ahs a total length of 9000 feet, varies in width from 80 feet to 330 feet, and is within 20 to 400 feet of the upper edge of the beach. A series of disconnected deposits occurs a little further west, approximately 400 ft.to 800 ft. distant from the beach . These deposits vary in width from 70 feet to 250 feet. The average combined width of the main deposit and the subsidiary western deposits is 300 feet. No appreciable quantities of heavy minerals were found on the beach. The thickness of the deposits (Plate 2) varies from a few inches to a maximum of 9 feet in the higher grade and 15 feet in the lower grade deposits. The average is 2 ft. 6 inches (Table 3).Reference to the sections of the bore lines (Plate 2) shows that the main deposit, from line 6000N to line 5250N (an probably from 7500N to 1500N) underlies two distinct dune strips, and easterly strip which occurs from the edge of the present beach to about the position 120W on the bore lines, and a westerly strip from about 150W to 300W. The development of these two dune strips, each with its underlying deposits of heavy minerals, is discussed in Section C.1. above (General Geology : The Beach and Coastal Dune Area). The sections of the bore lines, (e.g. line 6000N) indicate that, on the whole, the largest quantities of heavy minerals were deposited during the development of the westerly dune strip.

FOOTNOTE: This "Monazite" was a concentrate containing 99% monazite. It was not necessary to prepare a 100% monazite concentrate to obtain the required results.

Scout boring west of the Tweed River failed to locate more than traces of heavy minerals. The greatest proportion of heavy minerals, 0.8 per cent by weight, was found in the upper 3 feet of bore 6750N/80W on Greenbank Island. Many of the samples obtained from the coastal plain failed to show even traces of heavy concentrates on the Wilfley Table. It is concluded that, between Tweed Heads and Fingal Point, no deposits of heavy minerals occur, down to low water level, west of those shown in Plate 1.

(b) Shape and Attitude. The deposits beneath the dune adjacent to the beach extend unbroken for considerable distances as "seams" parallel to the beach. In cross section, that is, a section in a vertical plane at right angles to the beach, a seam commonly appears wedge-shaped, tapering off gradually towards the beach and dipping bodily towards the beach at an angle of a few degrees. The section on Plate 2 of the 2950N bore line shows that such a seam has been intersected in bore holes 80W, 40W, and 00. Commonly, two or more seams, each parallel to the beach and dipping towards it, are arranged en echelon, overlapping from west to east, to form a composite deposit. Such overlapping seams appear beneath the dunes near the beach in the sections, Plate 2, of bore lines 7500N, 3750N, and 750N. The westerly deposits (Block 2) appearing in lines 9000N to 7500N appear in the main to be due to wind concentration, and occur mainly as low active dunes, or portions of low dunes. In addition, the lower grade deposits appearing between levels of about 10 ft. and 20 feet in the beach portions of several of the bore lines are dune deposits. These are somewhat elongated in a direction parallel to the beach, and though frequently wedge-shaped in cross section, and dipping in an easterly direction, are much less regular in shape and attitude than the high-grade "seams" below them.

(c) The Levels at Which the Deposits Occur. The principal deposits intersected by the bores occur within limits of 3 feet to 11 feet above mean low water, i.e. their lower level may be down to mean sea level and their upper level may be 5 feet above mean high water level. (Footnote) Deposits of lower grade, from 120 lbs to 300 lbs of heavy mineral per cubic yard, occur in the main dunes up to a level of 21 feet, or 15 feet above mean high water, and, in the low-lying western part of Letitia Spit, down to 2 feet below mean low water. It is suggested in Section C.1. above that the Tweed River encroached temporarily on this area. If this supposition is correct, the low-level deposits are readily explained as concentrations effected by the current in the shallow eastern part of the river channel. Further details of the levels of the deposits are summarised in Table 2.

TABLE 2. THE TWEED-FINGAL AREA. LEVELS OF DEPOSITS.
Giving the maximum and the minimum level in each bore lines.

GRADE	LEVELS OF DEPOSITS. REFERRED TO MEAN LOW WATER.	
LB.PER.CU.YD.	TOP OF DEPOSIT (FT)	BOTTOM OF DEPOSIT (FT).
Over 300.	Average 9.3 Extreme Range. 5.6 to 12.8 Usual Range 8.5 to 10(Ø)	Average 4.3 Extreme Range 0.0.to6.6(≠) Usual Range 3.3 to4 (Ø)
120 to 300	Average 14.1 Extreme Range.7.5 to 21.3 Usual Range 10 to 11 (Ø) 16 to 19 (X)	Average 4.4 Extreme Range -2.0 to 10.9 (≠) Usual 4 to 5 (Ø) Ranges. Approx.10 - 11 (X)

REMARKS.
(Ø) Deposits formed by wave action.
(X) Deposits formed in dunes by wind action .
(≠) The lowest level is probably due to deposits formed in a former channel of the Tweed River.

FOOTNOTE. The lower levels of the deposits intersected by boreholes 4500N/110W and 1500N/170W were 2.5 ft. and 1.2 ft. respectively. Each of these bores was put down at the bottom of a hollow between dunes. It is likely that the bore site was originally marked out and levelled a foot or two above the bottom of the hollow. If so, these bottom levels would be a foot or two higher than recorded.

TABLE 3. TWEED - FINGAL AREA : SUMMARY OF QUANTITIES.

BLOCK AS SHOWN IN PLATE 1.	AREA OF DEPOSIT SQ. YDS.	WEIGHT OF HEAVY MIN. CONCENTRATE. TONS.	VOLUME CUBIC YARDS		AVERAGE THICKNESS FT.		AV. GRADE OF DEPOSITS LBS/CU/YD
			DEPOSITS	OVERBURDEN	DEPOSITS	OVERBURDEN	
BLOCK 1	252,614	36,259	222,262	476,285	2.6	5.6	364.5
BLOCK 2	90,250	11,065	67,275	20,750	2.2	0.7	368.4
TOTAL	342,864	47,324	289,537	497,035	2.5	4.3	365

AVERAGE COMPOSITION OF CONCENTRATE, AND WEIGHT OF EACH MINERAL.

	MONAZITE	ZIRCON	RUTILE	ILMENITE	GARNET (X)	OTHER MINERALS.(Ø)
PERCENTAGE	0.6	48.9	28.0	21.6	0.3	0.6
WEIGHT (TONS)	284	23,141	13,251	10,222	142	284

(X) This figure is somewhat low : varying proportions of garnet are lost when the sand is being tabled.

(Ø) The "other minerals" are chiefly :- tourmaline, garnet with occasional grains of epidote, corundum, spinel and amphibole.

2. Reserves.

(a) Total Reserves. A summary of the total reserves of heavy mineral and quantities of overburden is given in Table 3, while a statement of the reserves between each pair of bore lines appears in Table 6. Details of bores and samples are given in Table 7. When computing the reserves it was necessary to decide, somewhat arbitrarily, the minimum grade of sand which should be included, and the minimum thickness of sand of a given grade. The minimum grade has been fixed at 120 lbs. weight of heavy mineral concentrate per cubic yard of sand. This is a little greater than 4 per cent by weight (Footnote). The minimum quantity of mineral was decided on the basis that the product of thickness of seam in feet times pounds of heavy mineral per cubic yard should be at least 300. Thus a seam which has a grade of 600 lbs of concentrate per cu.yd. must be at least 6 inches thick, and a seam of minimum grade, 120 lbs per cu.yd, must have a thickness of at least 2 ft.6inches. Actually, the Tweed-Fingal deposits are predominantly much higher in grade than the minimum grade, given above. The overall average grade as stated in Table 3 is 365 lbs. per cu.yd, and it can be seen in Table 6 and 7, that a comparatively high grade is maintained at each bore line.

(b) Quantities now available for Mining. The plans given in Plate 1 show that the deposits occur almost entirely within the boundaries of G.L.3 and Special Lease Applications No.125 and 144. Thus, the quantities available for mining are substantially those given in Table 3. No mining has yet been undertaken in the Tweed-Fingal Area.

(c) Possible Future Deposits. No heavy mineral deposits were found on the Tweed-Fingal beach. However, it is possible that, in the future, the dunes adjacent to the beach top will build up and advance seawards some distance. Erosion during subsequent stormy weather may then effect concentration of their small quantities of heavy minerals, and form new deposits east of the deposits shown in Plate 1.

