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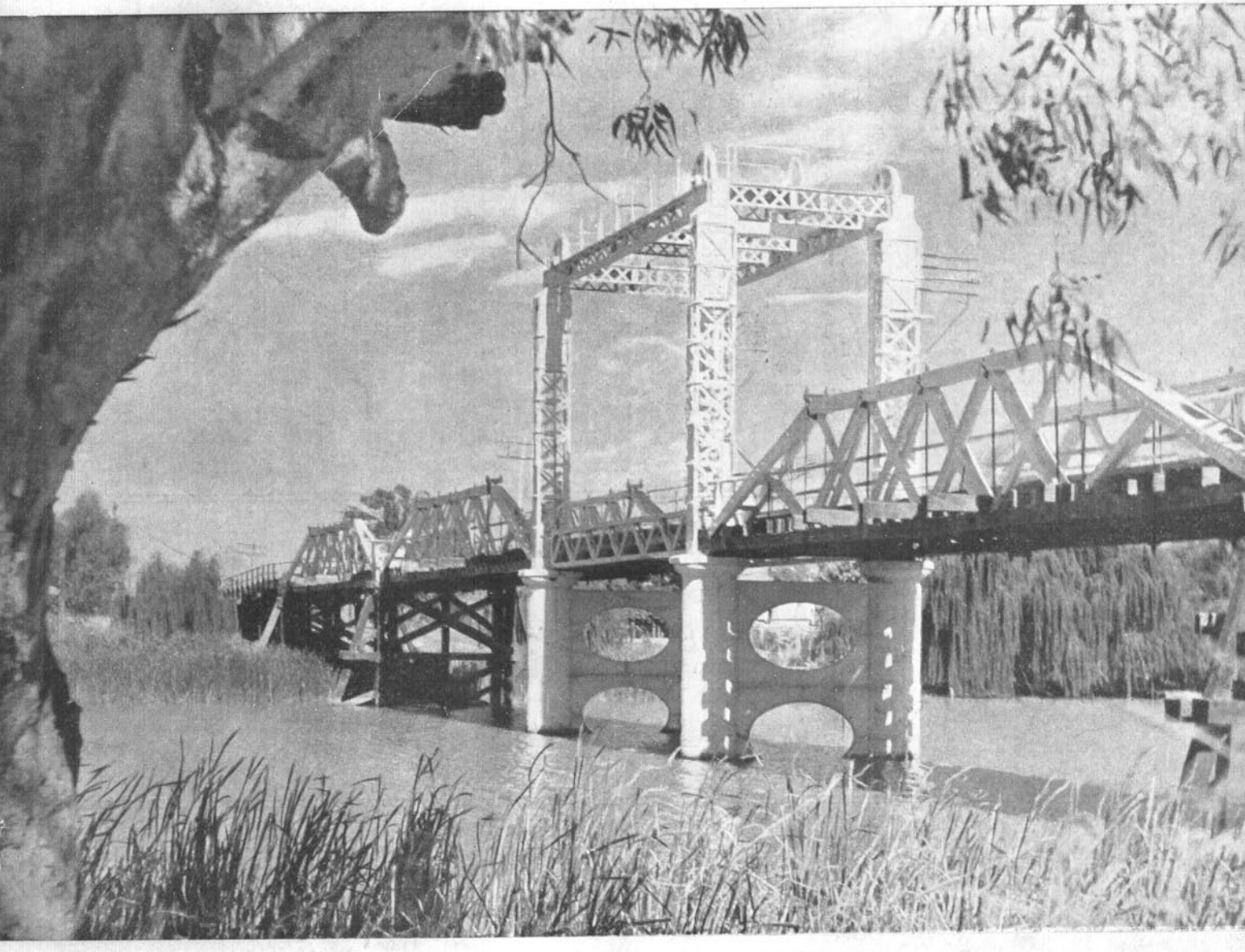
MAIN ROADS

A Record of the activities of the
Department of Main Roads, N.S.W.



Bridge over the Darling River at Wentworth. Built in 1893.

JUNE 1949

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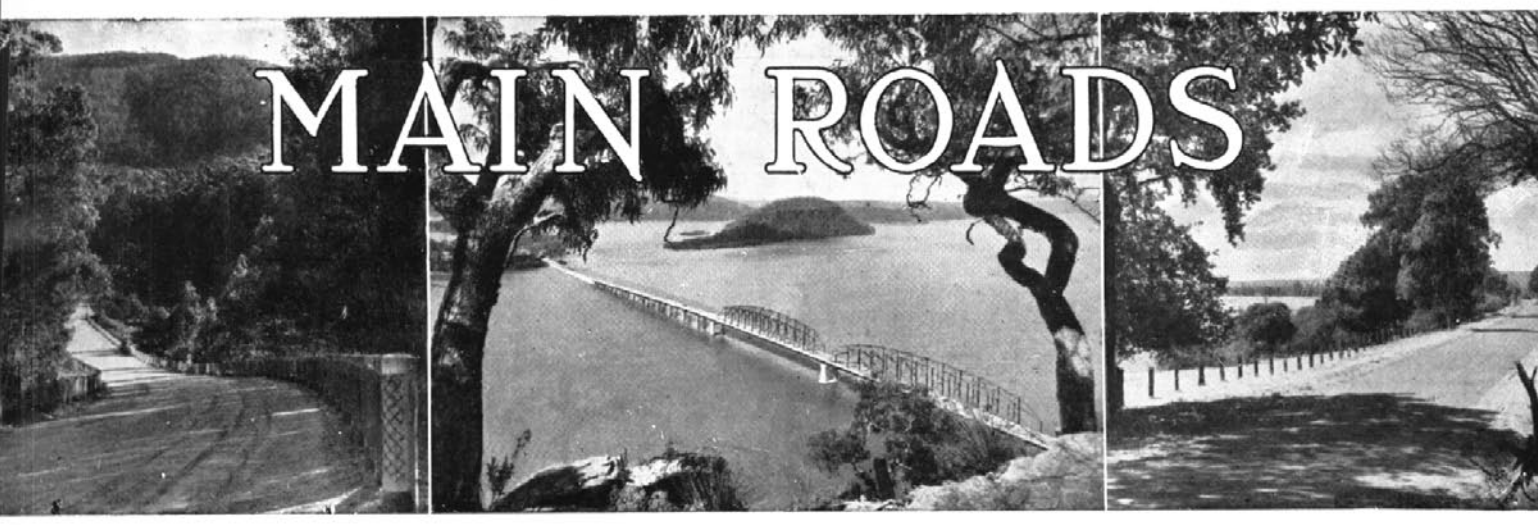

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Road Improvements in the Western Division.

RECENT PROGRESS ON BROKEN HILL TO WENTWORTH ROAD, AND ON WENTWORTH TO SOUTH AUSTRALIAN BORDER ROAD.

Broken Hill and Wentworth, 175 miles apart, have now been linked by a continuous road formation, following on recent work on State Highway No. 22 by an elevating grader unit of the Department of Main Roads.

A similar road formation has also been extended west on Trunk Road No. 68 from Wentworth to Cal Lal, 50 miles west of Wentworth and 15 miles from the South Australian border.

The mining city of Broken Hill has a population of 27,054 persons, and is so situated in western New South Wales (see map) as to require direct connection to South Australia and Victoria, as well as to Sydney and other parts of New South Wales. There are both rail and road links from Broken Hill to Adelaide and to Sydney, but connection to Victoria is by road only, via State Highway No. 22 to Wentworth, and thence to Mildura (Victoria), some 20 miles distant. Broken Hill is distant (by road) 735 miles from Sydney, 330 miles from Adelaide and 560 miles from Melbourne.

As well as being the largest metalliferous mining centre in New South Wales, Broken Hill is also an important centre of the pastoral industry over a wide stretch of territory in the western part of New South Wales, together with adjacent parts of South Australia to the west and Queensland to the north. Wentworth, situated at the junction of Australia's two greatest rivers, the Murray and the Darling, is also a centre for a large area of pastoral country, but, in addition, is the principal town serving a series of irrigation settlements along the Darling and Murray Rivers, in New South Wales. A little east of Wentworth, and on the southern side of the Murray River, are the extensive Victorian irrigation settlements surrounding Mildura. Yelta, Victoria, 12 miles from Wentworth, is the Victorian railway siding nearest to Wentworth and Broken Hill.

BROKEN HILL-WENTWORTH ROAD. (State Highway No. 22.)

The road linking Broken Hill and Wentworth not only serves as the main connection from Broken Hill to the south, but also forms the backbone of a local road and track system throughout the districts it traverses, providing residents with their main means of outlet either to the north or the south.

Except for short isolated sections of black soil, the Broken Hill-Wentworth road traverses red, sandy, loam country, mainly gently undulating or flat. There

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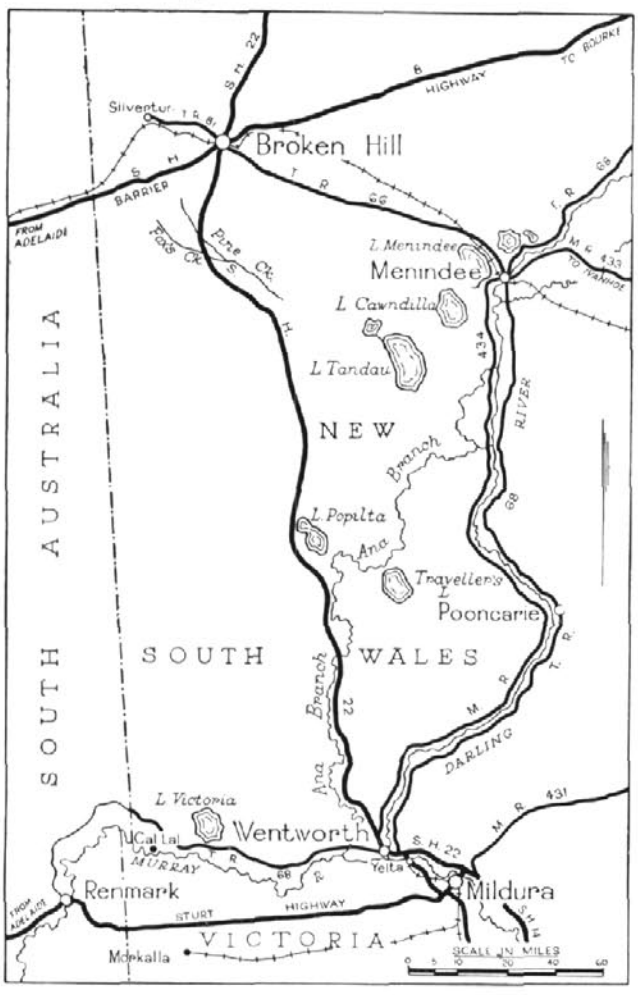
are some low-lying black soil flats. The construction of the road formation over the 175 miles involved was put in hand prior to the war, and a total length of 135 miles had been completed by 1942, when it became necessary to divert plant to defence works. Prior to 1941, new road formation work on this road had been carried out by blade grader, but in that year an elevating grader was introduced and proved highly successful. The unit comprises from two to three tractors, elevating grader, drawn grader, sheepsfoot roller, dozer and subsidiary items. It was not until 1946 that it was possible to resume formation work by elevating grader unit. In spite of delays resulting from plant breakdown, due to the age of tractors and other plant used, and inability to replace it, the work over the remaining 40 miles was finished in June, 1948.

The length of elevating grader formation work carried out on this road since the war totals 40 miles, and involvd the movement of 250,000 cubic yards of soil.

As the climate is arid, rainstorms are infrequent and watercourses are usually dry. For this reason cross-drainage provision is principally in the form of causeways, although some culverts were introduced. In two cases, stream crossings have been paved with concrete, namely, at Fox's Creek and Pine Creek.



Locality Map.

View of section of completed formation constructed by Elevating Grader 90 m. south of Broken Hill.

The completed work provides an easily trafficable road at all times other than during infrequent periods of heavy rain. Over the black soil section, from 1½ miles to 7½ miles north of Wentworth Bridge and extending beyond Pomona Settlement turn-off, a 6 inch consolidated thickness gravel pavement has been laid. The establishment of a formation throughout will facilitate the carrying out of systematic maintenance, and of further improvement as required from time to time. The road as built will give greater convenience and comfort to road users, and will reduce costs of upkeep and operation of vehicles. Travelling time for light vehicles is now about 4½ hours from Broken Hill to Wentworth, 175 miles.

The cost of the work carried out since the war over a length of 40 miles was £19,800, including new raised formation, together with causeways and culverts as required.

WENTWORTH-SOUTH AUSTRALIAN BORDER ROAD. (Trunk Road No. 68.)

This road at present serves primarily to give access from properties in the south-western corner of New South Wales to Wentworth and other towns. It also

Section 13 m. west of Wentworth prior to construction of formation.

serves to provide access to the Lake Victoria storage, about 40 miles west of Wentworth. In addition, Trunk Road No. 68 links Wentworth to the South Australian border 65 miles west of Wentworth, from which point a road leads on to the important town of Renmark, South Australia, 35 miles distant from the border.

Of the length of 50 miles from Wentworth to Cal Lal, sections totalling about 15 miles had been provided with a road formation in earlier years. The work recently completed included 25 miles of new raised formation constructed by elevating grader, and 10 miles of light formation constructed by motor grader, thus providing a continuous formation over a total length of 50 miles.

The country traversed is undulating to flat, having principally red, sandy, loam soil. There are isolated grey soil flats, and some areas of limestone gravel. The area is subject to both wind and water erosion. Some parts are liable to slight inundation in time of heavy rain.

Certain areas in the vicinity of Lake Victoria storage works are subject to permanent wetness and softening due to seepage, particularly from a channel carrying water from the Murray River into the lake. The formation was gravelled in this vicinity, but otherwise it is unsurfaced.

Tractor-drawn Elevating Grader constructing raised formation.

The total cost of the construction of the 25 miles of raised formation by elevating grader, the 15 miles of light formation by motor grader, and gravelling over a length of 5½ miles, was £11,000.

Motor Grader spreading gravel approaching Lake Victoria.

SYDNEY HARBOUR BRIDGE ACCOUNT.

Income and Expenditure for Period 1st July, 1948, to 31st March, 1949.

