COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Report No. 28

The Identification of the Boundary Between Coal Measures and Marine Beds, Singleton – Muswellbrook District, New South Wales

BY

M. A. REYNOLDS

Issued under the Authority of Senator the Hon. W. H. Spooner,
Minister for National Development
1956

LIST OF REPORTS

1. Preliminary Report on the Geophysical Survey of the Collie Coal Basin.—N. G. Chamberlain, 1948.
2. Observations on the Stratigraphy and Palaeontology of Devonian, Western Portion of Kimberley Division, Western Australia.—C. Teichert, 1949.
3. Preliminary Report on Geology and Coal Resources of Oaklands-Coorabin Coalfield, New South Wales.—E. K. Sturmfels, 1950.
4. Geology of the Nerrima Dome, Kimberley Division, Western Australia.—D. J. Guppy, J. O. Cuthbert and A. W. Lindner, 1950.
5. Observations of terrestrial magnetism at Heard, Kerguelen, and Macquarie Islands, 1947-48. (Carried out in co-operation with the Australian National Research Expedition, 1947-48.). —N. G. Chamberlain, 1952.
6. Geology of New Occidental, New Cobar and Chesney Mines, Cobar, New South Wales.—C. J. Sullivan, 1951.
7. Mount Chalmers Gold and Copper Mine, Queensland.—N. H. Fisher and H. B. Owen, 1952.
8. The Ashford Coal Province, New South Wales.—H. B. Owen, G. M. Burton and L. W. Williams, 1955.
9. The Mineral Resources of Papua and New Guinea.—P. B. Nye and N. H. Fisher, 1954.
10. Geological Reconnaissance of South-West Portion of Northern Territory.—G. F. Joklik, 1952.
11. The Nelson Bore, Victoria; Micropalaeontology and Stratigraphical Succession.—I. Crespin, 1955.
12. Stratigraphy and Micropalaeontology of the Tertiary Marine Rocks between Adelaide and Aldinga, South Australia.—I. Crespin, 1955.
13. Geology of Dampier Peninsula, Western Australia.—R. O. Brunnschweiler (in press).
14. A Provisional Isogonic Map of Australia and New Guinea, showing Predicted Values for the period 1955-65.—F. W. Wood and I. B. Everingham, 1953.
15. Progress Report on the Stratigraphy and Structure of the Carnarvon Basin, Western Australia. —M. A. Condon, 1955.
16. Seismic Reflection Survey at Roma, Queensland.—J. C. Dooley.
17. Mount Philp Iron Deposit, Queensland.—E. K. Carter and J. H. Brooks, 1956.
18. Petrology and Petrography of Limestones from the Fitzroy Basin, Western Australia—J. E. Glover, 1956.
19. Heard Island Magnetic Report.
20. Micropalaeontological Investigations in the Bureau of Mineral Resources, 1927-52.—I. Crespin.
21. Macquarie Island Magnetic Report.
22. Occurrence and Distribution of Oil in Glauconitic Sandstone at Lakes Entrance, Victoria.—R. F. Thyer and L. C. Noakes, 1955.
23. Seismic Survey, Darriman, Victoria.—M. G. Garrett.
24. Sedimentary Control of Uranium Deposition in Northern Territory.—M. A. Condon and B. P. Walpole, 1955.
25. Papers on Tertiary Micropalaeontology.—I. Crespin, F. M. Kicinski, S. J. Patterson and D. J. Belford, 1956.
26. The Mount Langila Eruption.—G. A. Taylor, J. G. Best and M. A. Reynolds (in press).
27. Magnetic Results from Macquarie Island, 1952—P. M. MacGregor.
28. The identification of the boundary between coal measures and marine beds, Singleton-Muswellbrook District, New South Wales.—M. A. Reynolds, 1956.
29. The Geology of the South-West Canning Basin.—D. M. Traves, J. N. Casey and A. T. Wells (in press).

Printed by Mercury Press Pty. Ltd.

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Report No. 28

The Identification of the Boundary Between Coal Measures and Marine Beds, Singleton – Muswellbrook District, New South Wales

BY

M. A. REYNOLDS

Issued under the Authority of Senator the Hon. W. H. Spooner,
Minister for National Development
1956

DEPARTMENT OF NATIONAL DEVELOPMENT

Minister—Senator the Hon. W. H. Spooner, M.M.
Secretary—H. G. Raggatt, C.B.E.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Director—P. B. Nye, O.B.E.
Deputy Director—J. M. Rayner.

This Report was prepared in the Geological Section.
Chief Geologist—N. H. Fisher.

THE IDENTIFICATION OF THE BOUNDARY BETWEEN COAL MEASURES AND MARINE BEDS

by

M. A. Reynolds

CONTENTS

SUMMARY

The lithology and stratigraphy of rock units lying at the top of the "Upper Marine Series" in the Singleton-Muswellbrook District are discussed. 35 bores have been examined, as well as surface showings, and nine lithological units have been distinguished in the transition beds between the "Upper Marine Series" and the Tomago Stage. The upper units are transitional and represent the final stage of marine deposition and the early stages of freshwater deposition; the lower units are referable to the "Mulbring or Crinoidal" Stage. The change is readily identified by the presence or absence of Ammodiscus multicinctus. Calcareous Foraminifera and Ostracoda previously thought to be restricted to the "Branxton Stage" have been found in the uppermost beds of the "Mulbring Stage".

Cold shallow water formed the environment of deposition of the sediments of the upper part of the "Upper Marine Series."

INTRODUCTION

During the years 1951 to 1954, the Bureau of Mineral Resources, Geology and Geophysics, in cooperation with the Joint Coal Board and the New South Wales Department of Mines, conducted an investigation into the reserves of open-cut coal. During this investigation much drilling was done to determine the extent of coal reserves; but although boring in the Singleton-Muswellbrook District has been primarily for coal reserves, penetration of the uppermost marine beds was often essential for purposes of correlation. This is because coal seams which can be correlated over small areas are often difficult to identify in more distant localities because of lensing and splitting of coal seams, the tectonic history of the area, or igneous intrusions.

The identification of sediments as marine has not been straightforward because:

(a) Megafossils are not common;

(b) The dominant Foraminifera in the uppermost marine sediments in the area are very hard to distinguish owing to the similarity of their composition to that of the enclosing sediments;

(c) Carbonaceous matter and plant detritus exist in the upper marine beds, although not to the same extent as in the coal measures;

(d) In appearance, the uppermost marine beds are identical with some bands encountered in the overlying fresh-water beds;

(e) The change from marine to fresh-water sediments (Tomago Stage, "Parnell's Creek Sandstone Member"[x])(Bursill and Veevers, 1952) is transitional rather than abrupt;

(f) The thickness of the transitional unit ("Bayswater Siltstone", Bursill and Veevers, 1952) is not constant.

Because of these and other difficulties it has been necessary to experiment with various methods for the determination of marine sediments.

As a result of the examination of the lithology and microfaunas of the marine beds it has been possible to make some observations which may be useful in determining the stratigraphical position of these beds.

THE IDENTIFICATION OF THE MARINE BEDS

Methods Employed

In the field. Hand-lens examination of core is the most practical and useful method of determining whether marine beds have been penetrated, where fossils are plentiful and conspicuous. Some larger foraminifera (*Hyperamminoides acicula*), crinoid stems, bryozoal and molluscan remains, and ostracods may be found by this means. But this can only be seen by breaking the core into small fragments and thoroughly examining each piece. The dominant Foraminifera in the uppermost marine sediments in the areas under discussion (*Ammodiscus multicinctus*) are difficult to distinguish from their matrix, and though they are sometimes abundant, they may remain undiscovered with the hand lens and the sediment may wrongly be considered unfossiliferous.

Lithological studies have revealed that nodules of pyrite may indicate marine to transitional sediments (see p.8).

In the field laboratory. If field determination is not conclusive, suitable samples are collected and examined in the laboratory. The sample may be

---

x Names in inverted commas are informal names used in the field and in unpublished reports as indicated.

disintegrated by boiling in a solution of sodium carbonate or sodium hydroxide or heating with an equal quantity of Glauber's Salts.

Possible Use of Electric Logging

The determination of the transitional and marine beds by electric logging should not be difficult for two reasons:

(a) The sequence of rock units from the uppermost marine to the transitional zone ("Bayswater Siltstone") appears to be consistent, and each unit is comparatively homogeneous in composition, apart from occasional thin bands of siderite, limestone (cone-in-cone structures), and crystal tuff;

(b) The salt content of connate water of sediments probably increases as the marine units are approached.

The curves obtained from such beds should form a distinctive pattern even though the rock units vary in thickness.

THE STRATIGRAPHICAL POSITION OF THE MARINE BEDS

Areas Discussed

Boring has been carried out in the following localities and areas: Ravensworth Trig Station; between Bayswater Creek and the railway bridge, approximately two miles north-west of Ravensworth; in the State Mine Reserve, south of Liddell Railway Station; in the Farrell's Creek, Parnell's Creek, Pond's Creek, and Jerry's Plains areas; along the western flank of the Muswellbrook dome from just north of "Plashett" homestead almost to Muswellbrook and extending as far to the west as Anderson's Gap. Marine and transitional sediments were penetrated in about 35 bores, most of these being in the Pond's Creek and Parnell's Creek areas.

In addition to the core examined from these holes, upper marine sediments have been examined in Bore No. BMR 1 S.C. St. Heliers (about 4 miles east of Muswellbrook), in outcrops a mile east of Hebden, in cuttings along the new railway track south and west of Padulla Siding, in outcrops near the Singleton railway bridge and just east of Long Point, and in railway cuttings north of Minimbah Station.

Nomenclature

The nomenclature of the sediments forming the Permian System in the Hunter River Valley has recently been discussed by the A.N.Z.A.A.S. Standing Committee on Stratigraphic Nomenclature (Raggatt, 1953). Of particular interest are the conclusions drawn from the examination of the term "Upper Marine Series":

"(a) a rock-unit name is required for the lithological entity represented by the "Upper Marine Series";

(b) the status of "Upper Marine Series" as a time-stratigraphic term, and the name itself, require critical examination;

(c) it is inadvisable to define local time-stratigraphic units unless there is available a complete marine sequence with a well-differentiated fauna; or the sequence contains fossils of known or demonstrable restricted range."

Literature as late as 1950 infers that the "Upper Marine Series" is a time-rock unit by the subdivision into "Branxton, Muree, and Mulbring or Crinoidal Stages" (David, 1950). As far as can be ascertained, these subdivisions are based on lithology alone, and the subdivision should be into rock rather than time-rock units.

Because of the limitations of the work done by the author in this district, it is not possible to form any definite conclusions on the status of the "Upper Marine Series" or its subdivisions. However, the following discussions of lithology and microfaunal distribution should prove useful when the nomenclature is reviewed. Marine sediments are tentatively divided into lithological units and numbered for the purposes of discussion.

Lithology

In order to describe the sedimentary sequences in bores shown in Figure 1, it has been decided to number the units into which they may be divided.