3. Distribution of the Mineral Throughout the Area.

(a) The Observed Distribution. The percentages of zircon, rutile, ilmenite and monazite in the composite samples of Table 1 representing portions of the deposits from east to west, and from south to north are given below in Table 4.

TABLE 4. Variation in Mineral Composition of Concentrates.

COMPOSITE SAMPLE	PERCENTAGE COMPOSITION (NEGLECTING THE PERCENTAGE OF GARNET AND OTHER MINERALS)				DIRECTION IN WHICH VARIATION INVESTIGATED.
	ZIRCON	RUTILE	ILMENITE	MONAZITE	
Block 1	48.6	29.0	21.8	0.64	EAST-WEST
Block 2	42.2	31.8	25.3	0.72	
C.1.	46.6	30.5	22.3	0.65	SOUTH-NORTH
C.2.	47.3	30.3	21.8	0.54	
C.3.	49.6	28.0	21.7	0.69	

It is seen that the more easterly block, Block 1, has a higher zircon content than the westerly block, Block 2, with a correspondingly lower rutile and ilmenite content. It is unusual that the monazite content of the composite sample from Block 2 is higher than that from Block 1, because, from previous investigations it appears that the higher values of monazite are generally found with the higher values of zircon. Plate 4 shows graphically the variation in percentages of zircon, rutile and ilmenite in composite samples from south to north.

The percentages of these minerals are fairly constant for the first 5000 feet, but from 5000 - 8000 feet, the percentage zircon rises abruptly while the percentages of rutile and ilmenite decrease. Some correlation can be made between the distribution of mineral and its specific gravity. The curves of zircon, of specific gravity 4.66 and rutile, S.G.4.2, diverge from each other appreciably, while the curve due to ilmenite which has an intermediate specific gravity of 4.5, has an intermediate position. A similar connection between specific gravity of a mineral and its distribution was noted in the Palm Beach Area. (Records 1950, No.7.)

The curve for monazite (Plate 4), like the curve for zircon, rises steeply in that part of the curve which represents the northern portion of the area. The curve for monazite, however, differs from that of zircon, in that the monazite curve representing the portion of the area from 00-5000 feet north dips sharply, while the zircon curve representing the same portion of the area continues to rise gently.

(b) Suggested Causes of the Observed Distribution of Heavy Minerals.

(i) Southern Part of Block 1. The lower percentage of monazite in composite sample C2 in comparison with composite sample C1 suggests that the monaztie, which has a higher specific gravity than the other heavy minerals, lagged behind as the minerals were being transported northwards by the surf. In the case of zircon, ilmenite and rutile there is but little variation in the southern portion of Block 1, represented by samples C1 and C2.

(ii) Block 2 and the Northern Portion of Block 1. In the northern portion of the area, represented by composite sample C3, i.e 7500 feet north of the 00 bore line to 9000 feet north of the 00 line, the percentage monazite increases. An increase in the percentage monazite in also seen in the composite sample representing Block 2, the more westerly block. It is possible that the increase in percentage monazite in Block 2, and the northern portion of Block 1 (viz. the portion represented by composite sample C3) is due to a former change in the position of the western bank of the Tweed River to approximately the position of the south-eastern margin of the nearby lagoon. The dune strip appearing between 150W and 300W on bore lines 5250N, 6000N and 6750N, with its considerable deposits of heavy minerals, was eroded northwards from the southern boundary of GL3. The Tweed River probably entered the sea at about the locality of bore line 8250N. The quartz sand in the eroded dunes was carried away by the river, but most of the heavy minerals remained more or less in situ. These concentrates, re-sorted by wind action, appear now as the deposits of Block 2. The mixed concentrates of these deposits contain a relatively high percentage of monazite, which may be expected. However, the percentage of zircon is relatively low. No ready explanation for this can be offered.

The supposed encroachment of the Tweed River implies that the dune strip adjacent to the present beach had not then been formed, since this easterly dune strip can be traced continuously to the northern end of the area, with no suggestion of a break about the 8250N bore line.

During its period of development, that portion of the eastern dune strip south of G.L.3 was protected from wind erosion by the older western dune strip. North of the southern boundary of G.L.3. the eastern dune strip with its deposits of heavy minerals was exposed to constant active erosion by the prevailing winds, blowing from the ocean. Much of the quartz sand and some of the lighter of the heavy minerals, viz.rutile and ilmenite were blown away westwards. As a result, the concentrates from the northerly portion of Block 1 became relatively richer in zircon and monazite and poorer in rutile and ilmenite

4. Thoria Content of the Monazite. Figures for the determination of thoria are given in Table 5. It is seen that the thoria content of monazite from Block 1, Block 2, and from the entire area (Blocks 1 and 2) is, respectively, 6.6 percent, 6.8 percent, and 6.8 percent.

TABLE 5. **TWEED FINGAL AREA : THORIA CONTENT OF MONAZITE.**

MONAZITE CONCENTRATE.	BLOCK 1.	BLOCK 2.	ENTIRE AREA (Blocks 1 & 2)
MONAZITE CONCENTRATE (M) SEPARATED FROM THE MIXED HEAVY CONCENTRATES OF THE BLOCK	Monazite (M1) 98.7 Zircon 0.5 Ilmenite 0.7 Other Minerals 0.1 100.0	Monazite (M2) 99.4 Zircon 0.1 Ilmenite 0.3 Other Minerals 0.2 100.0	Monazite (M1+M2) 98.8 Zircon 0.4 Rutile 0.1 Ilmenite 0.4 Other Minerals 0.3 100.0
MONAZITE CONCENTRATE (T) TESTED FOR THORIA (MADE UP FROM THE MONAZITE CONCENTRATE M ABOVE) IN THE CASE OF BLOCKS 1 AND 2, THIS CONCENTRATE WAS MADE UP BY MIXING CONCENTRATE M WITH ZIRCON.	Monazite (M1) 33.7 Zircon 66.0 Ilmenite 0.2 Other Minerals 0.1 100.0	Monazite (M2) 32.8 Zircon 67.0 Ilmenite 0.1 Other Minerals 0.1 100.0	The monazite concentrate tested was the Monazite Concentrate (M) shown above.
MONAZITE CONCENTRATE (C) THIS CONCENTRATE WAS MADE UP BY MIXING THE STANDARD MONAZITE (MS) WITH ZIRCON ETC.	Monazite (MS) 34.1 Zircon 65.8 Other minerals 0.1 100.0	Monazite (MS) 32.7 Zircon 67.2 Other minerals 0.1 100.0	Monazite (MS) 99.6 Zircon 0.2 Other minerals 0.2 100.0
MASS OF MONAZITE CONCENTRATE (T) (IN GRAMS)	11.470	11.927	11.137
MASS OF MONAZITE CONCENTRATE (C) (IN GRAMS)	11.484	11.927	11.156
EXCESS OVER BACKGROUND (COUNTS PER MINUTE) DUE TO MONAZITE CONCENTRATE (T)	696	700	1879
EXCESS OVER BACKGROUND (COUNTS PER MINUTE) DUE TO MONAZITE CONCENTRATE (C)	711	679	1852
COUNTS/GRAM/MINUTE OF MONAZITE (M1, M2 and M1 + M2) in monazite concentrate (T) ALLOWING FOR COUNTS DUE TO ZIRCON.	$\left(\frac{696-13.6}{3.865}\right) = 177$	$\left(\frac{700-14.3}{3.912}\right) = 175$	$\frac{1879}{11.003} = 171.$ (counts due to zircon negligible)
COUNTS/GRAM/MINUTE OF MONAZITE (MS) IN MONAZITE CONCENTRATE (C) ALLOWING FOR COUNTS DUE TO ZIRCON	$\left(\frac{711-13.5}{3.916}\right) = 178$	$\left(\frac{679-14.3}{3.900}\right) = 170$	$\frac{1852}{11.111} = 167$ (counts due to zircon negligible.
PERCENTAGE THORIA(ø) IN MONAZITE M1, M2, and M1 + M2.	$\left(\frac{177}{178} \times 6.6\%\right) = 6.6\%$	$\left(\frac{175}{170} \times 6.6\%\right) = 6.8\%$	$\left(\frac{171}{167} \times 6.6\%\right) = 6.8\%$

(ø) Calculated on the basis of the thoria content of the standard monazite/which chemical analysis gives as 6.6%.