Income.	£
Road Tolls	283,018
Contributions—	
Railway Passengers	96,095
Tramway Passengers	14,745
Omnibus Passengers	8,081
Rent from Properties	9,470
	£412,309

Expenditure.	£	£
Cost of collecting road tolls		18,207
Maintenance and minor improvements		42,341
Alterations to archways		8,167
Administrative Expenses		1,325
Loan Charges—	£	
Interest	186,000	
Exchange	20,250	
Sinking Fund	50,250	
Management Expenses	750	
		257,250
Miscellaneous		1,775
		£329,065

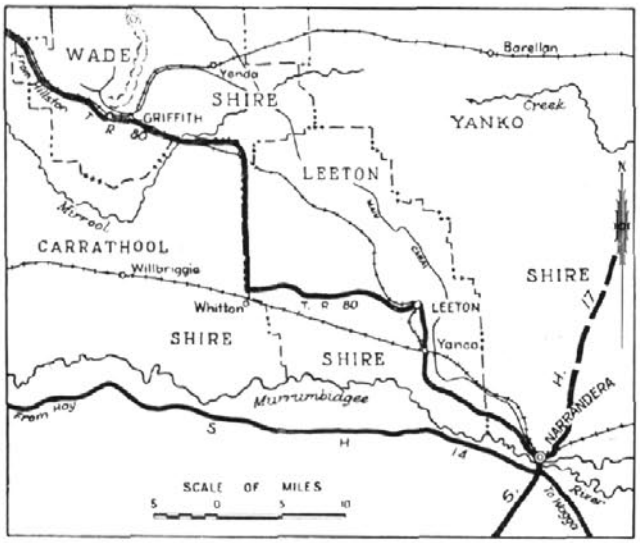
Bituminous Surfacing Extends.

PROGRESS ON MAIN ROADS IN MURRUMBIDGEE IRRIGATION AREA AND BERRIQUIN IRRIGATION DISTRICT.

MURRUMBIDGEE IRRIGATION AREA.

The principal main road in the Murrumbidgee Irrigation area is Trunk Road No. 80, which commences at the Newell Highway (State Highway No. 17) near Narrandera, and passes through Yanco, Leeton and Griffith, thus traversing the full extent of the area. Beyond the irrigation area the trunk road continues to Hillston and Mossgiel, but with a much reduced volume of traffic.

The Murrumbidgee Irrigation Area is in two main parts centred largely around the towns of Leeton and Griffith, which are 35¾ miles apart by road. Leeton is 19 miles from Narrandera, by road. (See locality sketch.) Traffic varies throughout the length of the road, reaching over 2,000 vehicles a day between Leeton and the smaller town of Yanco lying four miles to the south.



Locality Map.

In 1936-38, the Department of Main Roads, mainly with special funds provided for the purpose, carried out the construction of 44½ miles of Trunk Road No. 80 between Narrandera and Griffith. The work included drainage structures and gravel pavement and the bituminous surfacing of the more heavily trafficked sections in approach to the towns of Griffith, Leeton and Yanco. The bituminous surfacing comprised 13 miles in Leeton (then Willimbong) Shire in the vicinity of Yanco-Leeton, and 9.58 miles in Wade Shire between Yenda-Griffith (now mainly forming part of Main Road No. 254).

With the subsequent growth of traffic, bitumen surfacing throughout the entire length of the road has become desirable. Since the war, the Councils of the

View between Yanco and Leeton.

Shires of Leeton and Wade have proceeded with additional sections. The present position is that the sealing of the length between Narrandera and Leeton (19 miles) has been completed (Municipality of Narrandera, Shire of Yanco and Shire of Leeton), together with a further seven miles beyond Leeton (Shire of Leeton), with the exception of a short section ½ mile in length at the recently constructed Canal Bridge two miles west of Narrandera. This section will be surfaced late in 1949. This is followed by a gravel length of 17 miles, beyond which is a bitumen surface of 12½ miles leading into Griffith (Shire of Wade), followed by a length of 4¼ miles of bitumen extending beyond Griffith (Shire of Wade).

Main Irrigation Channel Griffith.

New bituminous surface 12 m. east of Griffith.

The bituminous work carried out during last summer comprised two lengths—(*a*) between 5.7 miles and 12.1 miles from Narrandera, in the Shire of Leeton, and (*b*) between 42.3 miles and 52.3 miles from Narrandera, in the Shire of Wade. The total cost for the two sections was approximately £23,500, of which 75 per cent. was contributed by the Department of Main Roads.

The country traversed is generally flat, the subsoil varying from sandy loam to loams carrying a high percentage of clay. Good gravels suitable for a bitumen surfaced pavement are not plentiful and hauls up to 10 miles in length are necessary to obtain material of satisfactory quality.

In both Shires, the reconstruction comprised shouldering and reshaping of pavement, which was carried out by day-labour using motor graders, and gravel resheeting to provide the required pavement thickness. The gravel resheeting was done by contract in Leeton Shire and by day-labour in the Shire of Wade. Bitumen spraying, and the supply of aggregate were done by contract in each case.

The Leeton Shire Council is now preparing for the bituminous surfacing of a further length of 8.8 miles, extending from 25.0 miles to 33.8 miles west of Narrandera. On the completion of this further extension there will be only about 8½ miles of gravel road remaining to be sealed, in order to link with a bitumen surface the two principal towns of Leeton and Griffith.

By progressive work over a period of years, a main traffic artery is thus gradually being improved by the Councils concerned, aided by the Department of Main Roads, to a standard appropriate to the importance of the districts it serves, and to the increasing volume of traffic it carries.

Rice being transported over bituminous section east of Griffith.

THE BERRIQUIN IRRIGATION DISTRICT.

The Berriquin Irrigation District is practically bisected by the Berrigan-Finley-Deniliquin Main Road (No. 331). Of its total length of 49¼ miles, Berrigan to Deniliquin, 20¾ miles are in the Shire of Berrigan, 24 miles in the Shire of Conargo, and 4½ miles in the Municipality of Deniliquin.

The Councils of the Shires of Berrigan and Conargo have undertaken a progressive programme for the reconstruction of that part of Main Road No. 331 which lies within their areas between Finley and Deniliquin. As well as being a main district traffic artery, the road serves also to link Deniliquin with the railway at Finley.

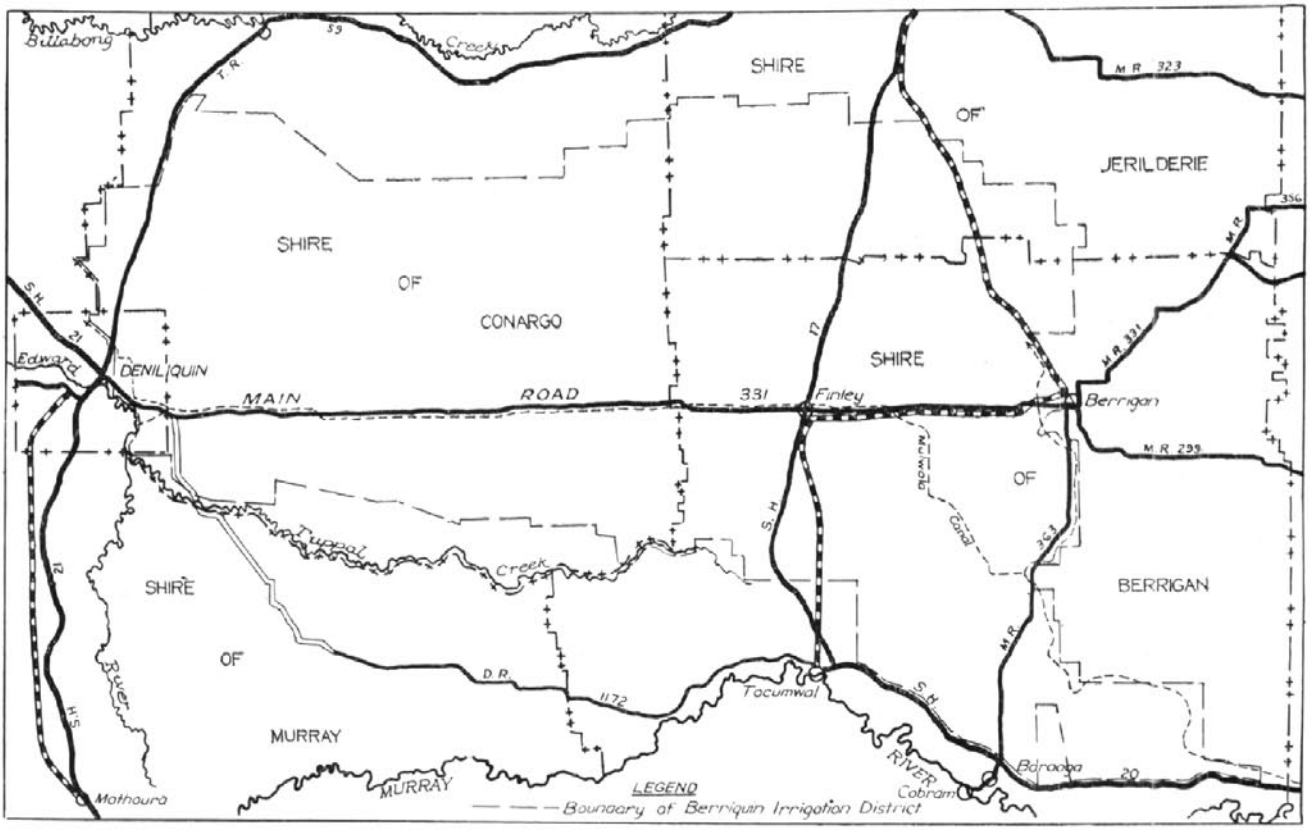
The total length between State Highway No. 17 at Finley and State Highway No. 21 at Deniliquin is 35¾ miles, and the two Shire Councils have undertaken as a first step, the reconstruction and bituminous surfacing of 17¼ miles, comprising a 12¼ mile length extending west from Finley (in the Shires of Berrigan and Conargo), and a five mile length extending east from the Deniliquin Municipal boundary (in the Shire of Conargo).

Portion of M.R. 331 west of Finley immediately prior to sealing.

The old road had originally been formed throughout and isolated sections dressed with loam, but the benefits of the earlier work had been largely lost as a result of traffic and weather. Further, some sections of the road were liable to inundation in time of rain.

The country is generally flat throughout the length of the road, but apart from low-lying sections, presents no special drainage problems.

The district is devoid of supplies of gravel, but contains various deposits of material generally known as "sandy loam". Experience on the Deniliquin-Moama Road (State Highway No. 21) and elsewhere has shown that if sandy loam can be obtained of a suitable quality, it can successfully support a bituminous seal coat.

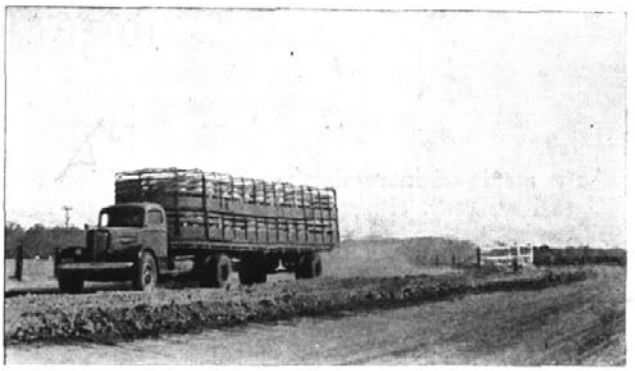


Locality Map.

It so happened that a soils survey of the district had been carried out by the Council for Scientific and Industrial Research. Using this as a guide, likely areas were prospected by boring up to a maximum depth of 12 feet, and deposits of from three feet to 12 feet depth, of suitable quality, were located after extensive search. In practically all cases it was found that the material in the deposits was horizontally stratified, and blending from top to bottom of each deposit was necessary in order to obtain uniformity in quality from each pit. This was constantly checked by sieve tests throughout the progress of the work. The results obtained in the

View of Mulwala Canal near Deniliquin with M.R. 331 alongside.

Scene on M.R. 331 9 m. west of Finley.



Sheep Transport east of Deniliquin.

construction of the pavement have fully justified the care taken in the selection and test of the materials used.

The work carried out comprises a 20 feet wide loam pavement, 26 feet formation width. Width of seal coat is 18 feet. Formation and pavement have been completed over a total length of 17¼ miles, and the sealing of a 12¼ mile section has been arranged. It is anticipated that the balance of the constructed length will be sealed next summer. The estimated cost of the complete reconstruction and sealing of the 17¼ miles involved is about £46,500, of which two-thirds is being provided by the Department of Main Roads.

PAYMENTS FROM THE ROAD FUNDS FOR PERIOD 1st JULY, 1948, TO 31st MARCH, 1949.

	Amt. Paid. £
COUNTY OF CUMBERLAND MAIN ROADS FUND—	
Construction of Roads and Bridges	447,804
Acquisition of Land and Buildings for Road Widening	7,221
Maintenance of Roads and Bridges	330,701
Interest, Exchange and Repayment of Loans	10,088
Other Expenditure	68,028
Total	£881,842
COUNTRY MAIN ROADS FUND—	
Construction of Roads and Bridges	775,967
Acquisition of Land and Buildings for Road Widening	5,688
Maintenance of Roads and Bridges	1,414,025
Interest, Exchange and Repayment of Loans	141,878
Purchase and Repair of Plant and Motor Vehicles	165,541
Other Expenditure	134,941
Total	£2,638,040
DEVELOPMENTAL ROADS FUND—	
Construction of Roads and Bridges	59,840
Other Expenditure	1,109
Total	£60,949
SUMMARY ALL FUNDS—	
Construction of Roads and Bridges	1,283,611
Acquisition of Land and Buildings for Road Widening	12,909
Maintenance of Roads and Bridges	1,753,726
Interest, Exchange and Repayment of Loans	160,966
Purchase and Repair of Plant and Motor Vehicles	165,541
Other Expenditure	204,078
Total	£3,580,831

New Bridge Design Loading.

UNITED STATES PRACTICE FOLLOWED.

As a result of increasing weights of vehicles, both civil and military, either in use or likely to be used, the Roads Authorities of the various States agreed on the need for a revised standard design loading for bridges on important roads. After detailed study of the matter, it was decided to adopt the standard loading of the American Society of State Highway Officials, known as loading "H20—S16—44," which is the general highway bridge design loading in use in the United States.

The A.A.S.H.O. loading provides for the following alternative loadings:—

1. A conventional vehicle comprising an axle load of 8,000 lb. followed by two axle loads of 32,000 lb., the first at a fixed distance of 14 feet behind the 8,000 lb. axle and the second at a variable distance of anywhere between 14 feet and 30 feet behind the first 32,000 lb. axle.

2. A conventional lane loading comprising a concentrated load (spread uniformly over the lane width), taken as 18,000 lb. for computation of moments, and 26,000 lb. for computations of shears, co-existing with a uniform load of 640 lb. per linear foot of lane.

Full details of the loading and its method of application are given in the A.A.S.H.O. Standard Specification for Highway Bridges.