Because of the economic importance of some seams encountered in the Tomago Coal Measures a considerable amount of work has been done on the quality of the coal in such seams, the nature of the seams, and the geology of the Tomago Coal Measures as a whole. In this discussion, therefore, it is proposed to separate only the bottom coal seam ("Barrett's") and the underlying greywacke sandstone unit("Parnell's Creek Sandstone Member") from the overlying beds so that the transition between the uppermost marine beds and the Tomago Coal Measures will be apparent. The units numbered 1 to 3 are, therefore, convenient lithological subdivisions of the lower part of the Tomago Coal Measures. Descriptions, including thicknesses of units Nos. 1 to 4, are given by Veevers (1952, 1953).

No. 1 unit - Conglomerate, greywacke, siltstone, claystone, shale and coal seams, ("Barrett's Sandstone Member").

No. 2 unit - Bottom coal seam, "Barrett's Seam" (mean thickness 9 feet).

No. 3 unit - "Parnell's Creek Sandstone Member": greywacke sandstone, generally light grey, grain size ranging from very fine to coarse with lenses of grey siltstone and claystone; 57 to 186 ft. thick.

No. 4 unit - "Bayswater Siltstone" (Veevers, 1952):grey siltstone with occasional beds of dark grey silty claystone towards the bottom and rare thin beds of very fine to fine-grained greywacke; 16 to 79 feet thick.

In the Parnell's Creek and Pond's Creek areas, five lithological units in the uppermost marine sediments have been separated. Further boring or the discovery of outcrops showing the complete stratigraphical sequence in this district is necessary before the extent of these units can be established.

No. 5 unit consists of silty claystone ("mudstone") to clayey siltstone with few beds of shale, dark grey, slightly micaceous, with rare pebbles in Hole No. BMR 3(S) Parnell's Creek. Some notes on the occurrence of nodules of pyrite, thin bands of tuffaceous shale, siderite and limestone with cone-in-cone structures are given later (p.8).

This unit is the uppermost of the marine beds encountered below the "Bayswater Siltstone". The boundary between the "Bayswater Siltstone" and this unit is not always evident, but certain features aid in the differentation. The unit is generally finer in grain size, darker in colour, and contains less carbonaceous matter. The occurrence of abundant Ammodiscus multicinctus in the upper portion of this unit, however, is a most important diagnostic feature (see p. 16).

The unit has not been completely penetrated in any one bore. Bore No. BMR 1 Bayswater was completed at 1500 feet in claystone ("mudstone") after penetrating 242 feet of the unit.

No. 6 unit consists of grey siltstone with numerous thin greywacke beds in the lower portion.

This is a transition zone between units Nos. 7 and 5 in Bore No. BMR 76 (T) Parnell's Creek. On lithological grounds, on extrapolation from structure contours of the top of the "Bayswater Siltstone", and on the microfaunal assemblage, the lower core from Bore No. BMR 4 (T) Pond's Creek is placed with this unit.

The thickness of this unit is 82 ft. 8 in. in Bore No. BMR 76 (T) Parnell's Creek. In Bore No. BMR 4 (T) Pond's Creek the upper weathered zone (37 ft. 8 in.)may possibly represent the lower portion of unit No. 5.

No. 7 unit consists of grey to light grey Greywacke, fine to very fine grained, with a mottled appearance due to the presence of small lenticles of greywacke surrounded by very fine layers of black carbonaceous matter; this unit is silty in part.

The unit was encountered in Bore No. BMR 76 (T) Parnell's Creek from 240 ft.11in. to 305 ft. 4 in., at which depth the hole was completed; and in Bore No. BMR 12 (T) Pond's Creek from the surface to 94 ft. 2 in.

The thickness of the unit is 94 ft. 2 in. in Bore No. BMR 12 (T) Pond's Creek; but since the unit was penetrated from the surface, the total thickness is not known.

No. 8 unit consists of interbedded light grey to grey very-fine-grained greywacke and grey siltstone.

This is a transition zone between units Nos. 9 and 7 in Bore No. BMR 12 (T) Pond's Creek. The upper 26 ft. of Bore No. BMR 11(T) Pond's Creek is a weathered zone. Only 8 in. was recovered from this zone, and by extrapolation it is possible that units Nos. 8 and 7 are represented.

The thickness of the unit is 17 ft. in Bore No. BMR 12 (T) Pond's Creek.

No. 9 unit is mainly siltstone and very-fine-grained greywacke, dark grey and grey, micaceous, with few thin bands of silty claystone and shale.

This unit is similar in appearance to unit No. 5 but is of slightly coarser grain size and more micaceous. Its relation to unit No. 8 was established in Bore No. BMR 12 (T) Pond's Creek. By lithology and extrapolation from structure contours, the cores from the following bores are placed within this unit:

BMR 14 (T)	Pond's Ck.		52'0"	-	105'6"
BMR 12 (T)	"	"	111'1"	-	154'0"
BMR 11 (T)	"	"	26'0"	-	99'0"
BMR 10 (T)	"	"	0'	-	101'6"
BMR 6 (S)	"	"	0'	-	217'8"

The unit's thickness is 217 ft. 8 in. in BMR 6 (S) Pond's Creek. Actual thickness cannot be given since this unit was penetrated from the surface to this depth.

Dips up to a maximum of 20° have been calculated from structure contours of the base of the "Parnell's Creek Sandstone Member" (unit No. 3) in the Pond's Creek area on the western flank of the Muswellbrook dome. The dip gradually decreases around the southern end to the eastern flank in the Parnell's Creek area. Thicknesses given are those estimated from the cores recovered, and in the Pond's Creek area, where the dip is greatest, no allowance has been made for the fact that true thicknesses will be less than the estimated thicknesses. Of the bores mentioned above, only the following will be affected by this anomaly:

BMR 14 (T) Pond's Creek
BMR 12 (T) " "
BMR 11 (T) " "

In these bores the approximate true thickness = estimated thickness x 0.94.

The above descriptions are based on the predominant lithology in each unit. Bands of other rock types and of nodules of pyrite occur:

(a) Thin bands of generally light coloured, sometimes sandy, crystal tuff, tuffaceous shale, and claystone are found from unit No. 9 up into the Tomago Coal Measures. Representative samples of bands, both from marine and fresh-water formations, have been forwarded to the Mines Department, Sydney, for comparison of salt content. Samples from an outcrop in the new railway cuttings west of Padulla Siding (about 4 miles N.N.W. of Singleton) have been tested by P.G.Duff, Petroleum Technologist, to establish their suitability for use in drilling fluids (see Appendix I).

(b) Thin bands of siderite and limestone with cone-in-cone structures are often associated and occur throughout the sediments described above. Occurrences of these and of the tuffaceous bands above are described in some detail by Veevers (1952,1953).

(c) The nodules of pyrite encountered in the "Bayswater Siltstone" and underlying sediments may indicate a marine or near-marine environment. Marcasite has been noted in seams of the Tomago Coal Measures but nodules of pyrite have not been found, as far as is known, in the enclosing sediments. Pyrite occurs in cleat and cleavage planes and in thin veins throughout all units described above.

The pyrite occurs as nodules in the basal beds of the "Bayswater Siltstone" and underlying marine beds, and as internal moulds and casts of fossils in marine beds. The nodules are generally less than one inch in diameter, and sections have revealed varying amounts of included silt and rare quartz grains. The nodules have been recorded in beds above the fossiliferous marine beds in Bore No. BMR 3 (S) Parnell's Creek and also in lenses of dark grey sideritic siltstone in a railway cutting south-west of Padulla Siding. In these occurrences, the beds are referable to the lower portion of the "Bayswater Siltstone". All other occurrences are in the underlying marine beds and it is suggested that there was little change in the environment between the deposition of the uppermost marine beds and that of the "Bayswater Siltstone".

The minerals pyrite and marcasite were not determined. Their identities have been assumed after comparison with similar occurrences in Tertiary beds in Victoria described by Edwards and Baker (1951).

Cores from units Nos. 5 to 9, when fresh, are generally compact, but after exposure to the atmosphere for a short period they develop irregular fractures and tend to disintegrate into small irregular nodules. This type of weathering appears to be characteristic and has been noted also in outcrops of rocks comparable to these beds. The tendency for tunnelling to occur in dams constructed in clays developed above marine beds in this district, and peculiar erosional features brought about presumably by this tendency, were mentioned by an officer of the Soil Conservation Service. As it was thought that certain salts might be responsible, samples of claystones and siltstones from units Nos. 3 and 4 and from the underlying beds were sent to the Mines Department, Sydney, for analysis of salt contents.

An extract of the descriptive log of Bore No. BMR 1 S.C. St. Heliers from 0 to 300 ft. is given hereunder since some analysis of the microfauna has been possible.

	Estimated Thickness Ft.	Estimated Thickness In.	Estimated Depth Ft.	Estimated Depth In.
Alluvium, brown clay and some silt with sand and rock gravel.	12	-	12	-
Sand, light coloured, very fine to coarse, with some clay.	5	-	17	-
Siltstone, light brown-grey, weathered, fossiliferous (as below, 56 ft. 3 in.).	3	-	20	-
Sand, as above, mostly fine-grained.	2	-	22	-
Siltstone, grey and brown, weathered for approximately 10 ft. to dark grey, sandy in part with some pebbles, micaceous, irregular shale-like cleavage in thin bands. (Fossils: Foraminifera, Bryozoa, Brachiopoda, Mollusca, Ostracoda and crinoid ossicles. A fragment of brown calcite)	56	3	78	3

	Estimated Thickness Ft.	Ins.	Estimated Depth. Ft.	Ins.
Greywacke, dark grey to grey, very-fine-grained, with irregular lenticles of dark grey siltstone and grey fine-grained greywacke to dark grey sandy siltstone; occasional pebbles; very micaceous, pyritiferous, fossiliferous as in siltstone above to very fossiliferous from 134 ft. to 138 ft 9 in. (Bryozoa from 138 ft. identified by Dr. Joan Crockford as <u>Fenestella dispersa</u>, see Appendix III).	60	6	138	9
Shale, grey to off-white, clayey, tuffaceous, with thin impure limestone band (cone-in-cone structure) at bottom.	1	-	139	9
Siltstone, dark grey, with sandy lenticles as above over top 2 ft., sand (fine to very coarse) and pebbles with occasional cobbles common.	18	9	158	6
Greywacke, grey and dark brown-grey mottled, very fine to fine-grained mostly, but medium to very coarse-grained sand, pebbles and cobbles are present and constitute about 15% of the sediments at the top. The percentage of fine-grained matrix decreases towards the bottom. Argillaceous to silty; fossiliferous, notably from 223 ft. downwards.	99	6	258	-
Greywacke, as above but mostly coarse-grained matrix.	26	6	284	6
Greywacke, grey to dark brown-grey very coarse-grained to fine-grained conglomerate, with argillaceous to fine-grained sandy matrix fossiliferous.	15	6	300	-

The irregular dips shown by lenticles range between 45° and 55°. The approximate true thickness is 65 percent of the estimated thickness given above.