However, the experimental error due to the equipment is ($\pm$ 0.3) percent. Hence, it may be concluded that the thoria content of monazite from Block 1, Block 2, and from the entire area is the same, within experimental limits, as the thoria content of the standard monazite. viz. (6.6 $\pm$ 0.3) percent.

ACKNOWLEDGMENTS.

The Beach Sands Investigation along the New South Wales Coast has received assistance from the New South Wales Mines and Lands Departments in the provision of lease plans and parish plans, and from operating companies who hold leases in the areas investigated. Information regarding leases in the Tweed-Fingal area has been provided by Cudgen Rutile-Zircon (Cudgen R-Z), Kingscliffe, and Tweed-Rutile Syndicate, Tweed Heads. Notes on the vegetation of the area have been compiled from information supplied by Mr. S.T. Blake of the Queensland Department of Agriculture and Stock. In the administrative and supply aspects of the work, much help has been received from the State Controller and officers of the Department of Supply and Development, Brisbane.

REFERENCES.

Fisher, N.H. 1949. (a) Mineral Resources of Australia, Summary Report No.1. Zirconium. Commonwealth Bureau of Mineral Resources, Geology and Geophysics.

Fisher, N.H. 1949. (b) Mineral Resources of Australia, Summary Report No.2. Titanium. Commonwealth Bureau of Mineral Resources, Geology and Geophysics.

TABLE 6 LOCALITY **TWEED-FINGAL AREA.** DETAILED STATEMENT OF QUANTITIES BETWEEN BORE LINES.

BLOCK 1

BORE LINES	DISTANCE BETWEEN LINES (YDS)	WIDTH OF DEPOSIT (YDS)		TOTAL BETWEEN LINES				AVERAGE THICKNESS (FT)		GRADE OF DEPOSIT (LBS /CU. YD)
				AREA OF DEPOSIT (SQ.YDS.)	WT. OF MIN. (LBS & TONS)	VOLUME (CUB.YDS)				
		AT LINE	AVERAGE			DEPOSIT	O'BRDN	DEPOSIT	O'BRDN	
9000N 8250N	250	27 24	25.5	6,375	561,250 250	675	15,500	0.3	7.3	831
9000N 8250N	250	45 70	57.5	14,375	5,210,250 2,326	17,425	2,800	3.6	0.6	299
8250N 7500N	250	24 32	28	6,950	2,767,250 1,235	3,775	24,400	1.6	10.5	733
8250N 7500N	250	28 78	53	13,250	8,031,250 3,585	8,050	19,825	1.8	4.5	998
8250N 7500N	250	70 85	77.5	54,250	10,643,000 4,751	26,750	1,000	1.5	0.1	398
7500N 6750N	250	32 24	28	7,000	2,752,750 1,229	4,300	26,050	1.8	11.2	640
7500N 6750N	250	78 24	51	12,750	8,313,000 3,711	8,950	19,175	2.1	4.5	929
7500N 6750N	250	85 12	48.5	12,125	7,491,750 3,344	14,125	6,125	3.5	1.5	530
6750N 6000N	250	24 27	25.5	6,375	1,663,500 743	5,425	20,750	2.5	9.8	307

TABLE 6 (Contd) LOCALITY **TWEED-FINGAL AREA.** DETAILED STATEMENT OF QUANTITIES BETWEEN BORE LINES.

BLOCK 1. (Contd)

BORE LINES	DISTANCE BETWEEN LINES (YDS)	WIDTH OF DEPOSIT (YDS)		TOTAL BETWEEN LINES				AVERAGE THICKNESS (FT)		GRADE OF DEPOSIT (LBS /CU. YD)
		AT LINE	AVERAGE	AREA OF DEPOSIT (SQ.YDS.)	WT. OF MIN. (LBS & TONS)	VOLUME (CUB YDS) DEPOSIT	VOLUME (CUB YDS) O'BURDEN	DEPOSIT	O'BURDEN	
6750N 6000N	250	12 45	28.5	7,125	2,897,750 1,293	3,475	22,175	1.5	9.3	834
6000N 5250N	250	72 86	79	19,750	9,838,750 4,392	42,250	34,250	6.4	5.2	233
5250N 4500N	250	86 58	72	18,000	8,375,250 3,739	41,750	25,750	6.9	4.3	201
4500N 3750N	250	58 97	77.5	54,250	4,933,000 2,202	15,600	44,250	0.9	2.4	316
4500N 3750N	250	23 53	38	9,500	1,442,000 644	8,975	10,825	2.8	3.4	161
3750N 2950N	267	97 93	95	25,365	7,975,824 3,561	22,134	56,577	2.6	6.7	360
2950N 1500N	483	93 63	78	37.674	13,538,007 6,044	31,878	97,083	2.5	0.7	425
1500N 750N	250	25 79	52	13,000	3,072,000 1,371	11,500	26,000	2.6	6.0	267
1500N 750N	250	38 53	45.5	11,375	2,546,750 1,137	7,750	15,500	2.0	4.1	329

TABLE 6 (Contd) LOCALITY TWEED-FINGAL AREA. DETAILED STATEMENT OF QUANTITIES BETWEEN BORE LINES.

BLOCK 1. (Contd)

BORE LINES	DISTANCE BETWEEN LINES (YDS)	WIDTH OF DEPOSIT (YDS)		TOTAL BETWEEN LINES				AVERAGE THICKNESS (FT)		GRADE OF DEPOSIT (LBS /CU. YD)
		AT LINE	AVERAGE	AREA OF DEPOSIT (SQ.YDS.)	WT. OF MIN. (LBS & TONS)	VOLUME (CUB.YDS) DEPOSIT	VOLUME (CUB.YDS) O'BRDN	DEPOSIT	O'BRDN	
750N 00	250	79 28	53.5	13,375	3,752,000 1,675	14,750	29,000	3.3	6.5	254
TOTAL BLOCK 1.				252,614	81,018,331 36,259	222,262	476,285	2.6	5.6	364.5
BLOCK 2.										
9000N 8250N	250	45 70	57.5	14,375	5,210,250 2,326	17,425	2,800	3.6	0.6	299
8250N 7500N	250	70 85	77.5	54,250	10,643,000 4,751	26,750	1,000	1.5	0.1	398
7500N 6750N	250	85 12	48.5	12,125	7,491,750 3,344	14,125	6,125	3.5	1.5	530
4500N 3750N	250	23 53	38	9,500	1,442,000 644	8,975	10,825	2.8	3.4	161
TOTAL BLOCK 2.				90,250	24,787,000 11,065	67,275	20,750	2.2	0.7	368.4

TABLE 7 TWEED-FINGAL AREA.
HEAVY MINERAL AND OVERBURDEN IN BORES.

ORIGIN OF CO-ORDINATES : Above top of beach, 1035' east of Training wall, as shown in Plates 1 and 2

LINE 10700N.

BORE	DEPTH FROM	DEPTH TO	LBS/ CU. YD.	O/BRDN FT.
134E	0'	0'9"	612.9	
	0'9"	3'	Tr	
Thickness		0'9"	612.9	
58E	0'	5'6"	Tr	
23E	0'	10'	"	
00	0'	16'6"	"	
63W	0'	6'	"	
138W	0'	4'	"	
198W	0'	12'6"	"	
395W	0'	5'6"	"	
543W	0'	7'	"	
658W	0'	3'9"	"	
850W	0'	3'6"	"	
1018W	0'	1'	"	

LINE 9000N.

Origin: Crest of foredune, 1417' east of lagoon, as shown in Plate 1 and 2.