The Department's new "Standard Loading Type A — 1948" shown in the appended diagrams and notes (Main Roads Standard No. A.4) is substantially the A.A.S.H.O. H20—S16—44 loading.

In applying the H20—S16—44 loading to New South Wales main road bridges, however, some minor departures from the United States standard have been made. This has been done to give a clearer interpretation of the application of the loading in some respects, to extend slightly the scope of the loading and to simplify calculations in certain cases.

In the Department's new standard loading there are included besides the vertical live loading on the carriageway, vertical live loading on footways, and loadings to be taken on kerbs and hand-railings. The latter are generally not vertical, the horizontal direction usually giving the worst case, although these loads may be assumed in any direction. Hand-railing loads differ from the A.A.S.H.O. specification, but kerb loads agree closely.

EFFECT OF NEW LOADING ON DESIGN.

The effect of the use of the new loading upon the design of bridges will not be great. Moments and shears in simply supported beams are increased over and above those previously used. The increase is most pronounced on spans between 40 feet and 105 feet in length.

Deck slab thicknesses will be slightly increased. Stringers and cross girders will be slightly heavier. Main trusses over about 105 feet span will be designed for a slightly smaller live load. Stresses will be slightly greater than in the past, due to increased dead load of deck and stringers, etc., and the fact that, with 10 feet wide lanes and 22 feet and 24 feet wide bridges, lanes can be unsymmetrically disposed on the deck. The total effect is small. Unsymmetrical loading of footways is now also taken into account (this was not formerly done) and results in further slight increase in stresses. The ultimate effect on trusses, say 120 feet and 140 feet spans, will be an approximate increase in weight of steel, etc., and consequently of cost of about 5 per cent. On plate girders, generally of about 50 feet to 90 feet spans, the cost increase may be 10 per cent. to 12 per cent.

Rolled steel beam spans with concrete deck were formerly 40 feet and 35 feet long for the two largest sizes of joists made in Australia, namely, A.S.B.'s 24" x 7½" and 22" x 7". These spans must be reduced to 39 feet and 33 feet for the same design stresses, with a resulting extra cost of about 5 per cent. to (possibly) 10 per cent., depending on the extent to which extra spans may be necessary.

With regard to concrete bridges, of the simple or framed beam span types, generally these are of shorter span length than steel bridges (other than R.S.J. spans) and the effect of live load moments and shears up to 30 per cent. greater than previously will be reflected in the design and economy of such bridges. Investigations have shown, however, that the expected increase in cost of such bridges will generally be less than 6 per cent., except for short span decked culverts whose cost will be increased by up to 10 per cent. Culverts under fills 5 feet deep or more are practically unaffected.

PREVIOUS STANDARD BRIDGE LOADINGS USED IN NEW SOUTH WALES.

Prior to the establishment of the Main Roads Board in 1925, the design loading generally used on principal bridges in New South Wales comprised either a conventional vehicle with two axles 10 feet 4 inches apart, and total weight 16 tons, of which 9½ tons was on the rear axle, or alternatively a distributed load of 84 lb. per square foot of bridge deck, reduced to 70 lb. per square foot on long trusses. A greater loading was adopted for some special bridges.

In 1914, the standard loading was increased for steel and concrete bridges to a conventional truck 24 feet long having axle loads of 16 tons and 8 tons 12 feet apart, preceded and followed by a uniformly dis-

tributed load of 100 lb. per square foot. This loading was used for a few years only, when the previous load was reverted to, except that 100 lb. per square foot was still used as the distributed loading on the decks of steel bridges.

A special loading was adopted for the Sydney Harbour Bridge.

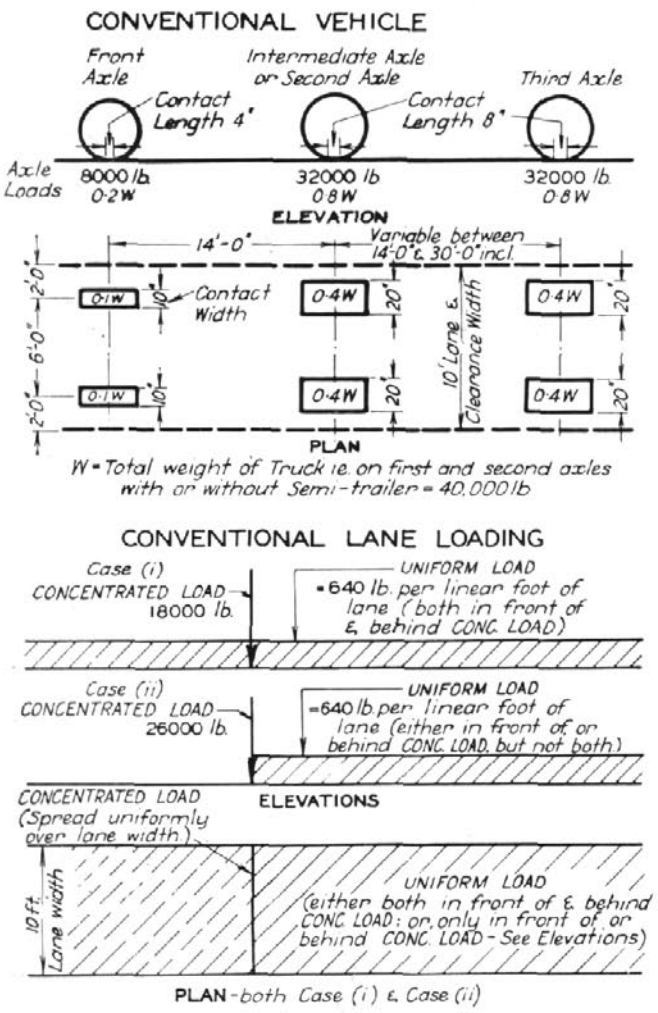
With the establishment of the Main Roads Board a standard design loading for main road bridges was adopted in 1927, following a study of loadings used abroad and that used on the Sydney Harbour Bridge. In the interim, a loading consisting of a 15-ton traction engine towing a 10-ton trailer had been tentatively adopted. The 1927 loading comprised a four wheeled vehicle with axles 12 feet apart, having 10,000 lb. on the front axle and 30,000 lb. on the rear axle, the vehicle being preceded and followed by a uniformly distributed loading. The distributed loading varied with span length, being 100 lb. per square foot for spans up to 100 feet, 90 lb. per square foot for spans from 100 feet to 200 feet, and 80 lb. per square foot for spans over 200 feet. Details of this standard loading appear in "Main Roads," Vol. 2, No. 5.

This loading continued in use until 1937, when a new loading, similar in principle, was adopted in agreement with road authorities in other States. (For details, see "Main Roads," Vol. 9, No. 3.) The 1937 modifications did not result in any substantial variation in the strength of bridges as designed, in comparison with those designed using the 1927 loading. This loading, with minor modifications, continued in use until 1948.

CONCLUSION.

The adoption of the new standard loading will give an improved strength to bridges to be designed and built in the future by the Department at small extra cost. It will bring road practice in New South Wales more closely into line with practice in other parts of the world, and will provide a margin of strength greater than allowed for previously for the relatively infrequent extraordinary traffic, *e.g.*, large industrial or military loads, thus reducing the possibility of high overstress due to such loads.

STANDARD LOADING.



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1. Lanes, Lane-widths, etc.

To determine traffic loadings on culverts, bridges and other highway structures, traffic is to be assumed to occupy parallel lanes ten (10) feet wide, having parallel edges, normally straight. On curves, lanes may be curved, however, in accordance with the road curvature.

2. Number of Lanes.

As many complete lane widths as can be accommodated on the carriageway shall be considered; that is, fractional lane widths or wheel loads shall *not* be considered. Lanes shall not overlap each other or the kerb, medial strips, etc.

3. Position of Lanes and Wheel Loads.

One or more lanes may occupy any lateral position on the carriageway, but wheel loads shall not be moved relative to their lane (except as provided below, paragraph 7). In curved lanes, wheels shall be considered as maintaining their symmetrical positions within the lanes as far as possible.

4. Live Loads from Roadway Traffic.

Each traffic lane may be occupied by a conventional vehicle or by a conventional lane loading (either case (i) or case (ii)). The latter is intended to represent a standard loaded truck preceded and/or followed by a train of less heavily loaded trucks.

5. Type and Arrangement of Loading.

The type and arrangement of loading, etc., for any particular stress under consideration shall in all cases be such as to make such stress a maximum.

6. Reduction of Stresses for Simultaneously Loaded Lanes.

Where more than two lanes are loaded to produce any particular stress (excepting stresses in bridge deck systems—other than main transverse members), the stress shall be reduced and the following proportions only shall be used:—

LIVE LOAD STRESSES.

Reduction of Stresses for Simultaneously Loaded Lanes.

Number of Lanes Loaded.	Proportion of Stress used in Design.
One or two lanes.	100%
Three lanes.	90%
Four or more lanes.	75%

7. Special Loading Cases.

(*a*) For the design of bridge decks only, a single large standard truck wheel may be placed at any point of the carriageway.

(*b*) The type and arrangement of loading on bridges having spans over 250 ft. long, or carrying more than four (4) lanes of traffic or carrying tramways, or having medial strips, shall generally be dealt with as special cases.

8. Impact Allowances on Carriageway Loading.

Live load stresses shall be increased by impact allowances, "I," as follows:—

(*a*) *Superstructure*—including columns, towers, trestles and legs of frames, etc., above ground line rigidly connected to the structure above (as in rigid frame or continuous structures)—

$$I = \frac{5{,}000}{L + 125}\ \%;$$

with a maximum of 30%,
and a minimum of 10%,

where L is the total horizontal length, in feet, of the influence line for the stress in the member or portion of the structure concerned, but, in continuous span structures, not greater than the length of any span carrying a concentrated load.

(*b*) *Substructure*—including structures, etc., above ground not part of the superstructure (as defined in (*a*) above),

$$I = 10\%.$$

(*c*) *Foundations*—all structures below ground,

$$I = \text{nil}.$$

(*d*) *Structures under fill*: I shall be reduced by the factor "f," given by—

$$f = \frac{3}{3} - \frac{H}{3},$$

where H is the height, in feet, of fill over the structure up to a depth of fill of three (3) feet—no impact allowance is to be made if H is greater than 3 feet.

9. Live Loads on Footway, Safety Kerbs, Cycleways, etc.

Footways and medial strips (except where subsequent conversion to carriageway is possible), safety kerbs two (2) feet wide or more, and cycleways shall be considered as loaded with a uniformly distributed load, F, given by

$$F = 100 - \frac{L}{2{\cdot}5} \text{ lb. per square foot;}$$

with a maximum of 80 lb. per sq. ft.,
and a minimum of 60 lb. per sq. ft.,

where L is calculated as for impact allowance.

Footway, etc., live loading shall be considered in the design of all members or portions of the structure, but *no* impact shall be included on such loading. The effect of unsymmetrical loading on one footway, etc., where structures carry cantilever footway(s), etc., shall also be considered.

10. Lateral Forces on Kerbs.

Kerbs and their connections to the remainder of the structure shall be designed to resist lateral forces (generally horizontally outward from the road centreline) of 500 lb. per linear foot of kerb applied 9 inches above the deck. Such forces generally need not be taken as coexistent with live loads from traffic.

11. Railing Loads.

Each rail of a roadway railing or of a footway handrailing shall be designed for a force of 150 lb. per linear foot applied in any direction (but in one direction only at one time). Posts and their connections to the remainder of the structure, shall be designed for the sum of all the loads which they are called upon to carry as the result of loading any one rail at one time only.

Solid parapets, panelling or grille type railings, etc., and their connection to the remainder of the structure shall be designed for a force of 150 lb. per linear ft. applied in any direction halfway between the top of the footway slab or roadway kerb, etc., and the top of the railing. The total force for a panel shall be divided, as far as possible, proportionately amongst the total number of individual units transmitting the force to the deck, etc.

The effect of railing loads upon the supporting structure shall also be considered in all cases, but such loads generally need not be taken as coexistent with live loads from traffic.

Land Use in Newcastle Region and its Physical Basis.

SURVEY LEADING TO ROAD PLAN.

The Department of Main Roads has under detailed review the question of the proclamation of additional main roads and the reclassification of existing main roads, following on individual and joint requests submitted by various councils throughout the State. The position is being examined on a regional basis, and the likely future developments in each region are being studied, in order that any additions or alterations made to the Main Roads system will best meet future needs.

The Newcastle Region comprises an area of 1,736 square miles on the central coast of New South Wales, and is made up of the Shires of Lower Hunter, Port Stephens, Kearsley and Lake Macquarie, the Municipality of Cessnock and the Cities of Newcastle and Maitland. As the Newcastle Region includes both extensive mining and manufacturing industries, as well as areas of intensive agricultural use, it was decided, in this Region, to carry out first a detailed survey of the resources and of likely trends of development, as being the first step in the estimation of future volumes and directions of traffic throughout the Region.

The survey, including the preparation of a land use map and of other maps, was carried out by one of the Department's officers, Mr. J. Brunt, B.Sc., during 1948.

One of the principal means of studying trends of development is the study of existing land use and of the physical factors which largely shape land use. For this reason a generalised land use map of the region was prepared, and this map, with notes on the physical resources of the region, is reproduced on pages 112 and 113.

In view of the establishment of the Northumberland County Council in the latter part of 1948 as a town and country planning authority for the Newcastle Region, a copy of the full series of maps prepared in the survey has been supplied to the Council. Further consideration will be given to the Main Roads needs of the Region when the work of the Northumberland County Council has reached an appropriate stage.

PHYSICAL RESOURCES.