Most of the above sequence was cored, but the following intervals were not cored: 0 - 21 ft. 9 in., 25 ft. 6 in. - 45 ft. 6 in., 78 ft. 3 in. - 81 ft. 9 in.

As the "Upper Marine Series" crops out in a number of places in the Singleton district, it was decided to examine as many of these as time permitted, for two reasons:

(1) To determine the sequence of the uppermost marine beds in order to verify the section established in the Parnell's Creek and Pond's Creek areas;

(2) To discover if there is definite evidence for referring units Nos. 5 to 9 to the "Branxton Stage" (see Appendix IV), considering both the lithology and microfaunal assemblages.

A number of outcrops has been examined, but it has not been possible to correlate them with any precision with the section compiled from bores in the Parnell's Creek and Pond's Creek areas. The two localities at which uppermost marine beds are represented are the railway cuttings west and south of Padulla Siding and outcrops east of Hebden. In both, however, the section between the "Bayswater Siltstone" and beds referable to unit No. 9 is only poorly represented.

East of Hebden, portions of a succession from "Upper Marine Series" to lower Tomago Coal Measures are revealed over a distance of 1½ miles in occasional outcrops in creek beds and cuttings. These beds dip to the east, and the lowest stratigraphical horizon examined occurs in a creek bed about 1¼ miles to the east of the Hebden Post Office. Outcrops sampled in ascending stratigraphical order were as follows:

Lowest stratigraphical horizon: sandy siltstone to very fine-grained greywacke, brown to grey, weathered to grey, with some pebbles. Samples: H5 and H4.

Outcrop approximately ½ mile to the east of the above:

Silty claystone to siltstone, brown to grey, weathered to dark grey at the base where compact and indurated by a thin sill. The middle portion of this outcrop contains abundant Hyperamminoides acicula - easily discernible with the naked eye. Samples: H3, H2 and H1.

Samples of brown-grey weathered silty claystone and brown weathered very fine to fine-grained greywacke, thought to form parts of the lower portion of the Tomago Coal Measures, were collected to the east of the above in isolated outcrops. Examination of these samples revealed that they contained no microfossils.

The lithology suggests that the outcrop containing abundant H. acicula in the middle portion is referable to unit No. 5. The section between these beds and the lowest stratigraphical horizon has been eroded and covered with alluvium.

The basal beds of the Tomago Coal Measures are to be seen in railway cuttings west of Padulla Siding. Beds referable to the "Bayswater Siltstone" occur in two new cuttings south of the above and immediately north of the convergence of the two railway lines; the sediments are predominantly siltstone and silty claystone with bands of light-coloured tuffaceous shale. There are rare pebbles and cobbles and, near the base, small lenses of dark grey sideritic siltstone containing pyrite nodules. The first cutting to the south of these two reveals sediments which vary little; they persist in cuttings south towards Singleton. The upper 7 feet in the north corner of this cutting consists of non-calcareous clayey siltstone, red-brown to light brown and grey, micaceous, with some calcareous lenses. The underlying beds are siltstone and very fine-grained greywacke, light brown-grey to light brown, micaceous, calcareous in part, with calcareous lenses up to four feet in length, and occasional pebbles. Some small faults were observed and lensing is indicated by the weathered surface. Tuffaceous shale occurs in thin bands and a very thin band of limestone was noted in beds (thought to be basal in this section) in cuttings nearer Singleton. The estimation of the thickness of strata missing between the upper 7 feet in this section and the base of beds referable to the "Bayswater Siltstone" in the cutting to the north has not been attempted because:

(a) Dips and strikes measured in the area reveal that these cuttings occur in the eastern flank of an irregular syncline; near them reliable dip readings are difficult to obtain;

(b) Faulting probably occurs in the parts of the section which do not crop out.

It is therefore difficult to ascertain the stratigraphical position relative to units Nos. 5 to 9 on lithology alone.

The lithology in outcrop suggests a division of the stratigraphical succession into two formations:

(i) The lower, mainly conglomerate with argillaceous to sandy matrix. Noted from 158 ft. 6 in. to 300 ft. in the St. Heliers Bore, in outcrops in the cliff section (south-east corner of Long Point), on, or near, the Singleton Jerry's Plains road in the vicinity of the turn-off to Broke, and possibly in the outcrops at the base of the section east of Hebden (Sample H5).

(ii) The upper, mainly siltstone. Samples from 17 ft. to 158 ft. 6 in. in the St. Heliers Bore, from east of the cliff section (south-east corner of Long Point), and possibly sample H4 from east of Hebden, come from the lower beds of this formation. Beds intermediate between the lower and upper parts of this formation are represented by outcrops in the left bank of the Hunter River upstream from the Singleton railway bridge and in railway cuttings north of Minimbah Station. (The lithology of these intermediate beds is similar, and in both outcrops there are calcareous concretions of large dimensions, glendonites, and an almost identical assemblage of megafossils including Martiniopsis, Chaenomya, Moeonia, Warthia, and Tribrachiocrinus.) Upper beds are represented by outcrops in railway cuttings south-west of Padulla Siding, outcrops east of Hebden (H3 to H1), and by units Nos. 9 to 5, the last representing the uppermost member of this formation.

The beds included in (i) above are referable to the upper part of the "Branxton Stage", and the "Mulbring or Crinoidal Stage", as recorded to the east of the areas under discussion, does not appear to be represented.

The division of the uppermost beds of the "Mulbring or Crinoidal Stage" into lithological units (Nos. 5 to 9) must remain tentative until more substantial proof of the existence of such units in other localities is available. The upper

7 feet of beds referable to the "Mulbring or Crinoidal Stage" in the railway cutting just south of where the lines converge (south of Padulla Siding) and the upper beds outcropping east of Hebden (Samples H3 to H1) appear to be more clayey and less sandy than the underlying beds. It is possible that these two outcrops are referable to unit No. 5. Correlation between units Nos. 6 to 9 and the other outcrops referable to the upper parts of the "Mulbring or Crinoidal Stage" has not been possible.

Microfaunal Distribution

Details of intervals or depths examined in bores and samples from outcrops are given in Tables I and II. All samples washed and specimens separated were forwarded to Miss Crespin; and though the first consignment was destroyed by fire, some charred notes of identifications were saved. Details of Miss Crespin's determinations from the first consignment and localities are given in Appendix II. The identifications of specimens from later consignments have been partly completed and details of these are given in reports by Miss Crespin,(Appendices III and IV).

Notes on Microfossils.

Since descriptions of most of the microfossils encountered in these areas have been given in various publications (Crespin, 1947), it is proposed in this report to make a few notes only on the two species which are most common in the uppermost marine beds.

Ammodiscus multicinctus Crespin and Parr, 1940, is the most commonly encountered species of Foraminifera in the uppermost unit, No. 5, of the marine beds. It occurs in unit No. 9 also but is missing from units Nos. 6 to 8, which are relatively more arenaceous. Although both microspheric and megalospheric generations are present, the lateral width of specimens is generally within the range of 0.2 to 0.5 mm. Specimens collected show all gradations from discoidal, irregularly evolute, to highly lenticular and compressed in the median plane. This is probably due to pressure of compaction, since discoidal types have their median plane parallel to the bedding plane while the short median axis of lenticular types was perpendicular to the bedding plane.

<u>Hyperamminoides acicula</u> Parr, 1940, is rare in the upper limits of unit No. 5 but more common in the lorer units, regardless of lithofacies. Fracture and compression of the test, originally tapering and tubular, may be due to conditions of deposition or to compaction pressure or both. The lengths of three specimens examined in situ in rock fragments from depths of 81 ft. 6 in. and 93 ft., Bore No. BMR 14(T) Pond's Creek, were approximately 4.5, 6.0 and 4.2 mm., the actual widths being 1.8, 119, and 0.25 to 0.4 mm. respectively. Specimens were noted at 265 ft. in BMR 76 (T) Parnell's Creek, up to 17 mm. in length, and "Parr records specimens of <u>H.Acicula</u> up to 20 mm." (Crespin, 1947). Fragments found in washings are generally less than 2 mm. in length and between 0.1 and 1 mm. in width. Figure 2 shows the variation in the actual widths of fragments taken from the outcrop of Hebden (H2). These specimens are typical of those found in the areas under discussion; allowance has been made in measurements for the sphericity of occasional specimens and for the fact that tests are often encrusted by <u>Tolypammina</u> <u>undulata</u> Parr.

A number of other species of arenaceous Foraminifera have been identified, but, as will be seen in Fig. 3, they do not occur as consistently as the above two species.

The value of species of the Family Lagenidae (hyaline forms) in indicating of the "Branxton Stage" is discussed later. Species of <u>Frondicularia</u> and <u>Nodosaria</u> are the more common types encountered. Because of their calcareous tests, they can be easily distinguished from the arenaceous foraminifera.

Ostracoda have been noted in some of the beds discussed. Their distribution in units Nos. 4 to 9 is shown also in Figure 3. The bivalved carapace is occasionally found intact, but more often the tests are crushed or fragmentary.

Other microfossils are rare. One specimen in the 37 ft. 6 in - 60 ft. interval of BMR 10(T) Pond's Creek resembled a radiolarian, and irregular fragments referable to sponge spicules were noted from Sample S 1-2 (cliff section, south-east corner of Long Point). Crinoid ossicles and productid spines have been found in some samples, and indeterminate fish remains were found in BMR 76(T) Parnell's Creek, 79 ft. - 81 ft.

Small particles of plant detritus have been noted in most of the samples examined from the marine sediments, but they are not common. Spores are rarely found.

The Distribution of Microfossils

In Figure 1, histograms of Ammodiscus multicinctus frequency, together with intervals examined, are shown against the graphic logs of bores divided into the units discussed under 'Lithology'. Figure 3 shows the distribution of Foraminifera and Ostracoda identified by Miss Crespin from samples from units Nos. 4 to 9, and the ranges of individual species are arranged relative to the base of unit No. 3 as in Figure 1.

At its upper limit, in most bores, unit No. 5 contains abundant A. multicinctus, but it is generally absent from the overlying unit. The division of beds into the "Parnell's Creek Sandstone Member", "Bayswater Siltstone", and marines was completed by J.J. Veevers (1952, 1953) independently of microfaunal analysis. It will be noted that in most bores, the boundary between units Nos. 4 and 5 based on lithology coincides with the limit of abundant A. multicinctus.

In Bore No. BMR 13(T) Pond's Creek, Miss Crespin records indeterminate fossils from 46 ft. to 65 ft. (Appendix IV), and rare A. multicinctus occur from 65 ft. to 95 ft. These beds are divided into units equivalent to Nos. 4 and 5 on lithological evidence with the boundary at 43 ft. 6 in.

In Appendix IV, Miss Crespin states: "The calcareous foraminifera, in all previous work in the Hunter River Area, with one exception, have not been found in beds stratigraphically higher than the Branxton", and later: "None of the five species of ostracoda recognised in the samples have been recognised above the Branxton". The beds from which these microfossils were extracted are referable on lithological grounds to the upper portions of the higher of two formations representing the "Upper Marine Series" in this area. It is suggested that calcareous foraminifera and ostracoda flourished towards the close of Upper Marine times, and that they are not limited to any stratigraphical horizon but rather are restricted by some factor such as ecological conditions. The evidence for this assumption, apart from lithology which has been discussed earlier, is given below.