BORE	DEPTH FROM	DEPTH TO	LBS/ CU. YD.	O/BRDN FT.
82E	0'	3'	Tr	
32E	0'	4'3"	"	
14E	0'	15'	"	
SECTION A.				
00	0'	15'	Tr	5.3
24W	0'	5'	Not sampled	
	5'	5'8"	605.9	5.0
	5'8"	10'6"	Tr	
Thickness		0'8"	605.9	
(X) 81W	0'	16'	Tr	4.9
Average		0.5'	719	4.8
104W	0'	17'	Tr	
147W	0'	12'	"	
216W	0'	16'	52.4	
282W	0'	2'9"	Tr	
337W	0'	4'	"	
SECTION B.				
382W	0'	4'	56	2.5
427W	0'	5'	788	0.0
472W	0'	4'	132.9	0.0
517W	0'	3'3"	88	2.0
Average		2.9'	445	0.75
569W	0'	6'	Tr	
792W	0'	1'9"	Not sampled	
985W	0'	2'4"	Tr	
1311W	0'	8'6"	54	
1341W	0'	2'6"	414	
	2'6"	10'8"	Not sampled	
1369	0'	6"	Not sampled	
1386W	0'	0'3"	"	"

LINE 8250N

Origin : 1000' east of lagoon as shown in Plates 1 and 2

BORE	DEPTH FROM	DEPTH TO	LBS/ CU. YD.	O/BRDN FT.
108E	0'	15'	Tr	
72E	0'	12'6"	21	

ALSO LINE 9000N, 8250N.

BORE	DEPTH FROM	DEPTH TO	LBS/ CU. YD.	O/BRDN FT.
SECTION A.				
36E	0'	11'6"	Tr	10.1
00	0'	10'	Tr	
	10'	10'3"	1360	10.0
36W	0'	16'	Tr	10.1
Average		0.12'	1360	10.1
72W	0'	14'9"	45	
SECTION B.				
108W	0'	13'	Tr	9.6
150W	0'	9'6"	Not calculated	
	9'6"	9'9"	1315	9.5
	9'9"	15'	Tr	
192W	0'	5'	Tr	9.6
Average		0.12	1315	9.5
234W	0'	4'	86	
276W	0'	1'6"	Tr	
318W	0'	4'9"	218	
360W	0'	2'	63	
SECTION C.				
402W	0'	1'6"	Tr	3.0
444W	0'	3'	373	0.0
	3'	6'	276	
	6'	7'	18	
Thickness		6'	324	
486W	0'	5'9"	182	0.0
528W	0'	3'	318	0.0
	3'	6'	134	
	6'	7'	Tr	
Thickness		6'	226	
570W	0'	4'3"	302	0.0
612W	0'	3'	Tr	2.1
	3'	5'	14	
Average		4.4	256	0.5
654W	0'	2'	29	
696W	0'	5'	Tr	
738W	0'	4'6"	256	
780W	0'	3'	48	
	3'	6'	84	
822W	0'	3'	265	
864	0'	3'	44	
	3'	6'	20	
	6'	9'	27	
	9'	10'	Tr	
948W	0'	9'6"	115	
960W	0'	7'3"	274	
(X) 54W	0'	4'6"	Tr	
	4'6"	5'3"	812.4	4.5
	5'3"	10'	45.5	
Thickness		0'9"	812.4	

TABLE HEAVY MINERAL AND OVERBURDEN IN BORES.

ORIGIN OF CO-ORDINATES : 715' east of lagoon as shown in Plates 1 and 2.

LINE 7500N. ALSO 6750N.

BORE	DEPTH FROM	DEPTH TO	LBS/ CU. YD.	O/BRDN FT.
160E	0'	3'9"	Tr	
95E	0'	6'	Tr	
60E	0'	12'6"	Tr	
SECTION A.				
20E	0'	14'	Tr	12.4
00	0'	10'	Tr	
	10'	11'	381	
	11'	14'3"	584	10.0
	14'3"	14'9"	1011	
	14'9"	15'6"	Not sampled	
Thickness		4'9"	555.3	
30W	0'	9'	Tr	
	9'	10'3"	Tr	10.25
	10'3"	10'9"	2013	
	10'9"	14'6"	573	
Thickness		4'3"	742.4	
75W	0'	12'2"	Tr	
	12'2"	12'5"	490	12.2
	12'5"	17'	Tr	
Thickness		3"	490	
Average		3'	659	10.8
SECTION B.				
75W	0'	12'2"	Tr	12.2
	12'2"	12'5"	490	
	12'5"	17'	Tr	
115W	0'	10'	Tr	
	10'	10'4"	2984	10.0
	10'4"	11'8"	2553	
	11'8"	13'	Not sampled	
Thickness		1'8"	2129	
145W	0'	7'	205.5	
	7'	9'6"	1111	
	9'6"	9'10"	1639	0.0
	9'10"	12'	Not sampled	
Thickness		9'10"	258.4	
190W	0'	2'	Not sampled	
	2'	4'6"	1948	0.0
	4'6"	8'9"	Not sampled	
235W	0'	0'6"	1057	0.0
	0'6"	4'	Not sampled	
280W	0'	4'3"	1030.5	0.0
310W	0'	2'6"	Tr	2.12
Average.		2.48	992	2.7
360W	0'	1'3"	123.4	Not Calculated.

BORE	DEPTH FROM	DEPTH TO	LBS/ CU. YD.	O/BRDN FT.
SECTION C.				
415W	0'	2'	Tr	1.0
460W	0'	1'6"	491.0	
	1'6"	2'	54.4	0.0
Thickness		1'6"	491.0	
505W	0'	1'	788.6	
	1'	2'	936.3	0.0
Thickness		20'	862.4	
560W	0'	3'	693	0.0
	3'	6'	559	
	6'	9'	320	
	9'	11'	205	
608W	0'	3'6"	467.4	0.0
670W	0'	5'3"	737.7	0.0
Average		3.9'	525.5	0.1

LINE 6750N.
Origin:
290' east of lagoon as shown on Plates 1 and 2.

BORE	DEPTH FROM	DEPTH TO	LBS/ CU. YD.	O/BRDN FT.
SECTION A.				
00	0'	13'	TR	11.9
36W	0'	11'6"	Tr	
	11'6"	12'3"	415.0	11.5
	12'3"	13'3"	Not sampled	
72W	0'	15'9"	Tr	11.9
Average		0.4'	415	11.7
SECTION B.				
108W	0'	11'	Tr	
	11'	11'3"	589	11.0'
	11'3"	14'6"	Not sampled	
144W	0'	4'	Tr	
	4'	4'6"	128	
	4'6"	10'	Tr	
	10'	10'6"	324	10.0
	10'6"	11'	Tr	
	11'	12'	712	
	12'	13'	Not sampled	
Thickness		2'	436	
180W	0'	16'3"	67	11.0'
Average		1'1"	445	10.5
SECTION C.				
216W	0'	16'	Tr	11.75
252W	0'	11'6"	Tr	
	11'6"	12'	1065	11.5
	12'	13'6"		Not sampled.
Average		.25'	1065	11.6

TABLE 7 HEAVY MINERAL TWEED OVER TUNGAL AREA BORES.

ORIGIN OF CO-ORDINATES : Above top of beach 1040' east of lagoon as shown in Plate 1 and 2.

LINE 6000N.

BORE	DEPTH FROM	DEPTH TO	LBS/ CU. YD.	O/BRDN FT.
100E	0'	4'	Tr.	
55E	0'	5'	Tr.	
35E	0'	13'	Tr.	
00	0'	14'6"	Tr.	
40W	0'	12'	Tr.	
	12'	12'4"	285.8	
	12'4"	13'	Not sampled.	
80W	0'	16'	Tr.	
SECTION A.				
110W	0'	12'3"	46	
	12'3"	12'6"	394	12.25
	12'6"	13'	Not sampled.	
140W	0'	3'	190.6	
	3'	3'9"	951.2	0.0
	3'9"	10'6"	191.2	
Thickness		10'6"	227.2	
160W	0'	13'6"	Tr.	
	13'6"	14'6"	354	
	14'6"	15'	Tr	
	15'	15'5"	1515	13.5
	15'5"	16'6"	Not sampled.	
Thickness		1.9'	518.5	
190W	0'	20'	Tr	14.5
Average		3.9'	273	9.2'
SECTION B.				
190W	0'	20'	Tr	11.25
210W	0'	10'	Tr	
	10'	10'4"	403	
	10'4"	11'	Tr	
	11'	11'5"	981	10.0
	11'5"	11'8"	Tr	
	11'8"	12'6"	1736	
	12'6"	15'6"	Not sampled	
Thickness		2.5'	795.9	
240W	0'	5'	Tr	
	5'	5'9"	2681.4	
	5'9"	6'	Tr	
	6'	6'9"	3348.5	5.0
	6'9"	8'6"	Tr.	
	8'6"	10'6"	167.3	
Thickness		5'6"	936.3	
260W	0'	9'	Tr	
	9'	10'	484	9.0
	10'	15'6"	33	
Thickness		1.0'	484	
325W	0'	9'3"	Tr	9.5
Average		1.8'	821	8.7
780W	0'	6'	Tr	
860W	0'	6'	Tr	
940W	0'	6'	Tr.	