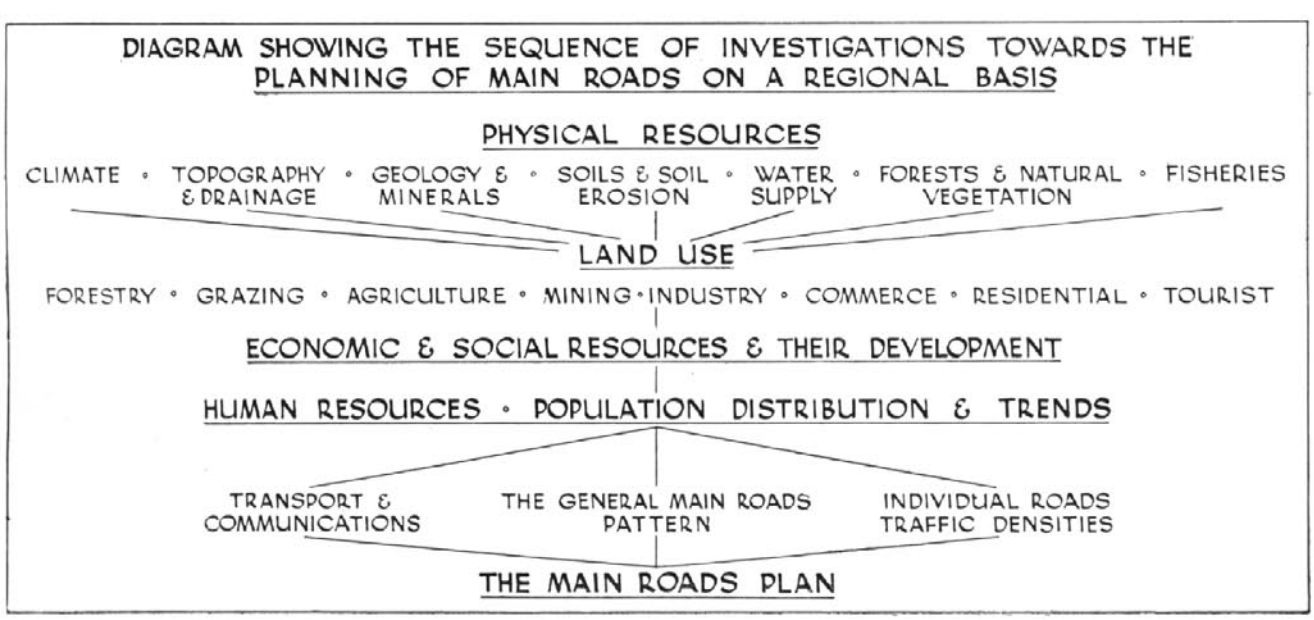
A. Climate.

The general climatic environment of the Newcastle Region is characterised by annual precipitations of between 30 and 50 inches, by equable temperatures and high relative humidities.

Total annual rainfall decreases uniformly from 50 inches in the north-east near Port Stephens to below 30 inches in the extreme west and south-west of the Region. A similar trend is apparent in rainfall reliability, the coastal districts enjoying 40 per cent. reliability with a decrease to less than 35 per cent. in the far south-west, rainfall reliability being defined as the percentage deviation from the mean annual rainfall over a period of years.

Precipitation is distributed uniformly throughout the year, with slight autumn and early winter maxima.

Frosts are completely absent in the coastal zone, but in the vicinity of Cessnock and to the south-west along the valley floor of Wollombi Brook, their occurrence is sufficiently frequent between May and



September to warrant attention as a factor in the climatic environment.

In general, climatic conditions in the Newcastle Region do not set very narrow limits to the use of the land. Comparatively high rainfall of high reliability and uniform seasonal distribution permit a fairly wide choice of agricultural pursuits. While the element of frost risk to crops becomes a factor in the south-west of the Region, frosts rarely are sufficiently severe to prove a deterrent to cultivation.

B. Topography and Drainage.

The general physiographic pattern is characterised by hilly to rugged uplands in the southern portion of the Region, and by extensive flats and maturely dissected slopes in the northern sector.

Four distinct topographical regions can be recognised, each having its own separate drainage system:—

(i) "The South-west Upland Region," comprising the southern half of the Shire of Kearsley, is a rugged inhospitable plateau dissected by narrow habitable valleys and having its stream pattern dominated by the Wollombi Brook.

(ii) "The South-eastern Hills and Slopes Region," occupied by the Shire of Lake Macquarie, comprises a rugged scarp in the west giving way to level to hilly country in the east. The area is drained by three small streams, Cockle, Dora and Wyee Creeks, which flow in a general easterly direction towards Lake Macquarie.

(iii) "The Hunter, Paterson and William Flats and Slopes Region," comprising all of the Lower Hunter Shire and parts of the Shires of Kearsley and Port Stephens, is an area of very extensive flood plain, partially surrounded by undulating and hilly terrain, drained by the Hunter, Paterson and Williams Rivers.

(iv) "The Port Stephens Swamps and Sandhills Region," comprising the eastern portion of Port Stephens Shire, is a low-lying area characterised by many swamps and areas of internal drainage interspersed amongst scattered sandhills.

In general, considerations of topography and drainage play an important part in determining the pattern of development in the Newcastle Region. The rugged nature of the southern uplands immediately suggest resistance to occupation and difficulty of access. On the other hand, the mature topography of the "Lower Hunter, Paterson and Williams Flats" permits easy access and suggests intensive occupation.

The general north-south alignment of valleys tributary to the Hunter provides natural means of access north and south from the main stream, and, at the same time, presents problems of east-west access if routes other than along the Hunter River flats are to be taken.

C. Geology and Minerals.

A consideration of geology is of fundamental importance in assessing the resources of the Newcastle Region. The nature and extent of geological formations determine the location and distribution of coal, which forms the basis of one of the most significant single activities in the Region, viz., coal mining.

The rocks range from Carboniferous to Recent in age, but it is solely within the sedimentary rocks of Permian age that the coal-bearing seams occur. These are found in two major measures—the Upper and Lower Coal Measures, separated by rocks of the Upper Marine Series, and forming the northern rim of a huge saucer-like structure with its centre in the vicinity of Sydney and its western and southern peripheries appearing on the surface at Lithgow and Wollongong, respectively.

The Upper Coal Measures exist in two stages, the Newcastle and Tomago stages, which appear as surface strata in the Newcastle-Lake Macquarie and in the East Maitland districts, respectively. The Lower, or Greta, Coal Measures appear at the surface in the form of a narrow V-shaped tract along a line joining West Maitland-Kurri Kurri-Cessnock-Millfield and Branxton.

The reserves of coal in the Newcastle Region are extremely large, the greatest deposits being located in the Maitland-Cessnock district.

The future location of collieries would depend, among other things, on the thickness, continuity, quality and accessibility of coal deposits.

D. Soils.

The soils of the Newcastle Region have developed under comparatively wet climatic conditions associated with natural forest growth (Wet Sclerophyll forest), and are included in the large group of soils known as "podsols," or fully leached soils. Within this broad group there are great variations in textural types and in depths of surface horizons, and these variations can in many cases, be related to mode of formation and to the nature of the parent rock material.

Since a detailed soil survey was impracticable in the limited time available for field work, it was determined to carry out a soils synthesis based on geological data and supplemented by the field sampling of soils in selected areas.

From the point of view of origin, the soils may be classified as follows:—

(i) Soils developed *in situ*—in the main these are shallow sands and sandy loams poor in mineral plant foods.

(ii) Wind-blown sands of the coastal region.

(iii) Silts, sandy silts, silty clays and sands of alluvial origin.

Class (i) soils, occupying the greater part of the Newcastle Region, display a wide range of inherent productivity. Those associated with Carboniferous and Early Permian rocks support excellent pastures, and in some parts are suitable for the growth of vines, vegetables and fodder crops, whilst those derived from the weathering of Late Permian and Triassic Sandstones are particularly inferior types generally not

PRIMARY INDUSTRIES IN THE NEWCASTLE REGION.

1. Cattle grazing on cleared pasture land near Mayfield.
2. Intensive Fodder cultivation. River flats near Maitland.
3. Vineyard adjoining Developmental Road 1124 near Pokolbin.
4. Market Gardens. City of Maitland in background.
5. Vegetable growing in the vicinity of Mt. View near Cessnock.
6. State Forest near Limeburner's Creek.

capable of much agricultural or pastoral development. From the potential productivity aspect, the most favoured soils of this class appear to be those in the Cessnock-Pokolbin-Lochinvar district, and on the lower slopes of the Paterson and Williams Valleys.

Class (ii) soils, occupying an area between Raymond Terrace and the southern shores of Port Stephens, and also a coastal strip between Swansea and Redhead, are in no way suited for agricultural development. Because of the textural predominance of sand, cultivation is generally out of the question, and the sparsity of grass cover on these soils permits little in the way of grazing possibilities.

The alluvials of the Lower Hunter, Paterson and Williams Flats are by far the most fertile soils of the Newcastle Region. They are deep, well drained grey argillaceous silts and sandy silts, which are continually being replenished by rich alluvial of basaltic origin after periodic heavy rains on the Hunter, Williams and Paterson catchments.

Their overall fertility suggests their use for intensive agriculture. Local soil differences, particularly of texture, largely determine the exact type of utilisation. Market gardening is favoured on the sandier soils, commercial fodder cultivation on the finer silts, and intense dairy cattle grazing on the swampy clays.

The soils factor is of fundamental importance in determining both the present and future uses of the land in the Newcastle region. Unfavourable soils endowment drastically limits the scope of man's activities in the south and south-west, for even where slopes are gentle, soil infertility usually outweighs topographic advantage.

On the other hand, the alluvials of the Hunter, Paterson and Williams Flats and the soils to the north and to the west, because of their inherent fertility, offer a wide choice of land uses. Within these areas, therefore, not only can the greatest intensity of agricultural use be expected, but also the greatest scope for future development in agriculture.

E. Water Supply.

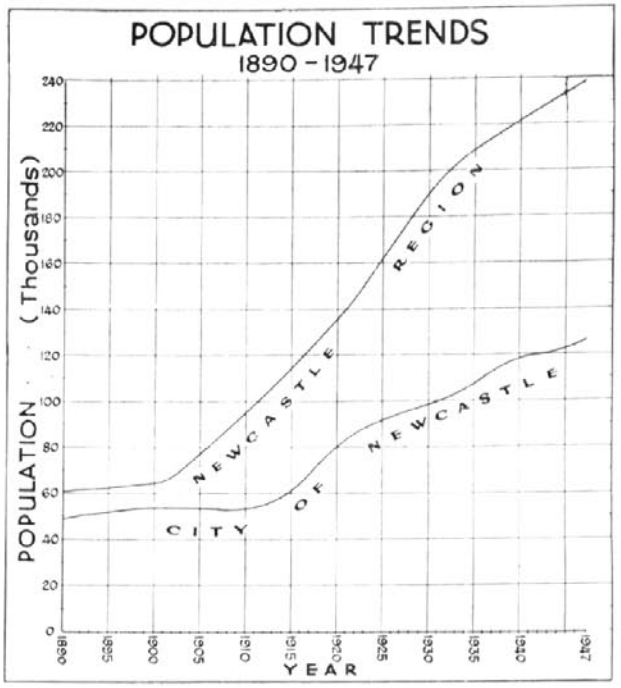
The region has considerable water resources suitable for town supply and other purposes. The most accessible water resources are principally those comprised in the upper courses of the Williams River and its tributaries, and in sand beds near Newcastle and Maitland.

The Williams River is situated in an area of evenly distributed and reliable rainfall, giving assured high volumes of stream flow throughout the year.

Sand beds supplies occur underground beneath the wind-blown sands of the district to the north and north-east of Tomago, and the alluvials of the Hunter River flats near Maitland.

F. Forests and Natural Vegetation.

In its original state practically the whole of the Newcastle Region was covered by an extensive open forest of hardwood eucalypts, giving way to Leptospermum-Banksia thicket (*Leptospermum laevigatum, Banksia integrifolia*) and stunted Banksia woodland



(*Banksia serrata* and *Banksia aemula*) on the sand dunes of the coastal belt, and being replaced in parts of the river valleys by brushwood rain forest vegetation.

Large tracts of the hardwood forest and practically all the softwood brush have been cleared during the course of agricultural and pastoral development, and most of the better class timber has been eliminated from the more accessible areas for commercial and mining use.

However, particularly in the rugged south-west, there remain considerable stands of good timber consisting mainly of Ironbark (*Eucalyptus paniculata*), Spotted Gum (*Eucalyptus maculata*), Sydney Blue Gum (*Eucalyptus saligna*) and Tallow wood (*Eucalyptus microcorys*), and to a lesser extent of Blackbutt (*Eucalyptus pilularis*) and Turpentine (*Syncarpia laurifolia*).

LAND USE MAP.

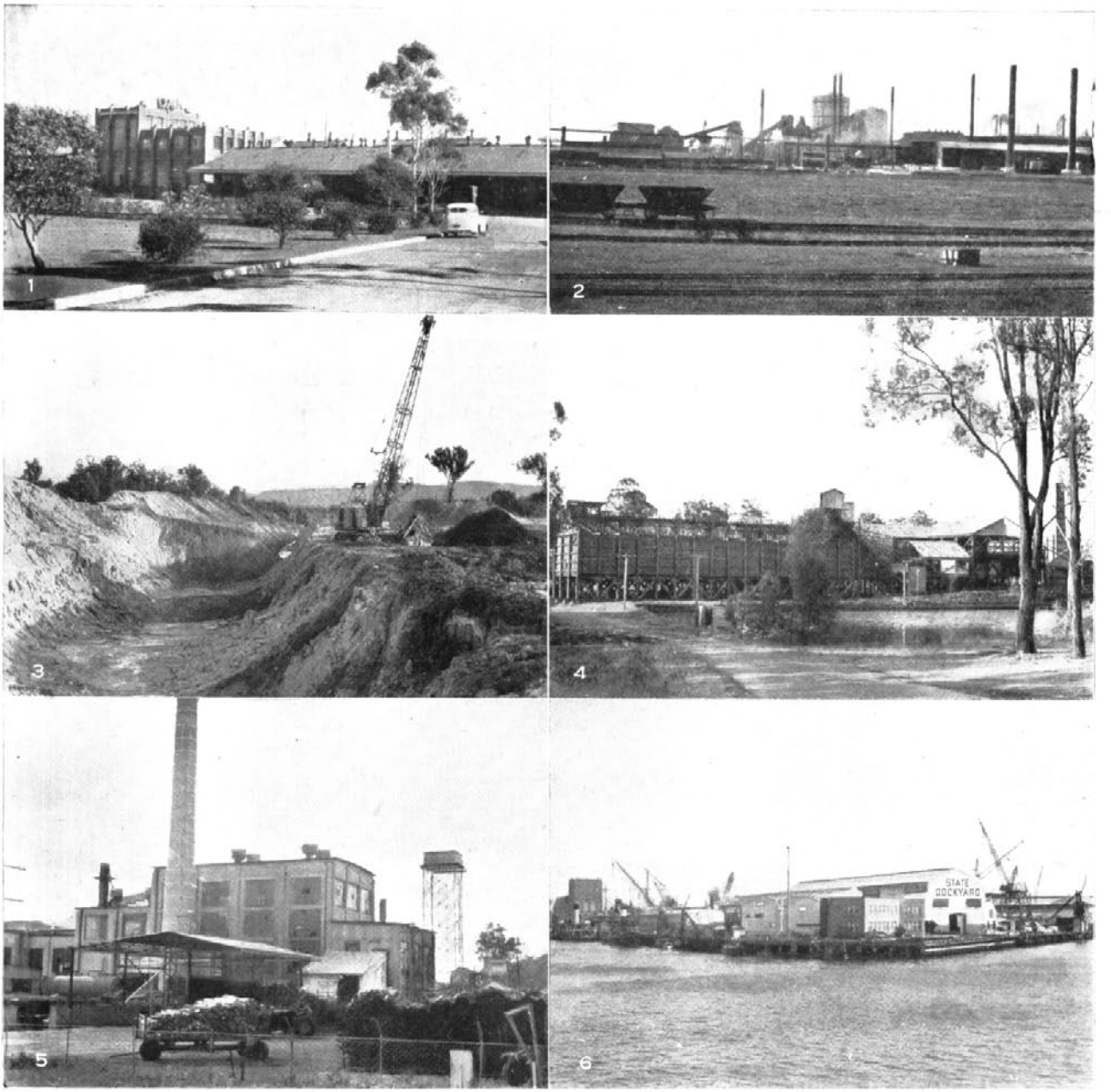
Land use is an expression of the extent to which man has turned his natural environment to account. Thus a study of land use is the logical sequence to a study of physical resources in regional investigation.