Calcareous microfossils have been noted in the uppermost limits of unit No. 5 in bores Nos. BMR 3(S) Edinglassie, 13(T) Pond's Creek (just above 95 ft.), and 16 (T) Pond's Creek. They include species of Nodosaria and Ostracoda, and Nodosaria sp. was noted by Miss Crespin at the top of the "Upper Marine Series" in the Kulnara Bore (Raggatt and Crespin, in Carroll, 1940). Species of Nodosaria in particular are considered to be indigenous rather than adventitious because, if they were present as remanie fossils, one might expect to find species of other hyaline foraminifera associated with them.

Figure 3 reveals that species of Frondicularia and Dentalina do not occur above 46 ft. in BMR 76(T) Parnell's Creek and that other occurrences of Frondicularia are restricted to unit No. 9. Whether these restricted occurrences have any significance cannot be ascertained with the small amount of evidence available. More detail would be available if the core from BMR 1 Bayswater could be examined.

In addition to their occurrence in the upper portions of the "Upper Marine Series" in the Parnell's Creek, Pond's Creek, and neighbouring areas, calcareous microfossils exist in sample S 3 - 17 from the section revealed in railway cuttings south and west of Padulla Siding. This sample is from beds regarded as high in the "Mulbring or Crinoidal Stage".

The sequence encountered in Bore No. BMR 1SC Ravensworth Trig is briefly described because of the unusual microfaunal assemblage found in the lowest bed. Normal coal measure strata persist from 0 ft. to 604 ft. 3 in., which is the depth of the base of the bottom band of coal. From this depth to 1081 ft. 7 in. there are alternate bands of fine to medium grained greywacke with occasional coarse-grained bands (77%) and siltstone (22%) with two thin bands of white claystone (1%). Interbedded fine to very fine grained greywacke (55%) and siltstone (45%) occur between 1081 ft. 7 in. and 1143 ft. 7 in. Dark grey siltstone with pyrite nodules and containing a few microfossils occurs from 1143 ft. 7 in. to the bottom of the hole at 1216 ft. The microfaunal assemblage of this siltstone consists of rare

Ammodiscus, Hyperamminoides, and other arenaceous foraminifera, a few hyaline types (mainly Nodosaria), and some Ostracoda. These are scattered sparsely throughout and the tests of calcareous forms are mainly fragmentary, although some ostracods and one specimen of Nodosaria were complete. It has been suggested that 1143 ft. 7 in. to 1216 ft. represents the uppermost marine bed in this locality.

Although only a relatively small number of outcrops has been examined, it appears that calcareous foraminifera do not exist in beds which are regarded as intermediate and basal in the "Mulbring or Crinoidal Stage" succession. The microfaunal assemblage of samples from cuttings north of Minimbah Station appears to be identical with that found in outcrops upstream from the Singleton railway bridge; and this conforms with the observations made in the discussion on the lithology.

The sample from the basal bed of the "Mulbring or Crinoidal Stage" outcropping east of the cliff section (south-east corner of Long Point) has been examined and compared with the underlying bed (uppermost bed referable to the "Branxton Stage"). Hyaline Foraminifera and Ostracoda were noted in the latter bed only. Similarly, Sample H5 from east of Hebden, thought to represent the uppermost bed referable to the "Branxton Stage", contained calcareous microfossils, whereas there were none in the overlying bed (Sample H4). A complete section from lower "Mulbring or Crinoidal Stage" down into "Branxton Stage" is obtainable from cores and cuttings from the St. Heliers bore, but there is some doubt whether the boundary between the two should be determined on lithological or microfaunal evidence. Calcareous microfossils similar to those which Miss Crespin describes (Appendix III) as belonging to the "Branxton Stage" occur from 47 ft. downwards, and, although some of these species have been noted in the upper beds of the "Mulbring or Crinoidal Stage", their absence in intermediate and basal beds in other areas indicates that the next lower occurrence of these forms is in the "Branxton Stage". Dr. Crockford identified Fenestella dispersa from a sample from 138 ft. (St. Heliers bore) and she considers that "the presence of bryozoa is indicative of a pre-Mulbring age" (Appendix III). In the discussion of lithology, a gradual change was noted from 300 ft., where the rock was mostly coarse grained with an argillaceous to silty matrix, to 158 ft. 6 in., where the rock type became an argillaceous siltstone to very fine-grained greywacke with rare erratics. On lithological evidence, the section from 17 ft. down almost to 158 ft. 6 in. could be regarded as representing the "Mulbring or Crinoidal Stage", but in view of the fossil evidence this interval is reduced to 17 to 47 ft., and 47 ft. to 158 ft. 6 in. is now considered as the upper bed of the "Branxton Stage."

Environment of Deposition

The ecological conditions indicated by the biofacies are discussed briefly by Miss Crespin (1947, p.20), and the discussion on "Ecologic Factors in Benthonic Environment" by Glaessner (1945) covers the families of foraminifera represented in the areas under discussion. Temperature and not depth is one of the more important factors governing distribution of microfossils, because Ammodiscidae, which are recorded as deep-water (low-temperature) forms in Glaessner's discussion, are found in abundance in sediments believed to have been formed in relatively shallow water: the sediments are overlain by a similar facies which is slightly coarser in grain size generally and represents a zone of transition from marine to fresh-water conditions. Because glacial conditions are believed to have existed in Australia at intervals during the Permian Period, it is considered that shallow water may have been of low temperature comparable with that of the polar regions of today.

Further evidence of cold shallow-water conditions is the presence on certain horizons of glendonites (David and Taylor, 1905), calcite pseudomorphs of large glauberite crystals. These would not have crystallized above relatively low temperatures and their existence can also be attributed to shallow-water conditions where evaporation allowed concentration of mineral salts.

The formation of glendonites also indicates that there was little movement of the water; this is further attested by the following two facts:

(1) Sediments in both "Branxton" and "Mulbring or Crinoidal" stages rarely show good bedding and are generally unsorted;

(2) Both valves of Pelecypoda and Ostracoda are, in many of the occurrences, intact.

The presence of syngenetic pyrite indicates, according to Edwards and Baker (1951), either a neutral or alkaline environment. Pyrite nodules in the upper marine beds and the "Bayswater Siltstone" show that this was the environment when these beds were deposited.

CONCLUSIONS

The stratigraphical nomenclature of the sediments which form the "Upper Marine Series" in the Hunter River valley is in need of review.

In the Singleton-Muswellbrook District, at least two formations have been recognised in the "Upper Marine Series". The upper, which consists mainly of siltstone, is referable to the "Mulbring or Crinoidal Stage" and the lower, which is mainly conglomeratic, is probably equivalent to the upper portion of the "Branxton Stage".

The division of the uppermost of the beds referable to the "Mulbring or Crinoidal Stage" into lithological units, Nos. 5 to 9, is tentative until further evidence is available.

The "Bayswater Siltstone" (unit No. 4) is a transition zone with the final phase of marine deposition represented in the lower portion.

Ammodiscus multicinctus is generally abundant in the uppermost bed of the "Mulbring or Crinoidal Stage" in the areas discussed.

Calcareous Foraminifera and Ostracoda, previously thought to be restricted to the "Branxton Stage", have now been encountered in beds referable to the upper beds of the "Mulbring or Crinoidal Stage" in the Singleton-Muswellbrook District. Their absence in lower beds of the "Mulbring or Crinoidal Stage" indicates that their occurrence is restricted by some ecological factor.

Deposition of sediments which form the upper part of the "Upper Marine Series" took place under cold, shallow-water conditions. There appears to have been little movement of this water and the environment was either neutral or alkaline.

REFERENCES

BURSILL, C., and VEEVERS. J.J., 1952 - Parnells Creek Area. Completion Report. Bur. Min.Resour.Aust.Rec. 1952/76.

CRESPIN, I., 1947 - Foraminifera in the Permian rocks of Australia. Bur. Min.Resour. Aust. Bull. 15 (Pal. Ser. 5)

DAVID, T.W.E. ed. BROWNE, W.R., 1950 - The Geology of the Commonwealth of Australia, Vol. 1. London, Arnold.

DAVID, T.W.E. and TAYLOR, T.G., 1905 - Occurrence of the pseudomorph glendonite in New South Wales. Rec. geol. Surv. N.S.W., 8(2), 161.

EDWARDS, A.B. and BAKER, G., 1951 - Some occurrences of supergene iron sulphides in relation to their environment of deposition. J. sediment. Petrol., 21(1), 34.

GLAESSNER, M.G., 1945 - Principles of Micropalaeontology. Melb.,Univ. Press

RAGGATT, H.G., 1953 - A.N.Z.A.A.S. Standing Committee on Stratigraphic Nomenclature; Report on first and second meetings. Aust. J.Sci., 15 (4), 122.

RAGGATT, H.G. and CRESPIN, I., 1940 - Discussion on CARROLL, D. - Possibilities of heavy mineral correlation in some sedimentary rocks, N.S.W. Bull. Amer. Ass. Petrol. Geol., 24(a), 1682.

VEEVERS, J.J., 1953 - Howick Area Report. Bur. Min. Resour. Aust. Rec. 1953/47.

APPENDIX I.

Details of Bentonites and Bentonitic Clays tested by P. G. Duff, Petroleum Technologist, 1953.

	Rodda	Bryce	McLeod	Commercial Minerals, coarse grade.	Foundry Supplies	N.Z. Survey	Newbolds	Comm. Mins. fine grade	* Padulla	Indus. Clays, fine grade	Industrial Clays, coarse grade.
Viscosity gms (Stormer)	145	105	100	85	80	82	75	65	55	55	45
Instantaneous Gel gms (Stormer)	90	45	0	6	0	0	10	0	0	1	0
10 minute Gel gms (Stormer)	125	50	0	20	0	2	12	4	3	3	0
Water Loss (30 mins at 100 psi)	9.2	15.0	8.0	17.6	10.3	8.0	133.5	19.5	26.8	30.8	61.6
Wall Cake (in mms)	1.0	1.0	0.5	2.0	0.5	0.5	5.0/6.0	4.0	1.5	2.0	5.0/6.0

*2% soda ash added to the Padulla sample before testing.

Products arranged according to Water Loss characteristics: The best is McLeod; the others follow in this order:

N.Z. Survey, Rodda, Foundry Supplies, Bryce, Comm. Min. (c.), Comm. Min. (f), Padulla, Ind. Clays (f), Ind. Clays (c), Newbolds.