ALSO LINE 5250N.

BORE	DEPTH FROM	DEPTH TO	LBS/ CU. YD.	O/BRDN FT.
1020W	0'	8'	Tr.	
1100W	0'	7'	Tr.	
1220W	0'	8'	Tr.	

LINE 5250N.

Origin: Above top of beach 1110' east of training wall as shown in Plate 1 and 2.

BORE	DEPTH FROM	DEPTH TO	LBS/ CU. YD.	O/BRDN FT.
00	0'	6'	Not Sampled.	
	6'	6'6"	169	
	6'6"	9'6"	Not sampled.	
	9'6"	10'6"	127	
	10'6"	11'6"	Not sampled.	
36W	0'	8'3"	Not sampled.	
	8'3"	8'6"	391	
	8'6"	14'	Not sampled.	
	14'	14'3"	123	
	14'3"	14'6"	Not sampled.	
SECTION A.				
72W	0'	14'6"	114	11.5
108W	0'	9'	Not sampled	
	9'	9'6"	1216	
	9'6"	13'6"	Not sampled.	
	13'6"	14'	813	9.0
	14'0"	14'3"	Not sampled.	
Thickness		5'	203	
150W	0'	3'	249	
	3'	6'	231	
	6'	9'	120	
	9'	12'	322	0.0
	12'	15'	56	
	15'	18'	32	
Thickness		12'	239	
190W	0'	3'	63	
	3'	6'	174	
	6'	9'	70	
	9'	12'	209	
	12'	15'	180	0.0
	15'	18'	55	
	18'	19'	27	
Thickness		12'	139	
230W	0'	3'	120	
	3'	6'	128	
	6'	9'	159	
	9'	12'	170	0.0
	12'	15'	140	
	15'	18'	111	
	18'	21'	Tr.	
Thickness		15'	143.	

TABLE 7 HEAVY MINERAL AND OVERBURDEN IN BORES.

ORIGIN OF CO-ORDINATES : above top of beach 1110' east of training wall as shown in Plate 1 and 2

LINE 5250N contd.
Section A.

BORE	DEPTH FROM	DEPTH TO	LBS/ CU. YD.	O/BRDN FT.
280W	0'	3'	125	
	3'	6'	147	
	6'	9'	123	
	9'	12'	238	0.0
	12'	15'	197	
	15'	18'	113	
	18'	21'	Tr	
Thickness		15'	166	
330W	0'	3'	10	7.5
	3'	6'	Tr.	
Average		9.6'	170	2.1
600W	0'	7'6"	Tr	
650W	0'	6'	Tr	
700W	0'	5'	Tr	
750W	0'	6'	Tr	
800W	0'	8'	Tr	

LINE 4500N.

Origin: East foot of foredune, 982' east of training wall, as shown in Plate 1 and 2

BORE	DEPTH FROM	DEPTH TO	LBS/ CU. YD.	O/BRDN FT.
240E	0'	2'6"	Tr	
140E	0'	2'	Tr	
50E	0'	6'	Tr	
SECTION A.				
34E	0'	11'6"	no sample.	9.4
00	0'	9'3"	Tr	
	9'3"	9'7"	939	9.25
	9'7"	13'	Not sampled.	
35W	0'	14'6"	Tr	
	14'6"	15'	789	14.5
	15'	19'6"	Tr	
80W	0'	9'6"	127	
	9'6"	10'	1430	0.0
	10'	12'3"	Not sampled.	
Thickness		10'	192	
110W	0'	3'	68	
	3'	6'	170	
	6'	7'	2194	3.0
	7'	10'	20	
	10'	11'	21	
	11'	12'	Tr	
Thickness		4'	664	
140W	0'	10'	Tr.	
	10'	10'6"	155	10.0
	10'6"	14'	Not sampled.	
Average		3'	336	7.4
205W	0'	3'	Tr	
285W	0'	2'6"	Tr	
545W	0'	3'	Tr	
582W	0'	10'	44.	

ALSO LINE 4500N & 3750N

BORE	DEPTH FROM	DEPTH TO	LBS/ CU. YD.	O/BRDN FT.
SECTION B.				
612W	0'	17'6"	Tr.	6.4
642W	0'	12'9"	158	0.0
	12'9"	18'	Not sampled.	
682W	0'	9'4"	110	6.4
Average		6.4'	158	4.6
722W	0'	11'	Tr.	
762W	0'	8'6"	Tr	
822W	0'	8'	Tr.	
910W	0'	5'6"	Tr	

LINE. 3750N.

Origin: East foot of first dune from beach, 930' east of training wall, as shown in Plate 1 and 2.

BORE	DEPTH FROM	DEPTH TO	LBS/ CU. YD.	O/BRDN FT.
108E	0'	11'6"	Tr.	
SECTION A.				
72E	0'	10'6"	Tr	10.9
36E	0'	10'3"	Not sampled	
	10'3"	11'6"	288	10.25
	11'6"	12'	Not sampled.	
00	0'	11'6"	Not sampled.	
	11'6"	12'6"	729	11.5
	12'6"	14'6"	Not sampled.	
36W	0'	4'6"	Not sampled	
	4'6"	5'	219	
	5'	10'	Not sampled	
	10'	10'6"	2362	4.5
	10'6"	10'10"	968	
	10'10"	11'	Not sampled.	
Thickness		6'4"	255	
66W	0'	8'3"	Not sampled	
	8'3"	8'9"	586	
	8'9"	10'	Not sampled	
	10'	10'6"	420	8.25
	10'6"	14'6"	Not sampled	
Thickness		2'3"	224	
108W	0'	11'	Not sampled	
	11'	11'6"	961	11.0
	11'6"	16'	Not sampled	
140W	0'	3'	243	0.0
	3'	6'	24	
	6'	8'	12	
Thickness		3'	243	

TABLE 7 ~~THIRD-TYPICAL AREA.~~ HEAVY MINERAL AND OVERBURDEN IN BORES.

ORIGIN OF CO-ORDINATES : East foot of first dune from beach, 930' east of training wall, as shown in Plate 1 and 2.

LINE 3750N. Contd. also 2950N.

Section A.

BORE	DEPTH. FROM	TO	LBS/ CU. YD.	O/BRDN FT.
180W	0'	3'	152.5	2.5
	3'	6'	550	
	6'	8'	Tr	
Thickness		2'6"	281.	
220W	0'	3'	85	7
	3'	5'	28	
	5'	7'	Tr	
Average		2.0'	298.2	6.5'

SECTION B.

BORE	DEPTH. FROM	TO	LBS/ CU. YD.	O/BRDN FT.
300W	0'	3'	26	7
	3'	5'	Tr	
	5'	7'	Tr	
340W	0'	3'	234	2
	3'	6'	74.5	
	6'	9'	48.1	
	9'	11'	Tr.	
Thickness		1'	234	
380W	0'	3'	156	0.0
	3'	6'	36	
	6'	8'	26	
Thickness		3'	156	
420W	0'	3'	132	2
	3'	6'	83	
	6'	9'	Tr	
	9'	11'	Tr	
Thickness		1'	132	
460W	0'	3'	Tr	8
	3'	6'	23	
	6'	8'	35	
Average		1'3"	166.8	2.8
550W	0'	17'	Tr	
600W	0'	16'	Tr	
650W	0'	15'	Tr	
700W	0'	9'6"	Tr	
750W	0'	12'	Tr	

LINE 2950N.

On berm 980' east of training wall, as shown on Plates 1 and 2.

SECTION A.