The various classes of land use represented in the land use map of the Newcastle Region reproduced herewith are as follows:—

A. Undeveloped Land.

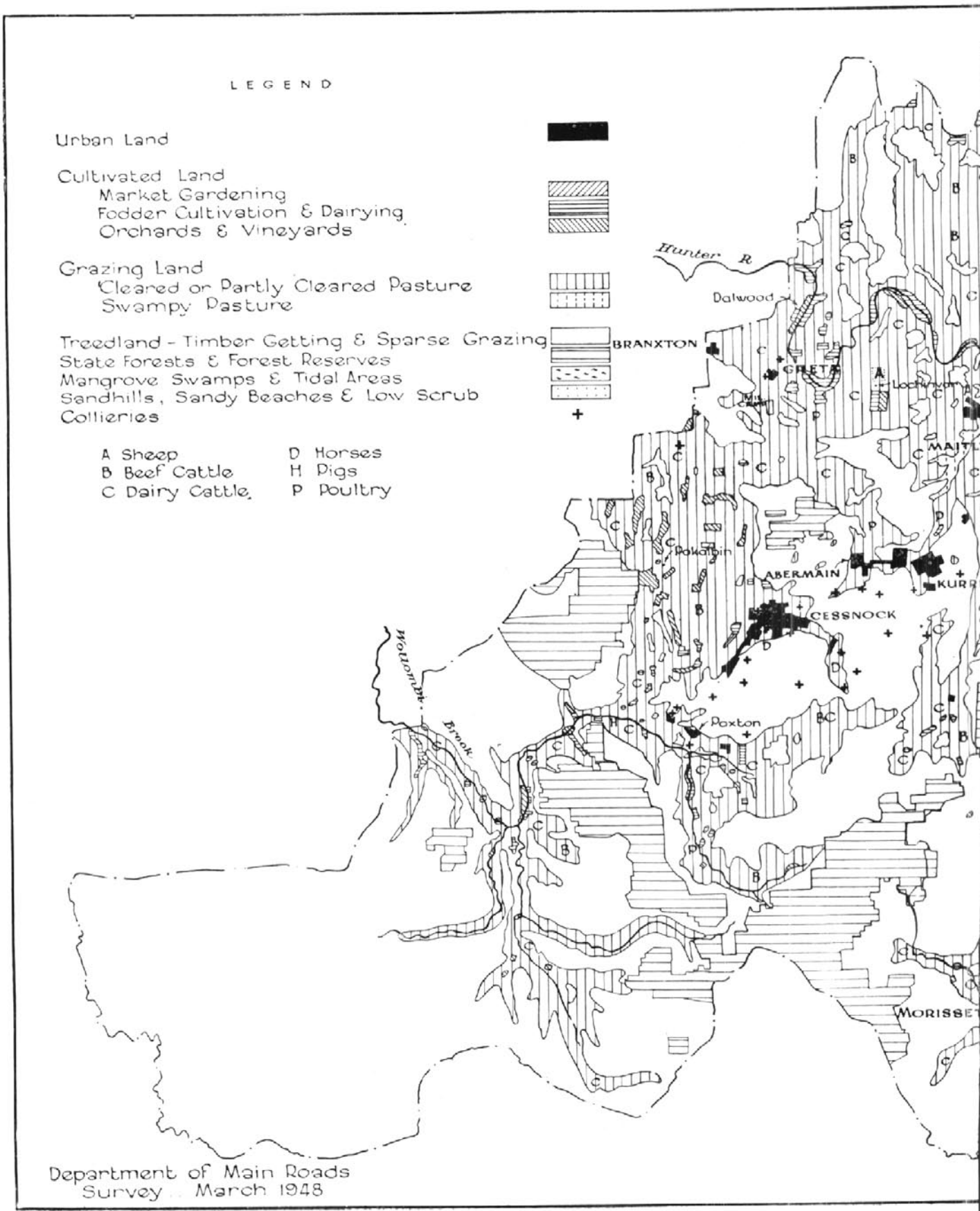
Two classes of undeveloped land are represented in the Newcastle Region. These are: (i) *"Sandhills, Sandy Beaches and Low Scrub,"* and (ii) *"Mangrove Swamps and Tidal Areas."*

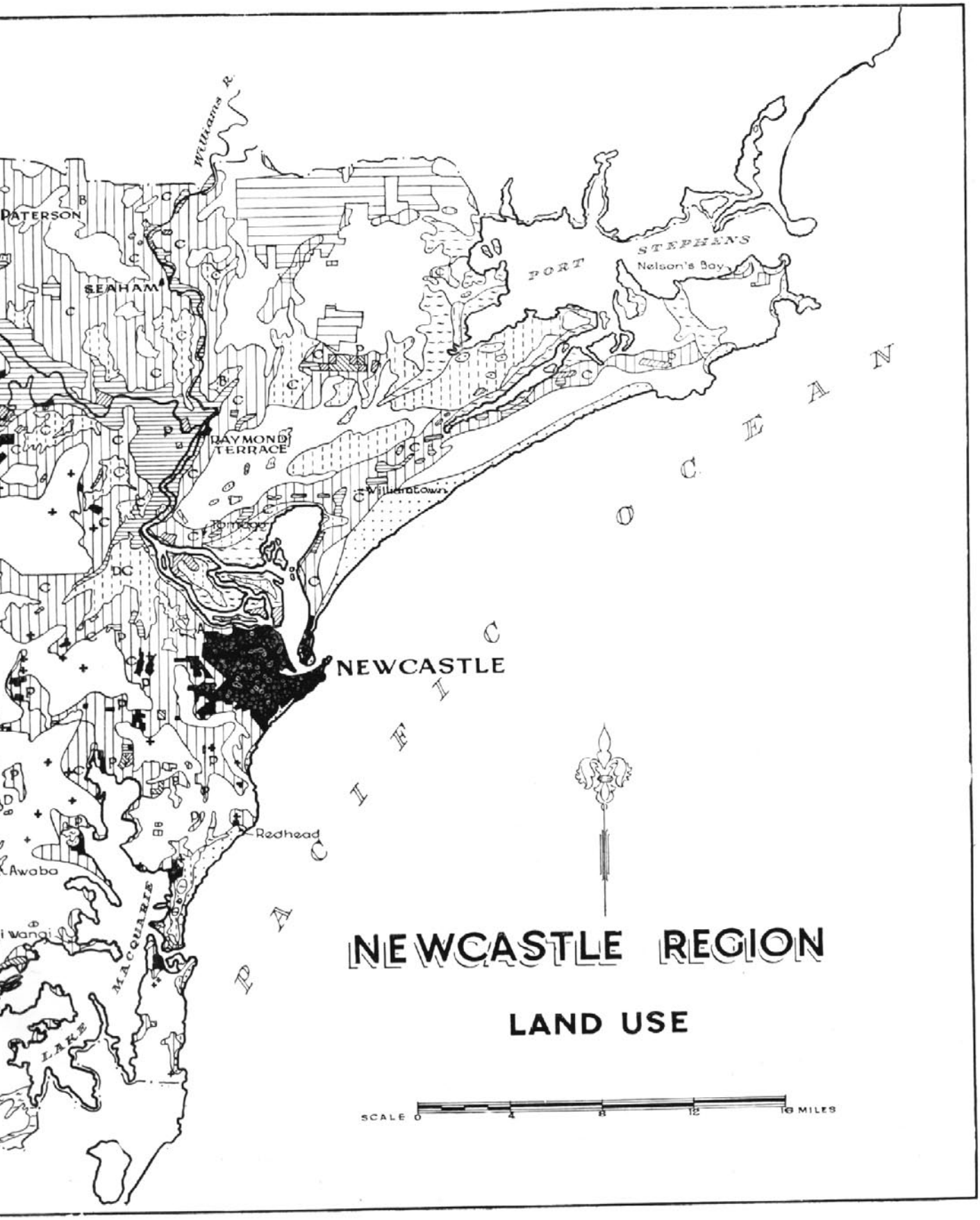
The former exist in their natural state as bare sandy beaches and sand dunes, or as sandhills vegetated by stunted Banksia woodland.



MINING AND MANUFACTURING IN THE NEWCASTLE REGION.

1. Hunter Valley Co-op. Dairy Co. Ltd. Butter Factory, Hexham.
2. Part of B.H.P. Co. Ltd. Steelworks, Newcastle.
3. Open cut Coalmine south of Branxton.
4. Ayrefield No. 3. Colliery near North Rothbury.
5. Masonite Corporation (Australia) Ltd. Factory south of Raymond Terrace.
6. State Dockyard, Walsh Island, Newcastle.


LEGEND
Urban Land
Cultivated Land
Market Gardening
Fodder Cultivation & Dairying
Orchards & Vineyards
Grazing Land
Cleared or Partly Cleared Pasture
Swampy Pasture
Treedland - Timber Getting & Sparse Grazing
State Forests & Forest Reserves
Mangrove Swamps & Tidal Areas
Sandhills, Sandy Beaches & Low Scrub
Collieries
A Sheep
B Beef Cattle
C Dairy Cattle
D Horses
H Pigs
P Poultry
Hunter R.
Dalwood
BRANXTON
GRETA
Lochinvar
MAITL
Pokolbin
ABERMAIN
KURR
CESSNOCK
Paxton
Wollombi Brook
MORISSET
Department of Main Roads
Survey March 1948


Williams R.
PATERSON
SEAHAM
RAYMOND TERRACE
Tomago
Williamtown
PORT STEPHENS
Nelson's Bay
PACIFIC OCEAN
NEWCASTLE
Redhead
Awaba
Wangi
LAKE MACQUARIE
NEWCASTLE REGION
LAND USE
SCALE 0 4 8 12 16 MILES

The latter are characterised by mud flats, mangrove swamps and reedy marshes subject to regular salt water inundation.

B. Land Developed for Forestry and Sparse Pasturage.

(i) *State Forests and Forest Reserves.*—The State Forests and Forests Reserves of the Newcastle Region are timbered areas totalling approximately 80,000 acres, mainly of mixed hardwood forest, which have been set aside solely for forestry purposes under the administration of the New South Wales Forestry Commission.

(ii) *Treed Land—Timber Getting and Sparse Grazing.*—"Treed land" refers to areas other than "State Forests and Forest Reserves" in which a natural tree cover dominates the appearance of the landscape. Partial clearing of trees has taken place in many of these areas, but no substantial grass cover become established.

C. Land Developed for Grazing Purposes.

(i) *Cleared or Partly Cleared Pasture.*—The cleared and partly cleared pastures of the Newcastle Region are represented by areas, previously tree covered, which have been fully or partially cleared in the course of pastoral development and are now used primarily for the grazing of dairy cattle.

(ii) *Swampy Pasture.*—Along the lower courses of the Hunter River and its tributaries, usually forming the outer limit of the alluvial flood plain, and in the low lying areas of the Tomago-Grahamstown district are groups of fresh water and brackish swamps which support sufficient grass cover to be classed as pastures. These have been classified as "Swampy Pastures" and are used for the summer grazing of dairy cattle and horses.

D. Cultivated Land.

(i) *Market Gardening.*—Areas devoted to the intensive cultivation of vegetable crops occupy approximately 2,400 acres of the most fertile portions of grey alluvial sandy silts in the Maitland district, and are characterised by small area farms (10-30 acres) growing a variety of crops.

(ii) *Fodder Cultivation and Dairying.*—Fodder cultivation, carried on in conjunction with the dairying industry, is the most important agricultural activity of the Newcastle Region, returns for 1939-40 showing 23,711 acres under cultivation for fodders.

Farms of 20-30 acres on the rich alluvial flats adjoining the Hunter River devote 90 per cent. of their area to lucerne, the remaining 10 per cent. being taken up by maize, oats, sorghum, millet and vegetables.

(iii) *Orchards and Vineyards.*—Horticulture and viticulture are practised in scattered areas throughout the west and south-east of the Newcastle Region, the major producing areas being in the Pokolbin district for vines and along the shores of Lake Macquarie for citrus and stone fruits. The total area under orchards and vineyards for the year 1939-40 was 2,368 acres, of which 1,308 acres were in vines, and 1,060 acres in orchard fruits.

E. Land Developed for Mining.

Coal mining is one of the most important industries of the Newcastle Region, annual production being two-thirds of the State's total. Collieries are located in three fields; the Newcastle, East Maitland and Maitland-Cessnock fields, which correspond to the Upper Coal Measures, Newcastle Stage, the Upper Coal Measures, Tomago Stage, and the Lower or Greta Coal Measures, respectively.

The location of individual colliery pit heads in the Newcastle Region is indicated in the land use map.

F. Urban Land.

The cities and towns of the Newcastle Region function as focal points of industrial, commercial and administrative activity. The most significant feature of urban land uses in the Newcastle Region is the high degree of industrial development in the City of Newcastle.

Tenders Accepted.

The following Tenders (exceeding £1,000) were accepted by the Department during the months of January February and March, 1949.

Council.	Road No.	Work.	Tenderer.	Amount.
				£ s. d.
Broken Hill District.	81	Resheeting with gravel 2 m. 1,042 ft. and 8 m. 915 ft. Ripping, loading, haulage and delivery of about 3,800 cubic yards of gravel.	Messrs. Lance Farrant & Co.	1,187 12 0
Hume S.	20	Surfacing sections, 1.95 m.—8.51 m. ; 8.51 m.—12.26 m., and 25.81 m.—28.81 m.	Chesterfield & Jenkins (Qld.) Pty. Ltd.	2,192 3 5
Namoi S. ...	17	Construction of timber beam bridge over Tunmallallee Creek.	A. Gam	3,561 19 6

Tenders accepted by Councils on page 127.