APPENDIX II

FOSSIL IDENTIFICATIONS

by

Irene Crespin

FORAMINIFERA:

Species	Bore No.	Depth or Interval of Sample.
Ammodiscus multicinctus Crespin and Parr	BMR 6(S) Pond's Ck.	20' 94' 6" 104' 7" ?194' 10" 217' 8"
	BMR 5(S) " "	290'
	BMR 76(T) Parnell's Ck.	20'-40', 40'-60', 60'-80'
Reophax cf. subasper Parr	BMR 6(S) Pond's Ck.	20'
Thurammina papillata Brady	BMR 6(S) Pond's Ck.	20'
Hyperamminoides acicula Parr	BMR 6(S) Pond's Ck. BMR 76(T) Parnell's Ck.	94' 6", ?104' 7", ?172' 7" 20'-40', 69'-71'.
Frondicularia woodwardi Howchin	BMR 6(S) Pond's Ck.	?194'10"
Dentalina grayi Crespin	BMR 76(T) Parnell's Ck.	69'-71'
Tolypammina undulata Parr	BMR 76(T) " "	69'-71'
Nodosaria serocoldensis Crespin	BMR 76(T) " "	60'-80'
? Hemigordius	BMR 76(T) " "	40'-60'

OSTRACODA:

Microkellinella aequivalvis BMR 76(T) Parnell's Ck. 72'-74'

FISH REMAINS:

Indet. fish remains BMR 76(T) Parnell's Ck. 69'-71', 68'-70'.

APPENDIX III

MICROFOSSILS FROM BORE BMR 1 S.C. ST. HELIER'S

by

I. Crespin

Core samples from the above bore from the depth of 64 ft. 10 in. down to 275 ft. 5 in. were examined. The beds through which the bore passed were very hard, but Foraminifera and Ostracoda were obtained by crushing, and Bryozoa were present on the fractured surfaces of one core sample. A detailed list of the microfauna found in the beds is given below.

64'10" - 68'10":

Foraminifera - Frondicularia woodwardi Howchin
Hyperamminoides acicula Parr
Thuramminoides sp. aff. T. Sphaeroidalis Plummer
Trochammina sp. aff. T. arenosa

Crinoides - Crinoid ossicles

Ostracoda - Basslerella australe Crespin

93'8":

Foraminifera - Frondicularia woodwardi
Frondicularia sp. aff. F. fissicostata (Cushman and Waters)
Hyperamminoides acicula

Ostracoda - Microkellinella aequivalvis Crespin
Form indeterminate

106'6":

Foraminifera - Frondicularia woodwardi (common)
Trochammina sp.

Ostracoda - Indeterminate

108'6":

Foraminifera - Dentalina cf. grayi Crespin
Frondicularia parri Crespin
Frondicularia woodwardi

Ostracoda - Basslerella australe

115' 0":

Foraminifera - Frondicularia sp. aff. F. excavata (Cushman and Walters)
Frondicularia woodwardi
Hyperamminoides acicula
Nodosaria sp.

Ostracoda - Microkellinella aequivalvis
Forms indeterminate

134' 9":

Foraminifera - Frondicularia woodwardi

Crinoidea - Crinoid stems

135' 6":

Foraminifera - Ammodiscus cf. nitidus
Frondicularia sp. aff. F. excavata
cf. Trochamminoides anceps

138':

Foraminifera - Ammodiscus cf. nitidus
Dentalina grayi
Frondicularia sp. aff. excavata
Frondicularia woodwardi
Hyperamminoides acicula
Thuramminoides sp. aff. T. sphaeroidalis

Bryozoa - Fenestella dispersa Crockford

Ostracoda - Healdia chapmani Crespin

227' 6":

Brachiopoda - Productid spines

274' 5":

Brachiopoda - Productid shells, indeterminate

Notes on the Samples

The assemblage of Foraminifera found in these samples is regarded as belonging to the Branxton stage. This age is confirmed by the presence of the fenestellid bryozoan Fenestella dispersa Crockford, which was described from the Ulladulla Mudstones. The specimens at 138 ft. in the bore at St. Helier's were sent to Mrs. Joan Beattie (nee Crockford) for identification and from her investigations of the Permian bryozoa in New South Wales, she considers that the presence of fenestellid bryozoa is indicative of a pre-Mulbring age.

Amongst the interesting foraminifera are those which show affinities with Frondicularia fissicostata (Cushman and Waters) and F. excavata (Cushman and Waters) (J. Paleont., 2 (4), 1928) from the Upper Pennsylvanian and Lower Permian of

Texas. The specimens of Thuramminoides have affinities with T. sphaeroidalis described by Mrs. Plummer from the Pennsylvanian of Texas (Univ. Texas Publ. 4401, 1945). This species is recorded from the Wandagee Beds in Western Australia.

APPENDIX IV.

MICROFOSSILS FROM BORE AND SURFACE SAMPLES FROM THE MUSWELLBROOK AREA, N.S.W.

by

I. Crespin

Samples from 13 bores and one surface sample from the Muswellbrook area were received from M.A. Reynolds. A detailed description of the microfaunal content of the samples is given below.

1. Outcrop at Hebden

Foraminifera: *Ammodiscus multicinctus*
Hyperammina cf. *clavata*
Hyperamminoides acicula
Tolypammina undulata

2. BMR 54(T), Parnell's Creek
140' - 146'10"

Foraminifera: *Ammodiscus multicinctus*
Thuramminoides sphaeroidalis
Trochammina sp.

3. BMR 76(T), Parnell's Creek
20-40 ft.

Foraminifera: *Ammodiscus multicinctus*
Glomospira aff. *simplex*

Ostracoda: Indeterminate

42 ft.

Foraminifera: *Ammodiscus multicinctus*
Trochammina sp.

40-60 ft.
Foraminifera: *Glomospira* aff. *simplex*
Hyperammina sp.

46-48 ft.
Foraminifera: *Ammodiscus multicinctus*
Frondicularia woodwardi
cf. *Trochamminoides anceps*

57-60 ft.
Foraminifera: *Ammodiscus multicinctus* (common)

Frondicularia woodwardi (microspheric)
Nodosaria cf. *serocoldensis* (forms A & I
Nodosaria sp. nov.
Dentalina grayi

60-80 ft.

Foraminifera: *Ammodiscus multicinctus*
Dentalina grayi
Nodosaria cf. *serocoldensis*
Nodosaria sp.
Hyperamminoides acicula (large and common)
Thurammina cf. *papillata*

Ostracoda: *Microkellinella aequivalvis*

Pisces: Indeterminate fragments

70-80 ft.

Foraminifera: *Nodosaria* sp.
Tolypammina undulata

Ostracoda: *Cavellina kulnuraensis*
Microkellinella aequivalvis

76 ft.

Foraminifera: *Ammodiscus multicinctus*
Hyperamminoides acicula

80-100 ft.

Foraminifera: *Ammodiscus multicinctus*
Hyperammina acicula

Ostracoda: *Healdia chapmani*

100-120 ft.

Foraminifera: *Nodosaria* sp.

Ostracoda: *Microkellinella aequivalvis*

121-122 ft.

Foraminifera: *Dentalina* cf. *grayi*
Hyperamminoides acicula

Ostracoda: *Healdia chapmani*
Microkellinella aequivalvis

120-140 ft.

Foraminifera: *Dentalina grayi*
Hyperamminoides acicula
Trochammina sp.

Ostracoda: *Bairdia grayi*

140-163 ft.

Plantae: Indeterminate

200-222 ft. No microfossils

240 ft.

Foraminifera: Hyperamminoides acicula

222-246 ft. No microfossils

4. BMR 1(S), State Reserve, Ravensworth.

713-734 ft.

Foraminifera: Ammodiscus multicinctus

739-746 ft.

Foraminifera: Ammodiscus multicinctus
Nodosaria sp

5. BMR 3(S) Pond's Creek

0-30 ft.

Foraminifera: Ammodiscus multicinctus

6. BMR 4(T) Pond's Creek

0-20 ft.

Foraminifera: Ammodiscus sp.
Digitina recurvata
Hyperamminoides acicula
Pelosina hemisphaerica

20 ft. - 37 ft. 8 in.

Foraminifera: Hyperamminoides acicula
Pelosina hemisphaerica
Trochammina pulvillus

7. BMR 6(S) Pond's Creek

74 ft.

Foraminifera: Ammodiscus multicinctus
Frondicularia parri
Frondicularia woodwardi
Haplophragmoides sp.
Hyperamminoides acicula
Trochammina pulvillus

94 ft. 6 in.

Foraminifera: Ammodiscus multicinctus

117 ft. - 119 ft. 6 in.

Foraminifera: Ammodiscus multicinctus
Trochammina cf. pulvillus

157 ft.

Foraminifera: Ammodiscus multicinctus
Hyperamminoides acicula

217 ft. 8 in.

Foraminifera: Nodosaria sp.
Hyperamminoides acicula

8. BMR 10(T) Pond's Creek

0-37 ft. 6 in.

Foraminifera: *Ammodiscus multicinctus*
Ammodiscus cf. *milletianus*
Crithionina teicherti
Digitina recurvata
Hyperamminoides acicula
Trochammina pulvillus

Ostracoda: *Bairdia grayi*

37 ft. 6 in. - 60 ft.

Foraminifera: *Ammodiscus multicinctus*
Ammobaculites woolnoughi
Digitina recurvata
Hyperammina cf. *spinescens*
Trochammina sp.

60 ft. - 85 ft.

Foraminifera: *Digitina recurvata*
Hyperammina cf. *clavacoides*
Hyperammina sp.

85 ft. - 101 ft. 6 in.

Foraminifera: *Ammodiscus multicinctus*
Frondicularia sp.
Hyperamminoides acicula
cf. *Moorinella biserialis*
Thuramminoides sphaeroidalis
Trochammina sp.

9. BMR 11(T) Pond's Creek.

26-50 ft.

Foraminifera:

Ammobaculites cf. *woolnoughi*
Ammodiscus cf. *planoconvexus*
Ammodiscus multicinctus
Ammodiscus nitidus
Digitina recurvata
Frondicularia woodwardi
Frondicularia parri
Hyperamminoides acicula
Nodosaria sp.
Pelosina hemisphaerica
Pelosina sp.
Reophax subaspera
Thuramminoides sphaeroidalis
Thurammina papillata
Trochammina pulvillus

50 - 77 ft.

Foraminifera: *Hyperamminoides acicula*
Nodosaria sp.

_77-99 ft._

Foraminifera: _Ammodiscus_ sp.
Ammodiscus multicinctus
Frondicularia sp.
Hyperammina sp.

Ostracoda: _Basslerella_ sp.

10. _BMR 12(T) Pond's Creek_

_111-154 ft._

Foraminifera: _Frondicularia woodwardi_
Nodosaria sp.