BORE	DEPTH. FROM	TO	LBS/ CU. YD.	O/BRDN FT.
40E	0'	3'	Tr	
	3'	6'	Tr	
	6'	9'	Tr	12
	9'	12'	43	
	12'	15'	Tr	
00	0'	3'	Tr	
	3'	6'	69	
	6'	10'	110	
	10'	12'	1284	10
	12'	15'	92.	
Thickness		2'	1284	
40W	0'	3'	40	
	3'	6'	Tr	
	6'	9'	38	
	9'	12'	84	
	12'	15'	274	12
	15'	18'	7	
	18'	21'	Tr	
Thickness		3'	274	
80W	0'	3'	31	
	3'	6'	12	
	6'	9'	58	
	9'	12'	51	
	12'	15'	291	
	15'	15'6"	83	12.0
	15'6"	16'	802	
	16'	17'6"	124	
	17'6"	18'	2830	
	18'	21'	Tr	
Thickness		4'3"	640	
120W	0'	3'	24	
	3'	6'	179	
	6'	9'	48	
	9'	10'	32	4'.0
	10'	10'4"	2705	
	10'4"	13'4"	205	
	13'4"	15'	Tr	
Thickness		5'4"	351.5	
160W	0'	3'	Tr	
	3'	6'	44	
	6'	9'	135	
	9'	12'	123	6'
	12'	15'	141	
	15'	18'	Tr	
	18'	19'	Tr	
Thickness		8'	133	
240W	0'	3'	Tr	6'
	3'	6'	-	
Average		3.2'	400.6	6.8'
320W	0'	6'	Tr	
400W	0'	11'	Tr	
520W	0'	6'	Tr	
600W	0'	6'	Tr	
680W	0'	11'	Tr	
760W	0'	6'	Tr	
860W	0'	6'	Tr	
960W	0'	11'	Tr	

TWEED - FINGAL AREA.

TABLE 7 HEAVY MINERAL AND OVERBURDEN IN BORES.

ORIGIN OF CO-ORDINATES : Top of beach, as shown in Plates 1 and 2.

LINE 1500N. ALSO 750N.

BORE	DEPTH FROM	DEPTH TO	LBS/ CU. YD.	O/BRDN FT.
75E	0'	2'	Tr	
30E	0'	3'9"	Tr	
18E	0'	10'	Tr	
00	0'	13'	Tr	
SECTION A.				
50W	0'	10'	Tr.	
	10'	10'5"	198	10.0
	10'5"	11'9"	Not sampled	
95W	0'	7'	Not sampled	
	7'	8'	207	
	8'	8'6"	Not sampled	
	8'6"	9'	515	7.0
	9'	12'	Tr	
	12'	13'6"	Tr	
Thickness		2'	232	
125W	0'	10'	Tr	
	10'	10'3"	485	10.0
	10'3"	12'	Trace.	
Average		1.2'	239	8.5
SECTION B.				
125W		as above.		
170W	0'	8'	70	
	8'	8'4"	3236	8.0
	8'4"	10'	429	
Thickness		2'	897	
200W	0'	3'	60	
	3'	6'	104	
	6'	9'	108	9.0
	9'	9'6"	1980	
	9'6"	12'6"	161	
	12'6"	13'	25	
	13'	16'6"	Not sampled	
Thickness		3'6"	421	
240W	0'	14'6"	57	10.7
Average		1.8'	599	9.2
305W	0'	14'6"	Trace	

LINE. 750N.
Origin;
Middle of berm, as shown on Plates 1 and 2.

BORE	DEPTH FROM	DEPTH TO	LBS/ CU. YD.	O/BRDN FT.
72E	0'	7'6"	Not sampled	
	7'6"	7'10"	19219	
	7'10"	11'6"	Not sampled	
36E	0'	11'	Tr	
00	0'	11'6"	Tr	
36W	0'	4'6"	Not sampled	
	4'6"	7'	Tr	
	7'	10'	Not sampled	
	10'	10'6"	107.2	
	10'6"	10'9"	Not sampled	
	10'9"	11'3"	141.4	
	11'3"	11'6"	Not sampled	
	11'6"	14'	Tr.	
SECTION A.				
72W	0'	8'3"	56.6	
	8'3"	8'9"	229.1	
	8'9"	10'6"	Not sampled.	8.25
	10'6"	10'10"	312.3	
	10'10"	11'	Not sampled	
112W	0'	3'	18	
	3'	6'	26	
	6'	9'	109	
	9'	12'	262	9.0
	12'	13'6"	1579	
	13'6"	14'	22	
	14'	15'	447	
	15'	17'	13	
Thickness		6'	443	
152W	0'	3'	24	
	3'	6'	55	11.0 (6.0 + 5.0)
	6'	9'	175	
	9'	12'	79	
	12'	14'	98	
	14'	14'6"	672	
	14'6"	17'6"	74	
	17'6"	19'	Tr	
Thickness		3'6"	246	
192W	0'	3'	Tr	
	3'	6'	175	3.0
	6'	9'	71	
	9'	12'	Tr	
Thickness		3'	175	
230W	0'	3'	56	
	3'	6'	190	3
	6'	9'	Tr.	
Thickness		3'	190	
270W	0'	3'	140	0.0
	3'	6'	36	
	6'	7'	Tr	
Thickness		3'	140	
310W	0'	3'	47	1.5
	3'	8'	Tr.	
Average		3.1'	269	5.2
SECTION B.				
350W	0'	3'	40	1.5
	3'	7'	Trace	
390W	0'	3'	178	0.0
	3'	5'	54	
	5'	6'	Trace	
Thickness		3'	178	

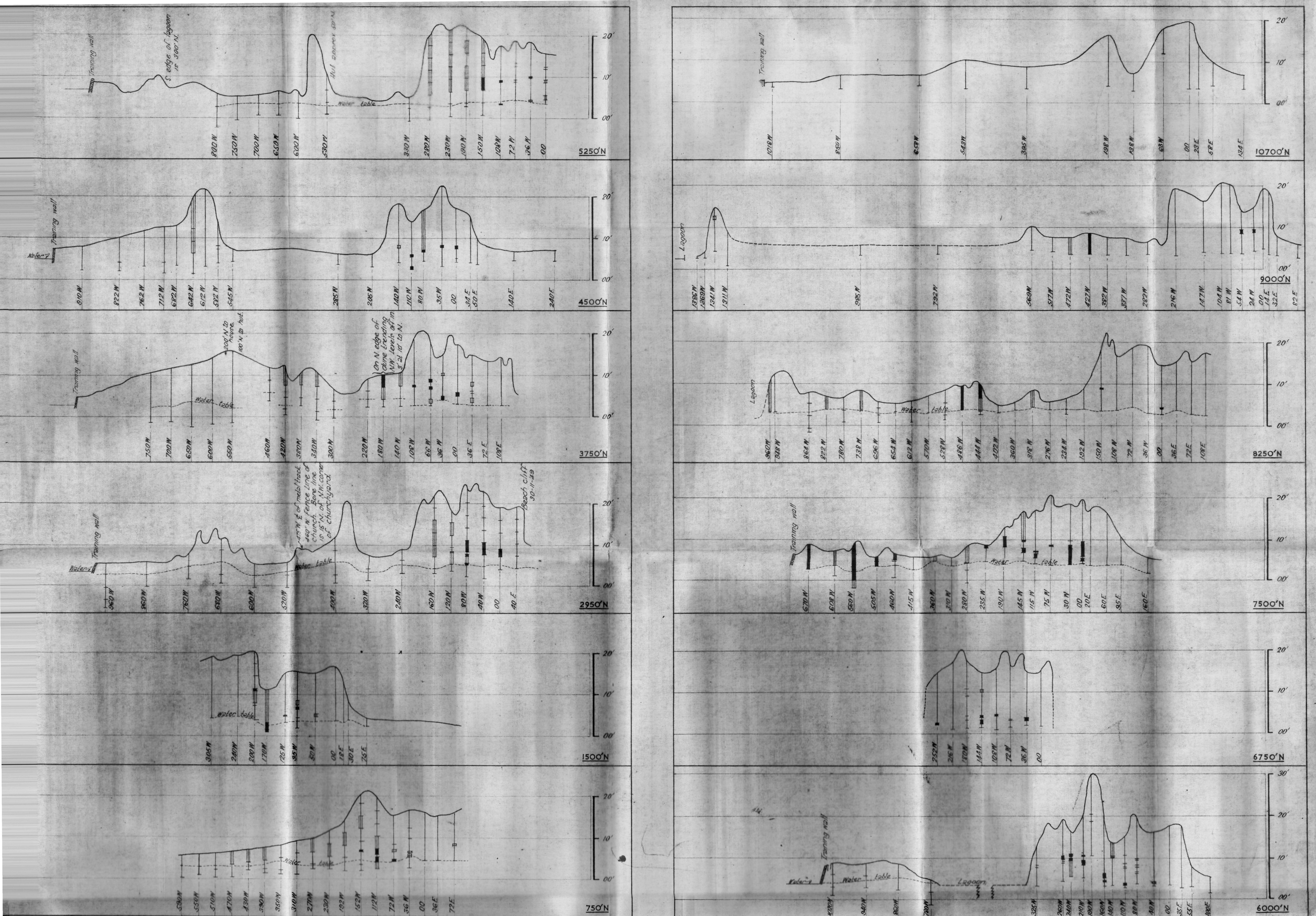
TABLE 7 HEAVY MINERAL AND OVERBURDEN IN BORES. [THIRD-FINGAL AREA.]