Cost Estimating for Road Construction

Cost estimating is the process of computing costs of work before the money is spent. A systematic approach is essential if the estimate is to be sufficiently accurate to fulfil its proper functions. Strict accuracy is not practicable, but the more accurate the details on which the estimate is based, the more accurate will be the total estimated cost.

A sound estimate should represent the lowest possible cost of completing the particular project under the conditions likely to prevail on the work when using the equipment and personnel available to the construction authority. If, however, the equipment available is not the most suitable, then it is essential to ascertain by preparation of a second estimate, the expected cost when using the most suitable equipment. Whether it is more economical to purchase extra equipment or more suitable equipment for the project will depend principally on:—

(*a*) The estimated resultant savings for the particular project concerned.

(*b*) The duration of the project and/or future projects for which the equipment can be effectively used as compared with its expected life.

Functions of Estimates of Cost.

An estimate of cost has several purposes beyond the actual predetermination of the cost. It is a fundamental part of any management and efficiency control system.

The main purposes of estimates are:—

(*a*) *Budgetary Purposes.*—Budgeting for expenditure is making a planned forecast of the funds required for projected works during a specific period, *e.g.*, a financial year. Sound estimates are a prerequisite for proper budgeting for expenditure and for the control of expenditure of available revenues to best advantage.

Unreliable estimating must result in an unreliable budget, possibly of little use. Overestimation on a large programme of works ties up funds unnecessarily, and where funds available are limited, delays commencement of new essential projects.

Estimates for budgetary purposes are often prepared on an approximate basis, if full information is not available at the time. In such instances the final budget is compiled as soon as the detailed estimates are completed.

(*b*) *Efficiency Control Purposes.*—A sound estimate establishes a measure of control prior to expenditure commencing. It enables attention to be focused on high-cost items of the project and often results in substantial savings by discovery of ways and means of reducing costs before work commences. It may indicate the need for time and method studies with a view to reducing costs. It serves as a means to judge the efficiency of operations during progress and on completion of a project. Viewed in this light the estimate is one of several effective instruments of cost control.

A sound estimate is also necessary for proper determination of the economy of contract compared with execution of a work by day-labour. An unsound estimate may result in an unsound decision in favour of one or either methods of execution.

To be sound, an estimate must be based on reliable output or production standards and costs for construction equipment and labour groups, or on previous unit costs of similar work carried out at satisfactory output standards.

Estimating Standards and Average Unit Costs.

Unit cost standards, plant and manual labour group output standards, and average unit costs are necessary prerequisites for use in preparing different types of estimates, dependent on the purpose for which the estimate is to be used.

(*a*) *Estimating Standards.*—"Standard" according to Webster's Collegiate Dictionary is that which is set up and established by authority as a rule for the measure of quantity. . . . value of. . . .

For an estimate to provide a measure of control prior to work commencing, it needs to be based on soundly established production and unit cost standards. The control can only be as effective as the standards used in estimating. The unit cost standards and the output standards may be described as the unit cost rates and outputs established by the construction authority for the purpose of estimating the cost of completing a particular project at the lowest possible cost. Unit cost standards to be satisfactory must be based on most efficient performance of plant and manual labour groups and, therefore, this type of standard is the expression of efficient production in a monetary form.

Cost estimating standards can be of different types. They may be based on the maximum performance possible of attainment when working under ideal conditions. Owing to the varying conditions associated with road construction works the road construction authority, when establishing such standards for efficiency yardstick purposes, should base the standards on the highest degree of efficiency practicable of accom-

plishment when working under *average* conditions with the plant and labour available for the project. However, under post-war conditions of working, when delays above normal are often experienced in repairing plant, due to shortages of skilled labour, shortage of spare parts, etc., the probable expenditure on the project may be greater than the total of the estimate prepared for efficiency control purposes, and where this is expected, additional funds provision should be made in the budget to cover the anticipated extra cost.

Output and average unit cost standards are determined from field studies and records of projects previously completed, *e.g.*:—

(i) Time and method studies of the performance of plant units and manual labour groups.

(ii) Analyses of road plant returns covering operations of bulldozers, tractors and scoops, graders, sprayers, quarry and stone-crushing plants, bituminous hot mix plants, rock drilling equipment, etc.

(iii) Job cost statements.

In establishing standards for particularly the main item of work, earthworks, a number of different standards of the same type (unit costs and outputs) are necessary to provide for (*a*) various types of earthwork materials, *e.g.*, earth, shale, granite, and (*b*) for the different methods of execution employed in carrying out the operations of preliminary loosening, excavating, transport of these materials to the dumping points and consolidation of embankments. For example, the following schedule of earthwork operations shows some of the different methods and types of materials for which separates standards need to be established:—

Operations.	Different Methods or Means of Execution.	Different Types of Earthwork Materials.
(*a*) Preliminary loosening prior to excavation and removal.	By ..... tractor and power ripper	(i) Earth and soft shale.
	,, ,, ...	(ii) Medium hard shale.
	By two jackhammer compressor and tungsten carbide tipped drills for drilling and blasting	(iii) Hard shale. (iv) Hard granite.
(*b*) Excavation	By ..... cu. yd. power shovel	(i) Hard shale.
	,, ,, ...	(ii) Hard granite.
(*c*) Transport of excavated material from shovel to dumping point.	By ..... cu. yd. motor lorries Lead 1,500'—2,000 lin. feet.	(i) Hard shale and granite.
(*d*) Excavation and removal to dumping point.	By ..... bulldozer lead 100—200 lin. ft.... ...	(i) Hard shale and granite.
	By ..... tractor and ..... cu. yd. carry-all scoop 300'—500' l. ft. 500'—700' l. ft.	(i) Earth, soft and medium shale.

For the earthwork operation of preliminary loosening shown in the schedule, there would need to be separate unit cost standards (*e.g.*, pence per cubic yard) and output standards (cubic yards per hour) for loosening in (i) earth and soft shale, (ii) medium hard shale, (iii) hard shale, (iv) hard granite.

(*b*) *Average Unit Costs.*—Average actual unit costs would be representative of the costs of a particular item of work of one or more operations connected with the carrying out of a particular item of work of similar nature. Where average costs represent the lowest possible costs when using most efficient equipment and personnel available to the construction authority they become "standards" for all practical purposes. However, danger lies in the fact that average unit costs, which are not the lowest possible cost, may when used in preparing estimates for efficiency control purposes, provide a false picture with all its undesirable features.

Variables in Civil Engineering Works.

In common with most classes of civil engineering works many variables are present in road construction works, and on this account it is not practicable in an article of this size to provide estimating data that would encompass all conditions. For example, type and quantity of material and length of haul are basic variables met with in earthworks, and principally for this reason unit rates are omitted in Appendix No. 2 where the process of building up an estimate is detailed. These variables affect the selection of equipment for the particular tasks and consequently the estimate of cost.

Selection of Headings for Estimating and Costing Purposes.

Uniformity in selection of estimate headings for different classes of work involved in construction of a road is essential for internal regulation of estimating and costing procedures. Uniformity increases the volume of dependable statistics for managerial uses.

Uniformity in headings is also necessary for the purpose of enabling ready comparisons to be made between estimated and actual quantities (volume) and costs, on what is called the "principle of exceptions." Under this principle, managerial attention as to the cause and controllability of the variation from the estimate is centred on those operations or items of work where variations are of sufficient magnitude to warrant attention. Where a large variation occurs it should be possible to analyse it and to determine the reason for the variation.

Estimates should, except where a flat overall rate covering a series of operations is used, be made or built up in the form of separate sub-headings covering the operations constituting the work represented by a main heading, and be so selected that it is practicable to keep reasonably accurate costs under each sub-heading or a combination of these headings.

The Department of Main Roads has a standard set of main estimate headings for use in estimating and costing of road construction as well as for other classes of works, such as bridge construction, bituminous surfacing, etc. Appendix No. 1 gives the estimate headings used for road construction works. As many sub-headings as necessary can be used in building up the unit cost of a major item of work, such as Item 18, Earthworks; Item 26, Base Course; and Item 27, Surface Course. Details of sub-headings need to be set out on a subsidiary statement attached to the Estimate of Costs. (For details of sub-headings, see Appendix 2.)

The items which constitute the total cost of a project may conveniently be divided into two groups in framing estimates of cost, viz.:—

(*a*) Direct work items, comprising the various types of work involved in actual construction of a road, such as clearing and grubbing, earthworks, drainage structures, pavement, fencing, etc.

(*b*) Items of expense incidental to the work, *e.g.*, transfer of construction organisation to site of work, establishment of camp and dismantling on completion, establishment of depot and dismantling on completion, camp and depot maintenance, workers' compensation insurance, pay-roll tax, engineering and clerical supervision expenses, etc. Such items are classed as Indirect Expense, or sometimes "Job On-Cost."

Different Types of Estimates.

Estimates may be divided into the following three types: (*a*) Preliminary estimates, (*b*) detailed estimates, and (*c*) estimates of the probable final cost.

(*a*) *Preliminary Estimates.*—Estimates of this type are usually required for the purpose of considering the approximate financial requirements of a proposed programme of construction works, and for the purpose of making a provisional allocation of funds for the works selected. Preliminary estimates are not prepared in the same detail as final detailed estimates, for at the time of their preparation, drawings for the purpose of ascertaining quantities of work items may not be available. However, in order to ensure that there will not be any great disparity between the preliminary and final detailed estimate, an endeavour must be made to ascertain approximately the quantities involved in the major items of work.

In addition, unit cost must be based on satisfactory unit costs of similar work carried out elsewhere under similar conditions. Reference should be made in the report accompanying the estimate as to the project or projects used as the basis for determining the estimated unit rates. This reference is essential, particularly for preliminary estimates, as the means available for checking this type of estimate are limited. The estimate form given in Appendix No. 1 is suitable for use in preparing preliminary estimates. In this case the subsidiary details sheet (Appendix No. 2) is not used.

(*b*) *Detailed Estimates.*—As the title implies this type of estimate is prepared in considerable detail for all except small works.

The detailed estimate is prepared after completion of the drawings and should, as previously mentioned, represent the lowest possible cost of completing a project under the conditions likely to prevail on the work when using the most efficient types of equipment and personnel available to the construction authority. This estimate is a yardstick for comparison with actual costs and is shown on the periodical cost statements for that purpose. Detailed estimates may be required at two stages for the larger construction projects —first, before the project is commenced, at which stage plant and equipment to be used have not been finally determined, and, second, when plant, equipment and labour have been assembled and work actually commenced.

The estimate of cost form given in Appendix No. 1, supported by the subsidiary details sheet (Appendix No. 2) is used in the preparation of final detailed estimates.

(*c*) *Estimates of the Probable Final Cost.*—Estimates of this type are used to provide a close prediction of the amount of the final cost of a project. An estimate of the probable final cost is prepared when work on a project has advanced to such a stage that unit costs of the completed work are sufficiently representative of the probable final unit costs to enable the estimate to be satisfactorily prepared. This is usually when a project is 75-80 per cent. completed. An estimate of this type is used mainly for the purpose of reviewing the funds requirements of a project, increasing or decreasing the amount already allocated as considered necessary.

A statement arranged on the following lines provides information as to probable final cost in a form that can be more readily checked.

Item No.	Estimate Headings.	Unit.	Actual Costs to— Qty.	Rate.	Amt. nearest £	Estimated Cost to Complete. Qty.	Rate.	Amt. nearest £	*Estimated Credits on Completion for Residual Values. £	Estimate of Probable Final Cost. £

* In this column would be shown against the particular item concerned the estimated residual values on completion of the project, *e.g.*, tents, camp and depot buildings, loose tools, etc., to be transferred elsewhere.

Prerequisites for Sound Cost Estimating.

The main necessary prerequisites of sound cost estimating may be expressed as follows:—

(1) Complete drawings, specifications and accurate quantities of the various classes of work to be undertaken in the construction of a road, *e.g.*, acres of clearing and grubbing, cubic yards of earthworks, etc.

(2) Information as to types and quantities of material expected to be encountered in earthworks. Types of earthworks are obtainable by prickings, borings and test pits. This information, coupled with particulars of quantities to be excavated and moved to fills, is essential also for arriving at the most suitable plant and labour groups for carrying out the work.

(3) Proposed sources of materials for use in construction of base course and surface course of the pavement. Sources of supply for other materials, such as fencing posts, steel reinforcement, cement, reinforced concrete pipes, bituminous binders, etc.

(4) Particulars of the type of plant and equipment and the labour groups required and available to carry out the work efficiently.

(5) Conversion factors for rock and earth of various types in pit, when loose, and when consolidated in bank.

(6) Details of proposed location or locations and number of camps and local depots to be established, number of tents, particulars of and size of camp and depot buildings.

(7) Details as to proposed arrangements for supplying camp and depot with provisions and water.

(8) Particulars of engineering and clerical staff required and available for the work.

(9) Classes of works for which minor contracts are proposed to be let.

(10) Anticipated time required to complete the project.

(11) A good costing system to record and provide unit costs, plant operating costs and output records of previous works for use in preparing estimates for new works and for other purposes. Unit costs of completed works should be recorded to show separately the cost of labour, materials, plant, haulage and total. Corrective percentages may be readily applied to each of these elements when necessary, so that costs of past works can be revised up to any desired date for variations in wages rates, materials prices and plant and haulage rates, that may have taken place since the works were carried out.

(12) Sound estimating standards covering outputs and costs for the various items of plant and manual labour groups used on road construction projects. These standards are established by analysing the outputs and costs of operations involved in carrying out previous projects.

(13) Copies of awards, award variations, plant hire and haulage rate schedules. Records of prices of the principal materials and stores used in construction of roads, such as coarse aggregates, tar, bitumen, cement, steel reinforcement, petrol, diesel fuel oil, etc. All records to be filed so that rates or prices for any particular item at any particular time can be readily ascertained. These records, as well as providing data for estimating purposes, are also required for the purpose of arriving at the corrective percentages referred to under paragraph No. 11.

Procedure Followed in Preparing Estimates of Cost for the Main Items.

Three different methods of estimating the cost of the main items of work involved in construction of a road may be used, viz.: (*a*) the overall average unit cost method covering a series of operations, (*b*) the operations—standard unit cost method, and (*c*) the production method.