11. _BMR 13(T) Pond's Creek_

Indeterminate fossils

12. _BMR 14(T) Pond's Creek_

_53-75 ft._

Foraminifera: _Ammodiscus multicinctus_
Ammodiscus nitidus
Digitina recurvata
Frondicularia cf. _excavata_
Hyperamminoides acicula
Glomospira aff. _simplex_
Hyperamminoides cf. _expansus_
Nodosaria aff. _irwinensis_
Nodosaria sp. nov.
Reophax tricameratus
Tolypammina undulata
Trochammina pulvillus

_75-97 ft._

Foraminifera: _Ammobaculites woolnoughi_
Frondicularia woodwardi
Frondicularia sp.
Hyperamminoides acicula
Thuramminoides sphaeroidalis

_80-97 ft._

Foraminifera: _Hyperamminoides acicula_

_81 ft. 6 in._

Foraminifera: _Hyperamminoides acicula_

Crinoidea: Crinoid ossicles

_93 ft._

Foraminifera: _Hyperamminoides acicula_

_94 ft._ Fossil indeterminate

_97 ft. - 105 ft. 6 in._

Foraminifera: _Frondicularia woodwardi_
Hyperamminoides acicula
Hyperammina sp.
Textularia cf. _eximia_

13. <u>BMR 16(T) Pond's Creek</u>

<u>190-205 ft.</u>

Ostracoda: *Microkellinella aequivalvis*

<u>236-259 ft.</u>

Ostracoda: Ostracod indeterminate

<u>259-281 ft. 9 in.</u>

Ostracoda: *Cavellina kulnuraensis*
Basslerella australe
Healdia sp.

14. <u>BMR 2(S) Mt. Arthur</u>

<u>55-60 ft.</u>

Foraminifera: *Ammodiscus multicinctus*
Frondicularia woodwardi
Hyperamminoides acicula
Nodosaria sp.
Trochammina sp.

Stratigraphical Notes on the samples based on the evidence of the microfauna.

Thirty species of Foraminifera have been recognized in the above samples. Eleven of these, including four probable new species, are calcareous and the remainder are arenaceous. Five species of Ostracoda have been determined.

It is difficult to get a complete stratigraphical picture of the microfaunal content of the bore samples because of the incompleteness of the bore sections sent for examination. The microfauna was picked out of the samples by M.A.Reynolds at Muswellbrook and in some cases microfossils were forwarded for examination from only one depth in a bore such as from 140 ft.-146 ft. 8 in. in BMR 54(T) at Parnell's Creek. Fairly complete sequences of samples were received from BMR 76(T) from 20 feet down to 241 ft., from BMR 10(T) from the surface down to 109 Ft. 6 in., from BMR 11(T) from 26 ft. down to 99 ft., and from BMR 14(T) from 53 ft. down to 105 ft. 6 in. Evidence based on previous work on the foraminifera in the Hunter River Area (Crespin, 1947) suggests that some bores passed from the Mulbring Stage into the Branxton. The surface samples from Hebden are definitely correlated with the Mulbring Stage.

It is quite possible that the beds represented by samples from 53 ft. down to 75 ft. in BMR 14(T), from 26 ft. down to 50 ft. in BMR 11(T) and from 30 ft. down to 40 ft. in BMR 76(T), are the equivalent of the Mulbring, but the presence of such calcareous species as Frondicularia woodwardi and F. parri in samples below those depths suggest that the bores have penetrated the Branxton Stage.

The arenaceous species of Foraminifera, which dominate the assemblage, range throughout the Permian in New South Wales, in the Lower Marine and throughout the Upper Marine. Amongst these forms three species should be considered. These are Ammodiscus multicinctus Crespin and Parr, Hyperamminoides acicula Parr and Digitina recurvata Crespin and Parr. Ammodiscus multicinctus was described from beds in a large railway cutting about 4 chains west of Farley Station (Allandale Stage).
It occurs commonly in the Mulbring beds and less commonly in the Branxton and lower stratigraphical stages. It is common in the samples from BMR 14(T) between

53 ft. and 75 ft., in BMR 11(T) between 26 ft. and 50 ft. and in BMR 76(T) from 20 ft. down to 40 ft. And it is for this reason that the beds in the upper part of these three bores are regarded as the equivalent of the Mulbring. Hyperamminoides acicula, a persistent species throughout the Permian of New South Wales and Western Australia, was described by Parr from the Wandagee Beds in Western Australia; and frequently it is the only form present whether the beds be Upper or Lower Marine in New South Wales. Digitina recurvata was described from the Victoria Pass Section, Mitchell Highway, from beds regarded as the equivalent of the Branxton. It was especially common in sediments ¼ mile east of Muswellbrook Station, which are Branxton, and it is common in the beds of the Allandale Stage of the Lower Marine in the Greta Harper's Hill Section, and in the John Brown's Reservoir Section, and in the sections west of Minimbah which are Mulbring.

The calcareous foraminifera, in all previous work in the Hunter River Area, with one exception, have not been found in beds stratigraphically higher than the Branxton. One specimen of Nodosaria serocoldensis Crespin was found in material from an outcrop at the Saw Mill, Mulberry Creek, near Mulbring. This species was described from the Middle Bowen Beds near Springsure, Queensland, where, as in New South Wales, it is usually associated with Frondicularia woodwardi Howchin and F. parri Crespin. F. woodwardi, described by Howchin from the Irwin River, Western Australia, occurs in many samples in the present collection and both microspheric and megalospheric forms are recorded. The species is common in beds referred to the Branxton at Wollong and in sediments at Fothanna Siding west of the railway cutting at Branxton. It is common in the beds in a cutting on the north side of the road along the railway opposite the bridge ¼ mile east of Muswellbrook, where it is associated with Frondicularia parri Crespin described from the Kulnura Bore at 4,203 ft., A. multicinctus, H. acicula, and D. recurvata. Both F. woodwardi and F. parri were well distributed in the sediments in the Kulnura Bore between the depths of 3,778 ft. and 4,490 ft., which are regarded as the equivalent of the Branxton. Another calcareous species in the present samples is Dentalina grayi, which was described by Crespin from the Middle Bowen, Springsure area, Queensland. The forms which are apparently new are tentatively referred to as Frondicularia sp. aff. excavata and F. sp. aff. fissicostata described by Cushman and Waters from the Upper Pennsylvanian of Texas.

None of the five species of Ostracoda recognized in the samples have been recorded above the Branxton. Bairdia grayi, Healdia chapmani, and Basslerella australe were described by Crespin from the Lower Bowen of Queensland and were found in the Kulnura Bore. Cavellina kulnuraensis and Microkellinella aequivalvis were described by Crespin from the depths of 3,865 ft. and 3,894 ft. respectively in the Kulnura Bore.

It is unfortunate that no Bryozoa or Brachiopoda are available in the bore samples to assist in determining the horizon of these beds. Because of the conflicting ideas of the field geologists who regard the beds as Mulbring and of the present evidence based on the foraminifera which suggests Branxton for the greater number of samples, it is suggested that systematic sampling be made of the type sections of the Mulbring and Branxton Stages, as well as systematic collecting in the Muswellbrook area.

TABLE I

BORE SAMPLES

Bore No.	Depths or Intervals of Samples	Remarks
BMR 1(S) State Reserve, Ravensworth.	680', 687', 700', 690'-713', 713'-734' 734'-739', 739'-746', 746'6".	
BMR 2(S) Pond's Creek	1062'6"-1077'3"	
BMR 5(S) Pond's Creek	290'	
BMR 6(S) " "	20', 47', 74', 94'6", 104'7", 117'-119'6", 129'4", 159', 172'7", 194'10", 197', 217'8"	
BMR 3(T) " "	0-?30', ?30'-80'.	These samples were taken from core which was left at the site without marker blocks. The top 30' represents weathered core. Depths were estimated from the descriptive log.
BMR 4(T) " "	0-?20', ?20-37'8", 37'8"-65', 65'-95'.	Samples from core left at site as above.
BMR 10(T) " "	0-7', 7'-37'6", 37'6"-60', 60'-85',85'-101'6".	
BMR 11(T) " "	26'-50', 50'-77', 77'-99'.	Only 8" of upper 26' recovered.
BMR 12(T) " "	0-23', 23'-60', 60'-111', 11'-154'	For the greater part, the sediment is fine-grained greywacke containing *Hyperamminoides*; other microfossils are rare and hence the intervals were increased.
BMR 13(T) " "	0-46', 46'-65', 65'-95'.	Upper core unfossiliferous.
BMR 14(T) " "	53'-75', 75'-97', 97'-105'6".	Top 53' is alluvium.
BMR 16(T) " "	190'-205', 205'-236', 236'-259', 259'-271'9", 271'9"-298'3".	
BMR 6(S) Parnell's Creek	671'-678'	
BMR 54(T) " "	140'-146'10".	Sample taken from core left at site as above for 3(T) Pond's Creek. Only bottom 6'10" could be recognised with certainty.

BMR 76(T) " "	20'-40', 40'-60', 68'-70', 69'-71', 60'-80', 80'-100', 100'-120', 120'-140', 140'-163', 144', 163'-185', 185'-200', 200'-222', 222'-246', 240', 246'-305'.	Additional samples were taken from some intervals in an attempt to delineate zones of interesting microfaunal occurrences. 246'-305' is fine-grained greywacke as in BMR 12(T) Pond's Creek.
BMR 1 S.C., Ravensworth Trig	1140'-1143'7", 1143'7"-1149', 1149'-1158', 1158'-1163', 1163'-1168'6", 1168'6"-1178', 1178'-1187', 1187'-1195'2", 1195'2"-1203', 1203'-1212', 1212'-1216'.	
BMR 2(S) Mt. Arthur	55'-60'.	Drilled to 63' and this sample from cuttings. 63'-200'6" cored but core not kept.
BMR 3(S) Edinglassie	452'-454', 454'-456', 456'-458', 458'-460', 460'-462', 462'-466', 466'-472', 472'-474'.	
BMR.1S.C. St. Heliers	2'-4', 14'-16', 18'-20', 20'-22', 22'-25'6", 27'6"-33'6", 33'6"-39'6", 39'6"-41'6", 41'6"-43'6", 43'6"-45'6", 45'6"-47'6", 47'6"-55'6", 55'6"-69'7", 69'7"-78'3", 81'9"-92', 92'-98'6", 98'6"-107'6", 107'6"-122', 122'-127', 127'-135'6", 135'6"-138'9", 139'9"-144'6", 144'6"-150', 150'-161', 161'-166'6", 166'6"-186'5", 186'5"-209'2", 209'2"-223', 223'-227', 227'-258', 258'-284'6", 284'6"-300', 801'1"-808'6", 840'-863'5"	0-17' = Alluvium with microfossils (remanie), 0-21'9" drilled.. contaminated to 22', 21'9"-25'6" cored, 25'6"-45'6" drilled.. samples contaminated. 25'6"-27'6" not sampled. 43'6"-45'6" examined but specimens not separated because of contamination. 45'6"-78'3" cored.. hyaline forms first noted in 45'6"-55'6" interval -; 45'6"-47'6" cuttings revealed that these forms first appeared in this interval. 78'3"-81'9" drilled, not sampled. 81'9"-300' cored .. 138'9"-139'9" = tuffaceous shale - not sampled. Last two samples from siltstone lower in the hole.