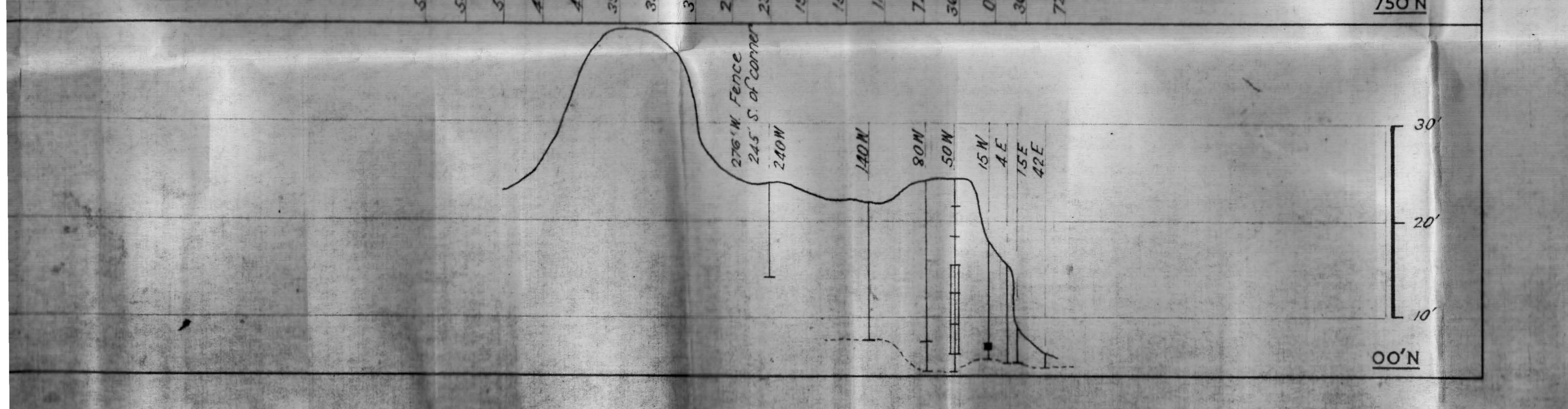
ORIGIN OF CO-ORDINATES : ~~Middle of berm, as shown on Plates 1 & 2.~~

LINE 750N. CONTD.

BORE	DEPTH FROM	DEPTH TO	LBS/ CU. YD.	O/BRDN FT.	BORE	DEPTH FROM	DEPTH TO	LBS/ CU. YD.	O/BRDN FT.
430W	0' 3' 5'	3' 5' 6'	212 46 Trace	0.0					
Thickness		3'	212						
470W	0' 3' 3'6"	3' 3'6" 6'	125 48 Trace	0.0					
Thickness		3'	125						
510W	0' 3' 4'	3' 4' 6'	71 72 Trace	1.5					
Average		2.2'	172	0.4					
550W	0' 3'	3' 5'	31 Tr						
590W	0' 2'6"	2'6" 5'	57 Tr						
LINE 00.									
276' east of point 245' south of north-east corner of allotment 340 as shown in Plates 1 and 2.									
42E 15E	0' 0'	1'6" 3'	Tr Tr						
SECTION A.									
4E	0'	10'	Tr	10.6					
15W	0' 10' 10'2"	10' 10'2" 11'3"	Tr 1080.8 243.8	10.0					
Thickness		1'3"	355.4						
50W	0' 3' 6' 9' 12' 15' 18'	3' 6' 9' 12' 15' 18' 20'	Tr Tr 59.3 238 184 172 48.2	9.0					
Thickness		9'	198						
80W	0'	19'6"	Tr	13.5					
Average		3.8'	215	10.3'					
140W 240W	0' 0'	14'6" 10'	Tr Tr.						

PLATE 1
REFERENCE
RECENT
Swamp
Low lying, sandy and peaty
Low lying and sandy
Sand
PLIOCENE
Basalt
LOWER PALAEOZOIC
Sediments
Heavy mineral deposits
Bore holes
Lease boundaries
Built up areas
Tweed Heads T.
GREENBANK
ISLAND
9000 N LINE
6750N LINE
Southern Breakwater
10700 N
9000 N
8250 N
7500 N
6750 N
6000 N
5250 N
4500 N
3750 N
2950 N
1500 N
750 N
00 N
Bench
GRASSY
FLAT
Ukerebagh
Passage
UKEREBAGH
ISLAND
ABORIGINAL RESERVE
Terranora
Creek
DRY DOCK ROAD LINE
PARRISH RD. LINE
Highway Line
NATIVE SETTLEMENT
OCEAN
RIVER
TWEED
Benched Spur
Benched spur
LINE 1
HIGHWAY
PACIFIC
KING
LINE
"3,00" LINE
EAST
Fingal Head
T.
Conglomerate
Basalt Boulders
COOK IS.
PACIFIC
TONY'S
ISLAND
TRIG. 254'
LOCALITY MAP
SHOWING POSITION OF AREA DEALT WITH IN REPORT AND REFERENCE TO AUSTRALIAN 1 & 4 MILE MAP SERIES
CABOOLTURE
REDCLIFFE
SAMFORD
BRISBANE
IPSWICH
BEENLEIGH
FLINDERS
TAMBOURINE
SOUTHPORT
OCEAN
SPRINGBROOK
COOLANGATTA
TWEED HEADS
SITE OF SURVEY AND BORING
QNSLD.
N.S.W.
MURWILLUMBAH
NORRIES HEAD
TWEED
HEADS
NIMBIN
BYRON BAY
LISMORE
BALLINA
WOODBURN
PACIFIC
MACLEAN
WOOMBAH
ONE MILE MAPS :- "BALLINA"
FOUR MILE MAPS :- "MACLEAN"
SEE FINGAL-CUDGEN AREA FOR DETAILS OF BORES SOUTH OF FINGAL HEAD.
MINERAL DEPOSITS
OF THE
TWEED - FINGAL AREA
NEW SOUTH WALES
PLAN
Scale: 1" TO 500'