(*a*) *Overall Unit Cost Method.*—This method is used in preparing preliminary estimates for projects of all sizes and also, in general, for final estimates for minor works. Under this method, the whole series of operations, for example, loosening, excavating, etc., involved in carrying out earthworks would be estimated at ..... cubic yards @ ..... per cubic yard = £....., without subdivision of the estimated cost into operations and methods of execution, etc., as is done when estimating the cost by methods (*b*) and (*c*).

In order that the overall rate can be checked, it should be supported by all possible information bearing on the cost, and which should be considered in arriving at the estimated rate, *e.g.*:—

(i) *Earthworks.*—The nature of materials expected to be met with in excavation, whether preliminary loosening is expected to be required, expected approximate quantities and average leads from excavation to dumping point, plant, etc., assumed in arriving at overall average unit rate for this item.

(ii) *Pavement (Gravel).*—Source of gravel supply, average length of haul from gravel pit to roadway, method of loading at gravel pit, etc., assumed in estimating the cost of this item of work.

(*b*) *Operations—Standard Unit Cost Method of Estimating.*—This method is used in preparing detailed estimates for all works whether to be carried out by either day labour or contract working, except minor construction projects.

In the case of major day labour projects this method is, in general, only used when

preparing detailed estimates in advance of commencement of construction at a time when particulars of plant and manual labour groups to be employed are not fully known. As soon as possible after commencement of a major day labour project the estimate prepared earlier on the operations—standard unit cost method—should be superseded by a final detailed estimate prepared on the production method of estimating, based on plant and men actually supplied or available for the project, as outlined under (*c*).

Under this method of cost estimating the main items of work involved in carrying out a project are estimated by separate operations using the unit cost standard rate established for the particular method expected to be employed for the operation. For example, earthworks.

Operation.	Method of Execution.	Type of Material.	Qty. Cubic Yard Solid Measurement.	Standard Unit Cost Rate.	Amt. nearest £
(1) Preliminary loosening prior to excavation.	(i) By D8 tractor and power controlled ripper.	Hard earth.	10,000	4d.	167
	,, ,, ...	Medium hard shale.	38,000	8d.	1,267
	(ii) Two jackhammer compressor and carbide tungsten tipped drills (drilling and blasting).	Hard shale.	40,000	6/-	12,000
		Hard granite.	10,000	14/-	7,000

An outline of the procedure for estimating the cost of all operations connected with earthworks execution by the unit cost method is shown under Item No. 18, Appendix No. 2.

Where materials form a considerable part of the total cost (*e.g.*, concrete pipe culverts, concrete box culverts) of an item of work, the approach to estimating the direct cost should be on the basis of separating materials costs from operations costs, *e.g.*:—

(*a*) Materials landed on site

(detailed as necessary) £

(*b*) Operations cost covering labour and equipment involved in putting (*a*) into place

(detailed as necessary) £

As materials costs on site can usually be closely estimated, the separation makes for a closer combined estimated cost for (*a*) and (*b*) than is usually possible when estimating on a flat overall unit cost basis covering materials and operations costs.

The operations—standard unit cost method of estimating is reasonably satisfactory provided the unit rates used are based on representative costs (suitably corrected if necessary) of similar work carried out efficiently with suitable plant units and manual labour groups.

Appendix No. 2 gives an outline of an estimate prepared on the operations, standard unit cost method of estimating.

(*c*) *Production Standards Method of Estimating.*—Under this method, estimating the cost is by operations, using output standards (cubic yards per plant hour, per man hour, etc.) and standard operating costs per hour established for the plant units and manual labour groups expected to be used in carrying out these operations. The cost per hour of operating plant is largely fixed for any given set of conditions and output and unit cost is in consequence dependent directly on rate of output. Appendix No. 3 shows a type of schedule suitable for use in preparing estimates for earthworks under this method. The production standards method is used in preparing final detailed estimates for the larger road construction works being carried out with day labour forces. The estimate is prepared as early as possible after commencement of work on a project at a time when it is practicable to analyse the organisation in detail in the light of men and plant actually engaged or available. The estimate can thus be based on the actual organisation established.

The method of estimating on production has the merit that when based on sound production standards, the estimated cost is representative of the performance of a proper degree of efficiency in carrying out operations. It provides greater managerial and costing control than is possible under (*a*) and (*b*) bases of estimating due to the fact that the estimate of cost is based on proper production standards for the plant and manual labour groups actually in use on the work. The output actually achieved per plant unit and manual labour group and their costs can therefore be compared directly with the output and costs adopted for each particular plant and manual labour group in preparing the estimate.

In preparing an estimate on the production basis, it is necessary first to determine the various tasks to be carried out, and then to fit the most suitable available types of plant, manual labour groups, etc., to these tasks. This determination can be undertaken by preparation of diagram and organisation schedule to show in respect of each major item of work (earthworks, pavement, etc.), the quantities and types of work involved and the plant units and manual labour groups proposed to be used for the various operations. The mass diagram on the road drawings and longitudinal section sheet of road drawings can be used for this purpose, on somewhat similar lines to the analysis for grading operations given in Fig. 63 of American Highway Practice, Vol. 1, by L. I. Hewes.

Preliminary
Final Detailed
Probable Final Cost

APPENDIX No. 1.

ESTIMATE OF COST

Council .....

Road No. ..... Classification ..... Name ..... Section .....

Pavement Width ..... Description of Work .....

Item No.	Description.	Unit.	Quantity.	Rate.	£	s.	d.
1	Provision for traffic	item					
2	Clearing and grubbing	acre					
3	Boundary fencing, post and wire	100 lin. ft.					
4	,, ,, (rabbit-proof) ...	,,					
5	,, ,, rail	,,					
6	,, removal and re-erection	,,					
7	Gates	each					
8	Concrete pipe culverts (including excavation and back-filling)	lin. ft.					
9	Concrete headwalls and inlet sumps for pipe culverts, including reinforcement	cub. yd.					
10	Excavation, etc., for box culverts	,,					
11	Concrete in box culverts	,,					
12	Reinforcement in box culverts	cwt.					
13	Wearing surface on box culvert deck	sq. yd.					
14	Pipe hand-railing, complete	lin. ft.					
15	Catch drains	100 lin. ft.					
16	Catch drain pitching	,,					
17	Rubble retaining walls	cub. yd.					
18	Earthworks (excavation and borrow)	,,					
19	Trimming and consolidating subgrade and shoulders	100 lin. ft.					
20	Earth formation type.....	,,					
21	,, ,, ...	,,					
22	Scarifying, re-forming and rolling	,,					
23	Table drain pitching	,,					
24	Sub-soil drains	,,					
25	Shoulder drains	each					
26	Base course type..... ..... ins. thick ...						
	Unit cost for complete	sq. yd.					
27	Surface course type..... ..... ins. thick ...						
	Unit cost for complete	sq. yd.					
28	Gravel for maintenance	cub. yd.					
29	Broken stone for maintenance	,,					
30	Screenings for maintenance	,,					
31	Fender posts at culverts	each					
32	Protection fencing (chain wire)	100 lin. ft.					
33	Protection fencing (ordnance type)	,,					
34	Maintenance of works	item					

		£
	TOTAL DIRECT CHARGES	
	INDIRECT EXPENSE OR LOCAL OFFICE ON-COST—	
35	Camp Establishment and Dismantling for.....men ... ...Item	
36	Camp Water Supply (only required if in excess of £200, otherwise include in Item No. 35) Item	
37	Depot Establishment and Dismantling for duration.....weeks ... ...Item	
38	Depot and Camp Maintenance for.....weeks ... ...Item	
39	Camping Allowance, fares, etc., for average.....men for.....weeks ... ...Item	
40	Holidays, Statutory, Annual, Short, Long Service, and Sick Leave @.....% on Gross Wages £..... ... ...Item (Sick Leave to be costed as separate Item.)	
41	Workmens Compensation Insurance ... @.....% on Gross Wages £..... Item	
42	Pay Roll Tax ... ... @.....% ,, ,, £..... Item	
43	Miscellaneous Charges ... ... @.....% ,, ,, £..... Item	
44	Engineering (No.....) and Clerical (No.....) Supervision ... ...Item	
45	Transfer of organisation to site of work ... ...Item (Total for Local Office On-Cost £..... = ...% of Direct Charges.)	
	SUB-TOTAL ESTIMATED COST	£
46	Public Utility Adjustments (Itemise)	
47	Property Resumptions	
	GRAND TOTAL ESTIMATED COST	£

APPENDIX No. 2.

DETAILS SHEET. To accompany Estimate of Cost.

Work : Road No..... Name..... Section.....

Estimated duration of work from start to finish.....weeks.

Estimate based on commencement between.....19..... and.....19

Item No.

1 *Provision for traffic.*—The nature of work required to be carried out varies considerably according to location of work requirements of traffic, etc., and each case needs to be dealt with on its merits.

	£
Watchmen for lamp lighting, etc., ... man weeks @ £..... per week	
Provision of traffic barriers, lamps, lighting and fuel ... ... Bulk sum	
Total ... £	

2 *Clearing and grubbing.*—

	Acres.
Brush and second growth 50% of total area	
Trees 6″—12″ dia. at butt 35 trees per acre	
15″—20″ „ „ 10 „ „	
Total area ...	

The method to be adopted on any particular job for these operations is dependent chiefly upon the size and density of the trees and the plant available to carry out the work. The principal methods used are by 'dozer, by tractors and ropes, by block and tackle or monkey grubber, by explosives or by a combination of one or more of the above methods.

Where extensive clearing is involved, a detailed examination of the country to be cleared should be made. The nature, size and density of the trees should be ascertained as the basis for determination of the method of clearing to be adopted and the plant to be used.

Where the unit cost basis of estimating is used, it is essential that actual unit costs are available for similar clearing and grubbing carried out efficiently by methods similar to those proposed for the work now to be undertaken. For this basis of estimating previous suitable unit costs are brought up to date by the use of corrective percentages applied to the various cost elements, as follows :—

	Per Acre.				
	Labour.	Mtls.	Plant.	Haulage.	Total.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Actual unit cost for ..... acres of similar clearing and grubbing carried out on M.R. No. ....., Section ....., between February and May, 1946					
Add for calculated percentage increases in Labour (.....%), Materials (.....%), Plant (.....%), Haulage (.....%), which have taken place since February May, 1946					
Total, being previous cost per acre brought up to present-day levels for use as a basis for estimating					

Total estimated cost for ..... acres = ... acres × £..... per acre ... ... £.....

3 *Boundary fencing*, post and wire—quantity ..... linear feet :—

	£
(*a*) Materials on site—	
Supply fencing posts, etc., F.O. Rail at	
No. ..... posts @ ..... each	
Rail freight to	
Haulage from railside to site of work ..... average haul ..... miles	
Supply ..... gauge wire ..... tons F.O.R.	
Rail freight to	
Road haulage from railside to site of work	
(*b*) Labour—Digging holes, erecting posts and attaching wires :—	
..... lin. ft. @ ..... per 100 lin. ft.	
(*c*) Lorry haulage—2-ton lorry hired at hourly plus mileage rates in connection with erection work—	
..... hours @ ..... per hour	
..... miles @ ..... per mile	
Total	
Unit cost per 100 lin. ft.	

APPENDIX No. 2—*continued.*

Item No.

4 *Boundary fencing* (rabbit proof) ... ... } On similar lines
5 ,, ,, post and rail ... ... } to
6 ,, ,, removal and re-erection ... ... } Item No. 3.

8 *Concrete pipe culverts*, including excavation and backfilling :—

Dia. of pipe	12"	15"	18"	21"	24"	30"
Item No.	8a	8b	8c	8d	8e	8f
(*a*) Materials : Cost F.O.R. ..... per lin. ft.						
Rail freight per lin. ft.						
Road haul from rail to job, ... miles, per lin. ft.... ...						
Total cost on roadside per lin. ft. ...						
(*b*) Excavation, laying, jointing and backfilling, per lin. ft.						
Total cost for (*a*) and (*b*), per lin. ft. ...						
Total quantity each size, lin. ft.... ...						
Total estimated cost each size ... ...£						

Operations connected with installation of concrete pipe culverts vary considerably and it is essential for estimating purposes to establish a table of typical actual costs covering total costs of (*a*) and (*b*) and man-hour outputs per linear foot covering operations (*b*). The man-hour outputs per linear foot for the various sizes are the most satisfactory figures to use, as wage rates expected at the time work is carried out can easily be applied to outputs to obtain up-to-date estimated costs. Actual costs, on the other hand, require the use of a corrective percentage to bring costs up to date, and thus is a more involved procedure. There should be on hand a record of approximate weights (lb. per lin. ft.) and approximate number of linear feet per ton for each size pipe in order that freight and haulage costs can be readily estimated.

11 *Concrete in box culverts.*—Where the estimated cost does not exceed, say, £1,000, a flat rate per cubic yard, based on costs of previous structures built under similar circumstances, corrected for subsequent variations in wage rates, materials prices, etc., will suffice. For example :—

	Per cu. yd. £ s. d.
Average costs of concrete in box culverts carried out on Main Road No. ..... between May and November, 1945	
Add calculated cost rises since then	
Total per cubic yard	

Total estimated cost ..... cu. yds. = £..... per cu. yd. @ £.....

(For larger structures, estimates in greater detail are necessary, dividing the estimate into (*a*) Materials on site (timber, cement, coarse aggregates, fine aggregates, steel reinforcement, etc.) and (*b*) Operations costs, under such headings as Falsework, Formwork, Mix and Place Concrete, place Steel Reinforcement, etc.)

	Per ton. £ s. d.
12 *Reinforcement in box culverts.* Quantity ..... tons (or cwts.)—	
(*a*) Materials on site. Estimated cost F.O.R. at	
Rail freight to ....., ... miles	
Road haul to job ..... miles	
Total unit cost for (*a*)	
(*b*) Bending (if any) on job	
(*c*) Placing	
Total estimated unit cost (*a*), (*b*) and (*c*)	
Total estimated cost (*a*), (*b*) and (*c*) for ..... tons (or cwts.)	

15 *Catch drains.*—A previous actual cost corrected for rises in wage rates and plant rates will generally be found suitable for estimating this item, separating earth and rock material where the latter is extensive, *e.g.* :—

	£ s. d.
(*a*) 5,000 lin. ft. hard sandstone rock @ ..... per 100 lin. ft.	
(*b*) 10,000 lin. ft. in earth @ ..... per 100 lin. ft.	
15,000	

The methods of execution allowed for in estimates for both classes of materials should be stated,

APPENDIX No. 2—*continued.*

Cu. yds. Solid Measurement.

Item No.

18 *Earthworks.*

Estimated quantities: (*a*) Earth ... ...
(*b*) Rock ... ...

Totals (*a*) and (*b*) ... ...