TABLE II

SURFACE SAMPLES

Area	Locality	Military Sheet Coordinates	Sample Nos.	Remarks
Singleton	Cliff section above left bank of Hunter River, south-east corner of Long Point.	Singleton 135724	S 1 - 1	Base of cliff
			S 1 - 1	Top of cliff
		138723	S 1 - 1	Siltstone outcrop, east of and overlying above.
"	Section above left bank of Hunter River, east Long Point.	144739	S 1 - 4 to S 1 - 8	Unfossiliferous; possibly basal beds of Upper Coal Measures.
"	Left bank of Hunter River, upstream from Singleton railway bridge.	162741	S 2	
" (Minimbah)	Cuttings from bridge railway towards Minimbah Station.	237634	Min. 1	6' thick opposite 141 mile 33 chain mark.
			Min. 2	10' thick. Cutting north of Min. 1; west side opposite 141 mile 65 chain mark.
			Min. 3	10' thick, overlying Min. 2, east side of cutting, opposite 141 mile 60 chain mark.
		233643	Min. 4	9' thick. Uppermost beds, just south of bridge opposite 142 mile mark.
Singleton	Singleton - Jerry's Plains road ½ mile east of Broke turn-off.	135666		"Branxton Stage" - crest of Loder Dome.
"	Small section left bank of Loder's Creek, just north of Singleton - Jerry's Plains road, ¼ mile N-W of Broke turn-off.	126672		Lower in "Branxton Stage"

Singleton	From new railway cuttings, west of Padulla Siding south towards Singleton.		S 3 - 1 to S 3 - 15	Unfossiliferous. Represent the lower beds of the Upper Coal Measures and the "Bayswater Siltstone"
			S 3 - 16	Upper 7' from cutting just south of where lines now converge.
			S 3 - 17	Underlying 5' approx. These samples are from a unit of consistent lithology and owing to lensing and minor faulting actual thickness is difficult to determine.
			S 3 - 18	" 12' "
			S 3 - 19	" 12' "
			S 3 - 20	" 14' " S 3 - 20 is from sediments north of a small fault and is thought to represent the basal beds in this cutting.
			S 3 - 21	S 3 - 21 is from south side of fault, opposite S 3 - 20.
		157779	S 3 - 22	Cutting south of above. 10' thick, including and underlying a thin limestone band which is repeated in cuttings to the south by faulting. Probably the base of sediments represented in these cuttings.
Hebden	Outcrops in creek beds and cuttings from 1 to 2½ miles east of Hebden Post Office.	Camberwell Sheet 092965 (approx)	H 1 to H 3	H 1 uppermost; H 2 rich in *Hyperammin-oides acicula*; H 3 indurated and overlying thin sill.
		084960 (approx)	H 4 and H 5	H 4 overlying and just north of H 5.

FIGURE 1

VERTICAL SECTIONS OF BORES WITH FREQUENCY HISTOGRAMS OF AMMODISCUS MULTICINCTUS.

(SECTIONS ARRANGED ACCORDING TO THEIR POSITIONS OR ESTIMATED POSITIONS RELATIVE TO THE BASE OF UNIT No. 3)

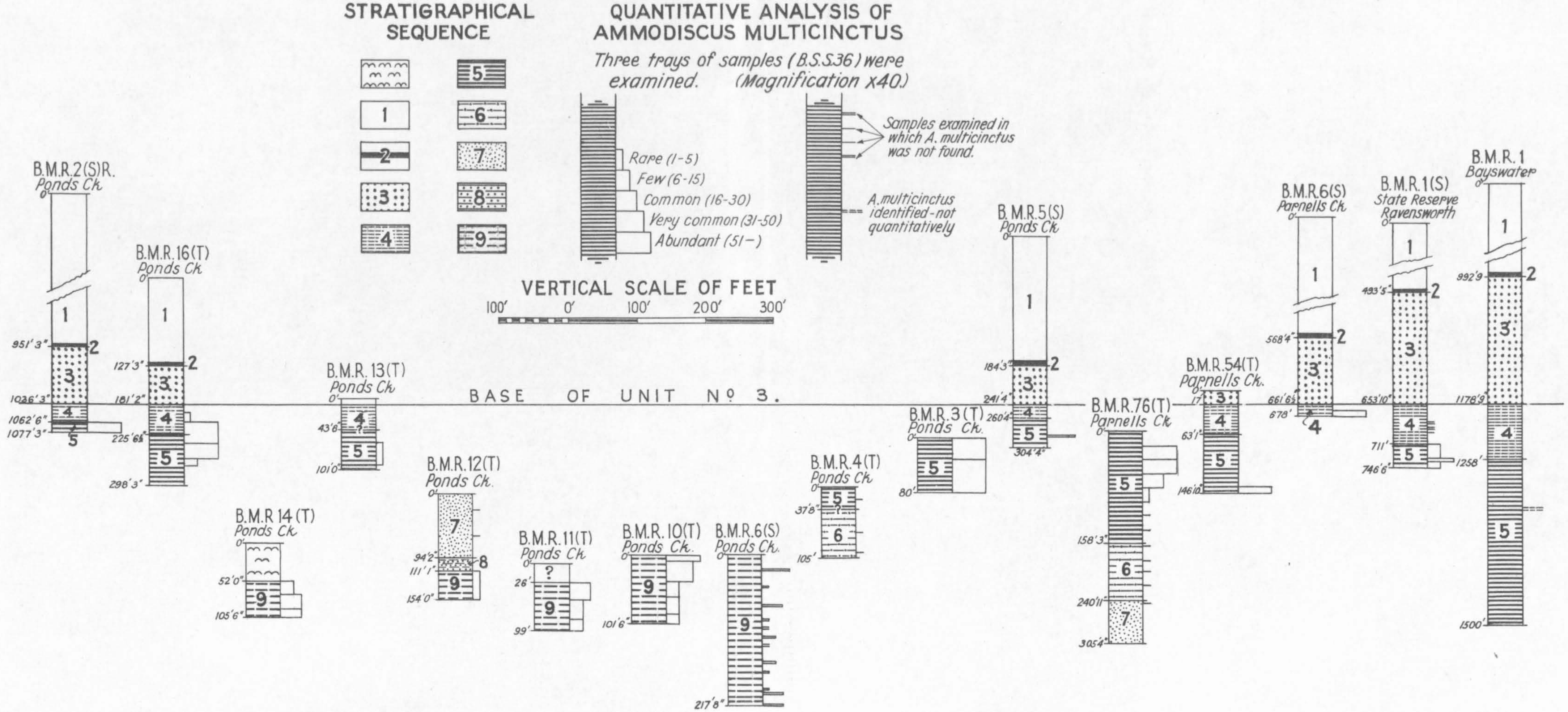
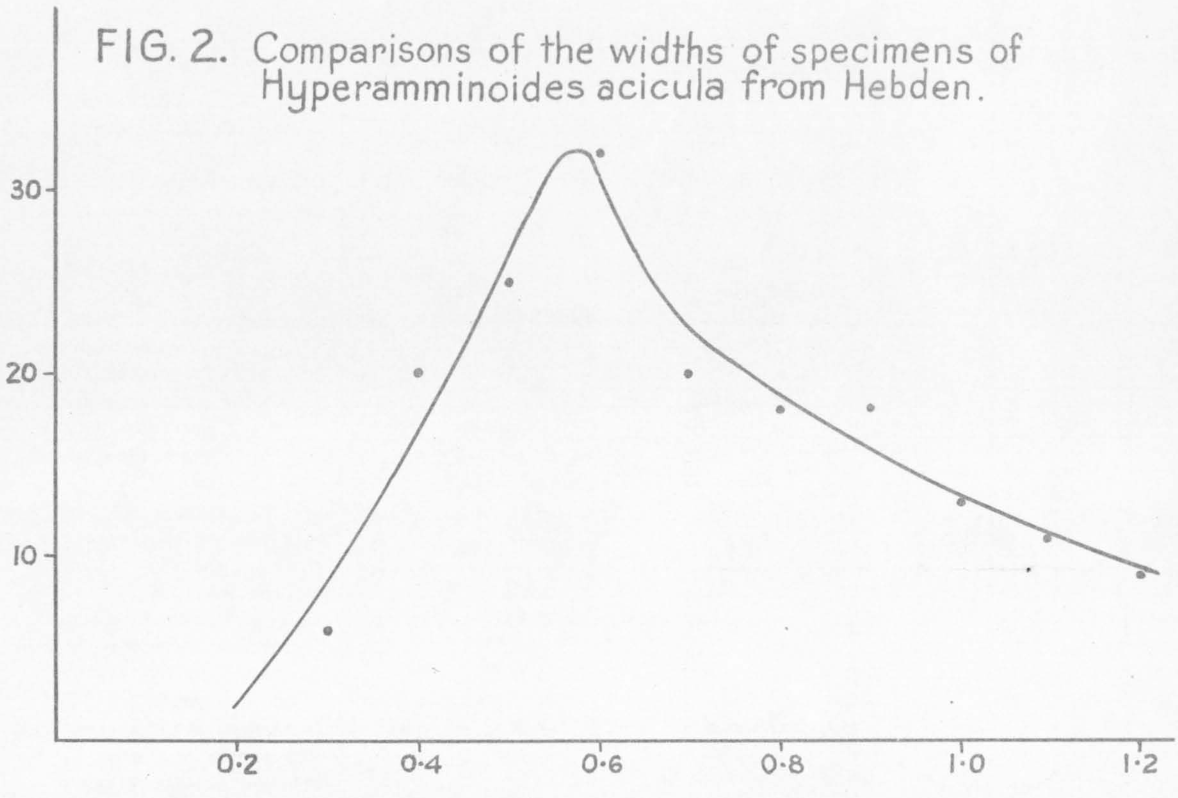
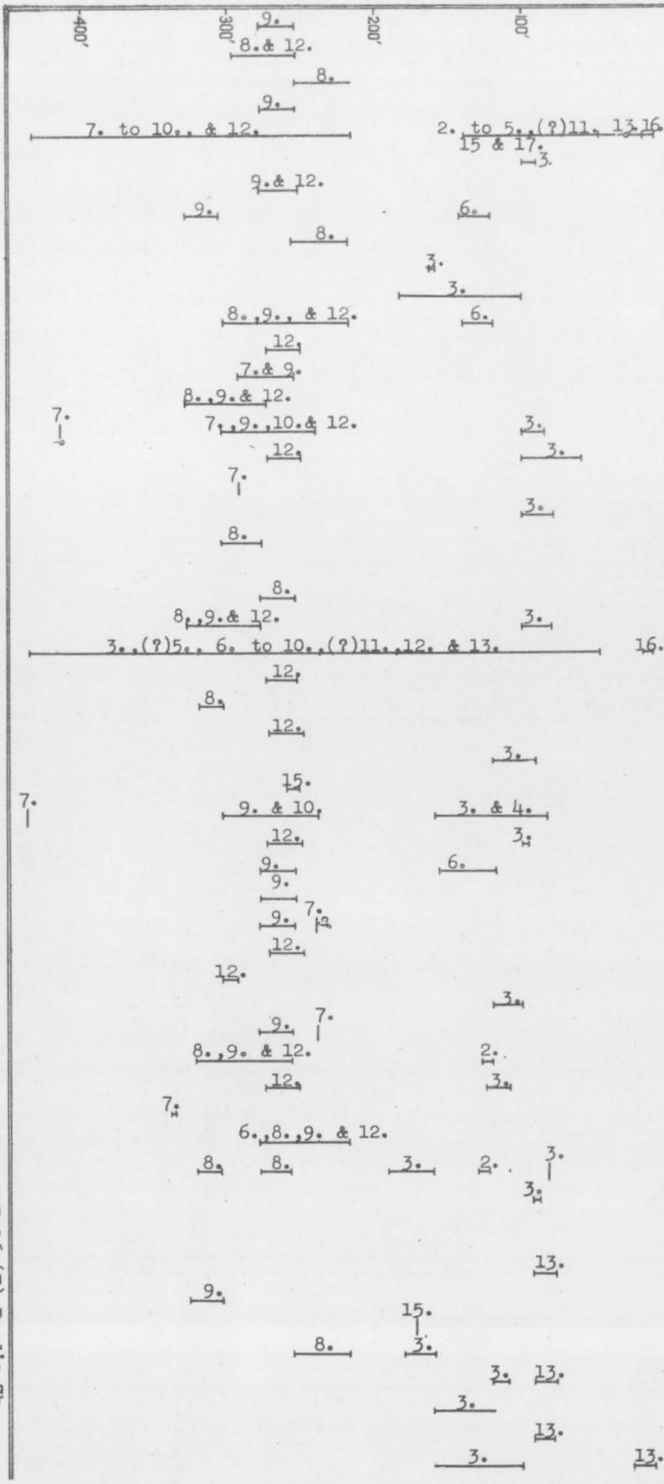