LEGEND

120–300 LBS. PER CUBIC YARD

OVER 300 LBS. PER CUBIC YARD

MINERAL DEPOSITS OF THE TWEED–FINGAL AREA

NEW SOUTH WALES

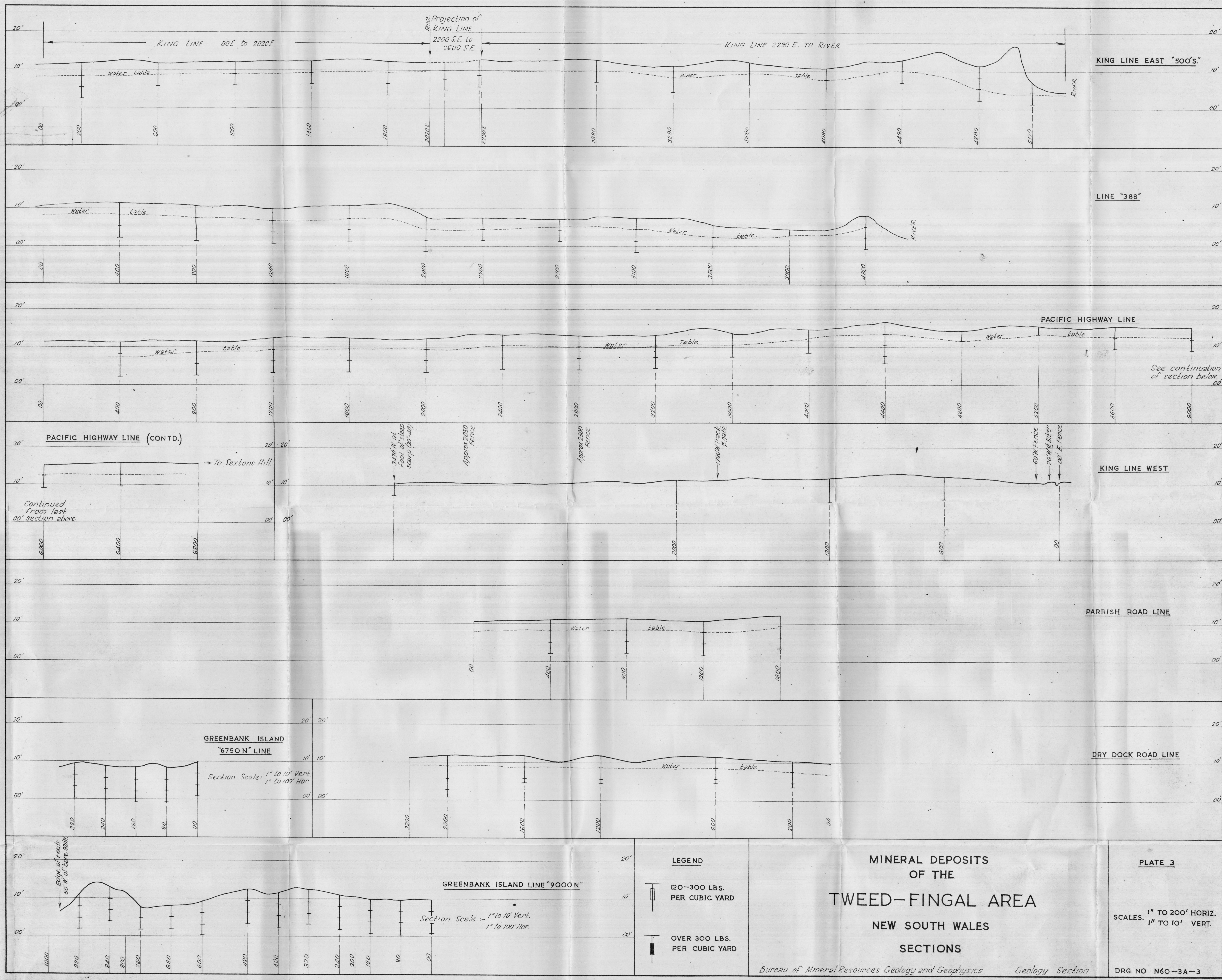
SECTIONS

Bureau of Mineral Resources Geology and Geophysics — Geology Section

PLATE 2

SCALES. 1" TO 100' HORIZ. 1" TO 10' VERT.

DRG. Nº N60–3A–2


KING LINE EAST "500'S"
KING LINE 00E to 2020E
Projection of KING LINE 2200 S.E. to 2600 S.E.
KING LINE 2290 E. TO RIVER
Water table
River
LINE "388"
PACIFIC HIGHWAY LINE
See continuation of section below.
PACIFIC HIGHWAY LINE (CONTD.)
To Sextons Hill
Continued from last section above
KING LINE WEST
Approx 2050 Fence
Approx 2600 Fence
PARRISH ROAD LINE
GREENBANK ISLAND "6750 N" LINE
Section Scale: 1" to 10' Vert. 1" to 100' Hor.
DRY DOCK ROAD LINE
GREENBANK ISLAND LINE "9000 N"
Section Scale :- 1" to 10' Vert. 1" to 100' Hor.
LEGEND
120–300 LBS. PER CUBIC YARD
OVER 300 LBS. PER CUBIC YARD
MINERAL DEPOSITS OF THE
TWEED–FINGAL AREA
NEW SOUTH WALES
SECTIONS
Bureau of Mineral Resources Geology and Geophysics
Geology Section
PLATE 3
SCALES. 1" TO 200' HORIZ. 1" TO 10' VERT.
DRG. NO N60–3A–3

TWEED - FINGAL AREA

LONGITUDINAL VARIATION IN COMPOSITION OF MINERAL CONCENTRATES

FIG. 1

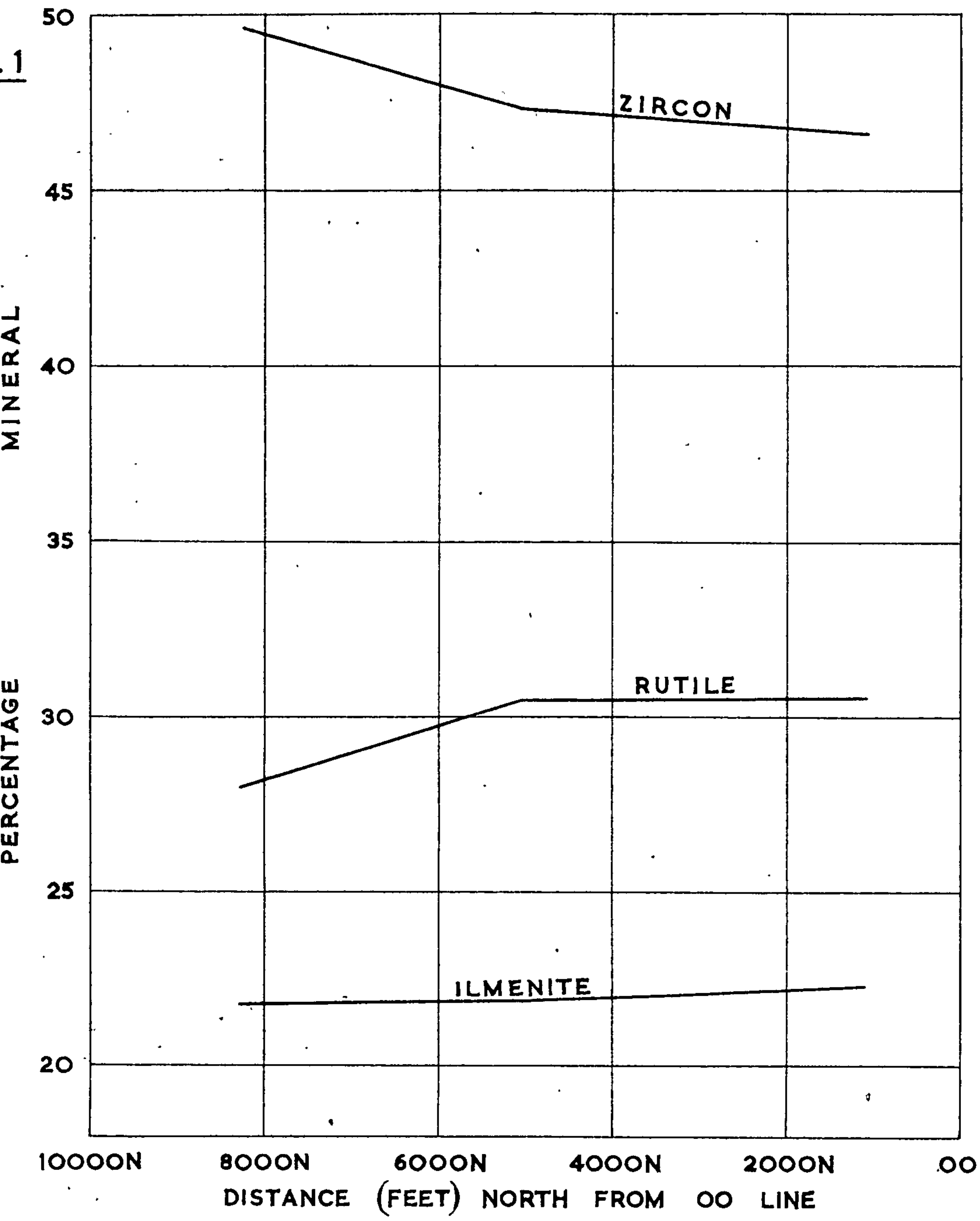


FIG. 2