FIG. 2. Comparisons of the widths of specimens of Hyperamminoides acicula from Hebden.



INTERVAL or DEPTH (Actual or Calculated) below BASE of UNIT No. 3.



SPECIES

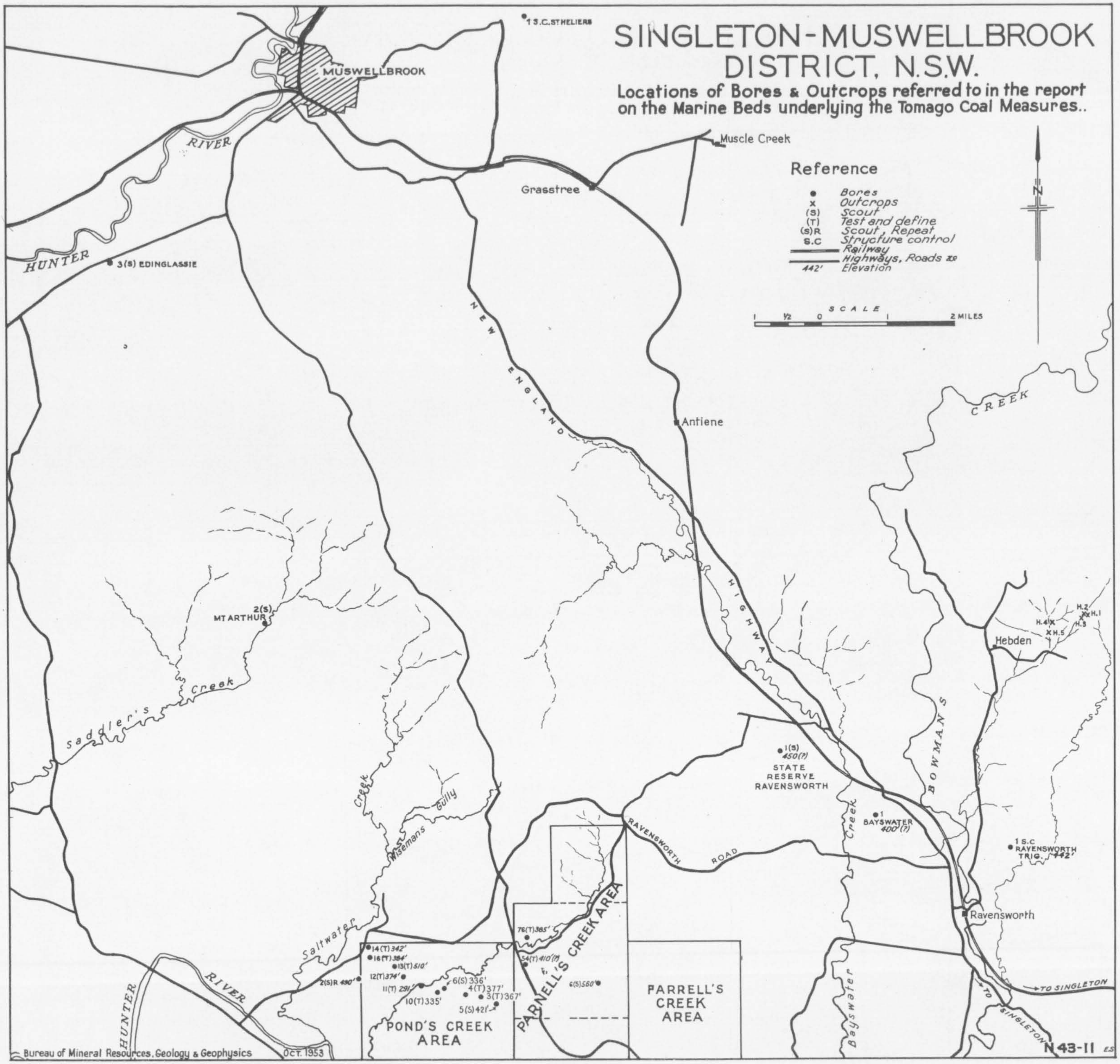
Ammobaculites cf.woolnoughi
" woolnoughi
Ammodiscus cf.milletianus
" " planoconvexus
" multicinctus
" " (c)
" nitidus
" sp.
Crithionina teicherti
Dentalina cf.grayi
" grayi
Digitina recurvata
Frondicularia cf.excavata
" parri
" sp.
" woodwardi
Glomospira aff.simplex
Haplophragmoides sp.
(?) Hemigordius
Hyperammina cf.clavacoides
" "
" " spinescens
" sp.
Hyperamminoides acicula
" cf.expansus
cf.Moorinella biserialis
Nodosaria aff.irwinensis
" cf.serocoldensis
" serocoldensis
" sp.
" sp.nov.
Pelosina hemisphaerica
" sp.
Reophax subasper
" tricameratus
Textularia cf.eximia
Thurammina cf.papillata
" papillata
Thuramminoides sphaeroidalis
Tolypammina undulata
Trochammina cf.pulvillus
" pulvillus
" sp.
cf.Trochamminoides anceps

OSTRACODA

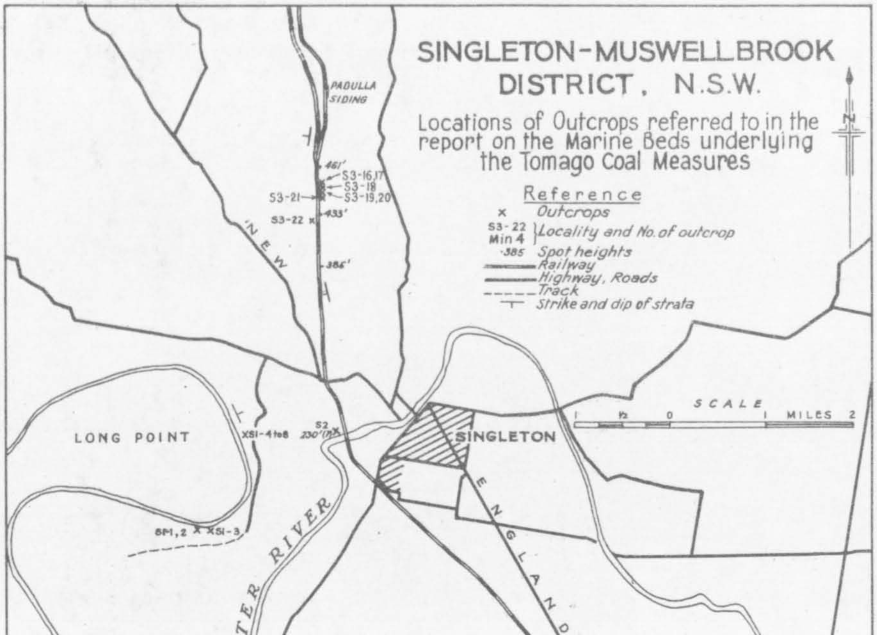
Basslerella australe
" sp.
cf.Basslerella
Bairdia grayi
Cavellina kulnuraensis
Healdia chapmani
" sp.
Microkellinella aequivalvis

1. Hebden
2. BMR 54 (T) Parnell's Ck.
3. BMR 76 (T) " "
4. BMR 1 (S) State Reserve, Ravensworth.
5. BMR 3 (T) Pond's Ck.
6. BMR 4 (T) " "
7. BMR 6 (S) " "
8. BMR 10 (T) " "
9. BMR 11 (T) Pond's Ck.
10. BMR 12 (T) " "
11. BMR 13 (T) " "
12. BMR 14 (T) " "
13. BMR 16 (T) Pond's Ck.
14. BMR 2 (S) Mt. Arthur.
15. BMR 1 Bayswater.
16. BMR 6 (S) Parnell's Ck.
17. BMR 5 (S) Pond's Ck.

FIGURE 3: Distribution of Foraminifera and Ostracoda in Units, Nos.4 to 9.



SINGLETON - MUSWELLBROOK DISTRICT, N.S.W.
Locations of Bores & Outcrops referred to in the report on the Marine Beds underlying the Tomago Coal Measures..
Reference
Bores
x Outcrops
(S) Scout
(T) Test and define
(S)R Scout, Repeat
S.C Structure control
Railway
Highways, Roads &c
442' Elevation
SCALE
1 1/2 0 1 2 MILES
N
1 S.C. ST HELIERS
MUSWELLBROOK
Muscle Creek
Grasstree
HUNTER RIVER
3(S) EDINGLASSIE
NEW ENGLAND HIGHWAY
Antiene
CREEK
2(S)
MT ARTHUR
Saddler's Creek
Wisemans Creek
Gully
1(S)
450'(?)
STATE RESERVE RAVENSWORTH
Creek
1
BAYSWATER
400'(?)
BOWMANS
Hebden
H.2
H.1
H.4
H.3
H.5
1 S.C
RAVENSWORTH TRIG. 442'
RAVENSWORTH ROAD
Ravensworth
Saltwater
HUNTER RIVER
14(T) 342'
16(T) 384'
13(T) 510'
12(T) 374'
2(S)R 490'
11(T) 291'
6(S) 336'
4(T) 377'
10(T) 335'
3(T) 367'
5(S) 421'
76(T) 385'
54(T) 410'(?)
6(S) 560'
PARNELL'S CREEK AREA
PARRELL'S CREEK AREA
POND'S CREEK AREA
Bayswater
TO SINGLETON
TO SINGLETON
Bureau of Mineral Resources, Geology & Geophysics
OCT. 1953
N 43-11
ES



Reduce AC (8") to AB (4")