(*a*) *Earth*— £

(1) Loosening by ..... tractor and ripper ..... cu. yds. @ ..... per cu. yd.... ... ...
(..... cu. yds. estimated not to require loosening.)

(2) Excavating and removal to embankments—
(i) By ..... tractor and 'dozer. Lead up to 300 ft., ... cu. yds. @ ..... per cu. yd.
(ii) By two ..... tractors and 8 cu. yd. carryall scoops—
Lead 300'— 500' ..... cu. yds. @ ..... per cu. yd. ... ...
500'— 800' ..... cu. yds. @ ..... per cu. yd. ... ...
1,000'—1,200' ..... cu. yds. @ ..... per cu. yd. ... ...

(3) Battering sides cuttings by heavy duty motor grader ..... lin. ft. of cuttings @ ..... per 100 lin. ft. ... ...

Total estimated cost for Earth (1), (2) and (3) ... ...

Total estimated unit cost for Earth (1), (2) and (3) per cu. yd. solid measurement ... ...

(*b*) *Rock*— £

(1) Loosening by ..... tractor and ripper—
Material, *e.g.*, soft shale ..... cu. yds. @ ..... per cu. yd. ... ...
Loosening by drilling and blasting ..... compressor, 2 jackhammers, drills, tungsten carbide tipped. Material, *e.g.*, hard granite—
Depth of cuts 5'—10' ..... cu. yds. @ ..... per cu. yd. ... ...
... ,, ,, 10'—15' ..... cu. yds. @ ..... per cu. yd. ... ...

(2) Excavation and removal to fill—
(i) By ..... tractor and ..... cu. yd. scoop. Lead 300'—600' ..... cu. yds. @ ..... per cu. yd. ... ...
Material, *e.g.*, soft shale.
(ii) By ..... tractor and 'dozer. Lead 100'—600' ..... cu. yds. @ ..... per cu. yd.
Material, *e.g.*, hard granite.
(iii) By ..... cu. yd. power shovel. Load by shovel ..... cu. yds. @ ..... per cu. yd.
Haulage and tip by 4-ton lorries ..... cu. yds. @ ..... per cu. yd. ... ...
average lead ..... lin. ft. ... ...
Spread by 'dozer ..... cu. yds. @ ..... per cu. yd. ... ...
Material, *e.g.*, hard granite.

(3) Labour—Miscellaneous labour engaged on battering rough sides of rock cuttings that cannot be handled by plant. Four men for ..... weeks ..... man weeks @ ..... per week ...

Total estimated cost for Rock (Total of (1), (2) and (3)) ... ...
Total estimated unit cost for Rock (1), (2) and (3) per cubic yard solid measurement ...

(*c*) Compaction where carried out as a separate operation by ..... tractor and sheepsfoot roller ..... hours @ ..... per hour ... ...

Grand total estimated cost earthworks (*a*), (*b*) and (*c*) ... ...

Average unit cost all earthwork (rock and earth) per cu. yd. solid measurement ... ...

26 *Base course, e.g.*, gravel ..... inches consolidated thickness. Sources of supply for material—

(*a*) New pit to be established at ....., estimated quantity loose measurement, from this pit ..... cu. yds. ... ...
Average haul to roadway ..... lin. ft.

(*b*) New pit to be established at ....., estimated quantity loose measurement, from this pit ..... cu. yds. ... ...
Average haul to roadway ..... lin. ft.

Total qualtity ..... sq. yds. estimated equivalent pit measurement ..... cu. yds....

Method and Equipment—
Clearing site by ..... 'dozer.
Loosening material by ..... tractor with power ripper.
Excavation and loading material, *e.g.*, over loading platform ("Chinaman") by ..... cu. yd. carryall scoop into motor lorries. Haulage from pits to roadway b.y, *eg.*, 4-ton motor lorries with payment at piecework haulage rates.

Estimate— £
Clearing site "A," surface area ..... acres, light timber and brush @ £..... per acre ...
Clearing site "B," ,, ,, ,, ,, ,, ,, ...
Establishment and dismantling "Chinaman" at pit—"A" ... ... £..... ...
,, ,, ,, ,, ,, "B" ... ... £..... ...
... ,, ,, ,, ,, at pits "A," and "B"

APPENDIX No. 2—*continued.*

Item No. 26 Estimate for Base course—*continued.* £

Winning and loading at both pits, ... cu. yds. loose @ ..... per cu. yd. loose ... ...
Haulage, tipping and spreading—
..... cu. yds. pit "A" @ ..... per cu. yd. loose... ... ...
..... cu. yds. pit "B" @ ..... per cu. yd. loose... ... ...
Rolling and grading ..... sq. yds. @ ..... per sq. yd. ... ...
Watering ..... galls. @ ..... per gall. ... ...
Royalty ..... cu. yds. gravel @ ..... per cu. yd. ... ...

Total estimated cost... ...

Unit cost for base course, complete, ... per sq. yd.

27 *Surface course.*—As for Item 26, Base course.

35 *Camp establishment and dismantling on completion.*
(Each camp to be established should be estimated separately.)
First camp to be established at ..... estimated duration ..... weeks.
No. tents to be provided .....

£

(*a*) Clearing site (light brush) with 'dozer, ... acres @ ..... per acre ... ...

(*b*) *Tents*—

Materials per tent—	Estimated cost*. £ s. d.	Estimated residual value on completion of job. £ s. d.	Estimated cost chargeable to job. £ s. d.	£
Tent size ..... new				
Fly size ..... new				
Timber (boarded floors and frames)				
Stretcher				
Filling for mattress, etc.				

Total for materials per tent ... ...
Erection and dismantling per tent ... ...

Estimated total cost per tent erected ... ...

Estimated total cost for ..... tents.

* Where used tents are being partly used these would need to be dealt with separately from new tents.

NOTE.—A flat rate of £..... per tent is sometimes adopted for erection, dismantling, including supply of tent, fly and fittings, where conditions are such that this method of estimating can be relied upon.

(*c*) *Camp buildings.*

	Estimated cost. £ s. d.	Estimated residual value of materials on completion of job. £ s. d.	Estimated cost chargeable to job. £ s. d.	£
..... galleys, erection and dismantling on completion				
Messroom, erection, including lighting and fittings. Size ..... x ..... (Estimate on cost per sq.)				
Messroom, dismantling on completion of job				
Latrines, No. ....., erection and dismantling on completion				
And so on.				

Total estimated cost (*a*), (*b*), and (*c*) ... ...

Item No.

36 *Camp water supply.* £

(*a*) Establishment—

Set up of ..... inch pump plant at ..... Creek ..... miles from camp and depot site ...

Erection of ..... x ..... gall. tanks at camp ... ... *

(i) Supply of tanks ... ...

(ii) Erection of stands, including materials ... ...

Erection of ..... x ..... gall. tank at depot ... ... *

(i) Supply of tanks ... ...

(ii) Erection of stands, including material ... ...

* Estimate provides for new tanks with ..... % allowance for residual value at end of job.

(*b*) Running costs—

Hire of ..... inch pumping plant and engine for ..... weeks @ £..... per week ... ...

Lorry hire hauling water (..... trips per week), 1 x .....ton hired lorry on hourly plus mileage basis :—

	£ s. d.
Per week ..... hours @ ..... per hour	
..... hours @ ..... per mile	
Total per week	

Total for lorry hire for duration of job ..... weeks @ ..... per week ... ...

Hire of water tank for use on lorry ..... weeks @ ..... per week ... ...

Total estimated cost ... ... £

37 *Depot establishment and dismantling.* Each depot to be established to be estimated and costed separately. £

Depot to be established at chainage .....

Estimated duration required ..... weeks.

Clearing depot site by 'dozer (light brush) ..... acres @ £..... per acre ... ...

Construction access and internal roads ..... lin. ft. @ £..... per 100 lin. ft. ... ...

Construction depot drainage. Bulk sum ... ...

Erection and dismantling depot buildings, etc.—

	Estimated cost. £	Estimated residual value on completion. £	Estimated cost chargeable to job. £	£
Engineering and clerical office building. Size ..... x				
Main store building. Size ..... x				
Second-hand store building. Size ..... x				
Inflammable liquids store. Size ..... x				
Workshop. Size ..... x				
Blacksmith shop. Size ..... x				
Kitchen and staff mess. Size ..... x				

And so on.

Total estimated cost ... ...

Buildings to be estimated on basis of per sq. ft. of floor area.

38 **Depot and camp maintenance* for No. 1 camp established at ..... Estimated duration of maintenance ..... weeks.

	Estimated Cost per week. £ s. d.	£
Camp steward per week		
Depot man per week		
Watchman, casual, at week ends only (..... hours)		
Provisions for camp—		
1 x ..... ton hired truck and driver ..... trips per week to ....., average ..... hours and ..... miles per trip		
Firewood for camp—		
1 x ..... ton truck and ..... men for ..... hours and ..... miles per week		
Sundry labour cutting up firewood		
Saw bench and engine cutting up firewood		
Camp lighting, lighting set hire, and operation costs		
Sundries, garbage removal, repairs to camps and buildings, etc.		
Total estimated cost per week...		

Total estimated cost for ..... weeks ... ... £

*NOTE.—Where more than one camp is to be established the maintenance cost for each camp should be estimated and costed separately.

APPENDIX No. 2—*continued.*

Item No.

39 *Camping allowances and fares*, provided for under Awards.

..... men camping at rate of ..... shillings per man week. £

Total for ..... weeks .....

..... men, living at home and travelling to and from work at average fare ..... shillings per man week.

Total fares for ..... weeks .....

Total ... ...

40 *Holidays and leave* during estimated duration of work between ..... 19.... and ..... 19....

Holidays and leave can be estimated on the following lines :—

	Days per Man.
Statutory holidays. No. days for duration of period	
Annual holidays. Proportionate No. days for duration of period	
Sick leave. Estimated No. days for duration of period	
Short and long service leaves—Proportionate No. days for duration of period	
Total	

£

Estimated total cost for duration of work, for ..... men for ..... days, calculated at estimated average wages of £..... per week ... ...

41 *Workers' Compensation Insurance*

42 *Pay Roll Tax.*

Calculate estimated cost of these items on estimated gross wages expenditure for the project, using the flat insurance rate for Item 41 and the Statutory rate (at present 2½%) for Item No. 42, *e.g.* : £

Workers' Compensation Insurance @ .....% on estimated gross wages of £..... ... ...

Pay Roll Tax @ .....% on estimated gross wages of £..... ... ...

43 *Miscellaneous charges.*—Includes such items of expenditure as " General " freights and haulage, and blacksmiths' and tool-sharpeners' wages where it is not practicable to apportion such costs to direct work items ... £

Estimated cost .....%* on estimated gross wages of £..... ... ...

* Rate can be based on cost records for similar classes of works.

44 *Engineering and clerical supervision.*—Includes resident engineers', foremen's, cost clerks', timekeepers' salaries, including statutory holidays, leave, etc., motor transport used for supervision and timekeeping, officers' travelling expenses and allowances, office rent, telephone and lighting charges. The number and classifications of officers required varies with the size and composition of the works organisation and with the nature, duration and location of the project. For these reasons it is generally more satisfactory to estimate expenditure under this heading on an item by item basis, *e.g.* :—

	Estimated expenditure per week, including any allowances. £ s. d.
(*a*) Engineer Class	
(*b*) Assistant Engineer	
(*c*) Foreman	
(*d*) Cost Clerk	
(*e*) Time and Storekeeper	
Total per week	

£

Total (*a*) to (*e*) for estimated duration of ..... weeks £..... x ..... weeks ... ...

Utility truck ..... cwt. Allowing average weekly mileage of ..... the total mileage for duration of ..... weeks is ..... @ ..... per mile ... ...

Telephone, including rental. Bulk sum ... ...

Lighting ..... per week for ..... weeks ... ...

Total ... ...

NOTE.—Where more than one camp is to be established the maintenance cost for each camp should be estimated and costed separately.

APPENDIX No. 3.

Production Method of Estimating.

Outline of form of Schedule suitable for use in compiling estimated cost of earthworks.

Operation.	Method of execution.	Type of material.	Quantity cubic yards solid measurement.	Length of haul, lin. ft.	Production standard rate cu. yds./per hr. while actually loosening, excavating, etc.	Total estimated production hours while actually loosening, excavating, etc.	Idle time.		Total estimated time (hrs.) column (7) and Column (8).	*Plant comprehensive standard cost. per hour.	Total estimated cost.	Estimated unit cost per cubic yard.
							% of column (7).	hours.				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)		(9)	(10)	(11)	(12)
(i) Loosening	D7 tractor and power controlled ripper.	(i) Soft shale.	...	(Not involved)	...	...	...	...	...	...	...	...
		(ii) Earth	...	Do. ...	(No preliminary loosening required.)	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.
(ii) Excavation and haulage to dumping points.	By 2 x D7 tractors and 9 cu. yd. carryall scoops.	Earth and soft shale of good loading quality.	...	300–500	...	...	...	...	...	...	...	...
			...	500–700	...	...	...	...	...	...	...	...
			...	700–1000	...	...	...	...	...	...	...	...
Etc., etc.												

* Rate includes hire rate of plant unit, covering depreciation, repairs, interest, insurance, wages of operator, and all running costs (fuel, servicing, etc.) based on total available working hours.

To determine the total estimated production hours, Column (7) above, divide the total units or quantity of work involved, Column (4), by the standard hourly output rate, Column (6), established for the particular item of plant when working in each type of material, *e.g.*—

Loosening (i) above : $\frac{\text{Total quantity} \quad \text{cu. yds.}}{\text{Production on standard rate ... cu. yds. per hour}}$ = Total estimated plant hours.

Tenders Accepted.

The following Tenders (exceeding £1,000) were accepted by the respective Councils during the months of January, February and March, 1948.

Council.	Road No.	Work.	Tenderer.	Amount.
				£ s. d.
Abercrombie S. ...	54, 252	Resurfacing	B.H.P. By-Products Pty. Ltd.	1,541 8 5
Armidale C. ...	9, 74, 124	Supply and delivery to stockpiles of 1,777 cu. yds. of aggregate for bituminous seals.	Chesterfield & Jenkins (Qld.) Pty. Ltd.	2,487 7 6
Bellingen S. ...	76, 118, 378	Surfacing	B.H.P. By-Products Pty. Ltd.	5,324 19 1
Berrigan S. ...	331, 363	Heating and spraying binder, loading and spreading aggregate, sweeping and rolling.	Chesterfield & Jenkins (Qld.) Pty. Ltd.	1,342 10 0
Bland S.	6	Resurfacing	G. Broad	1,040 0 0
,, ...	7	Supply and delivery of gravel	,, ...	1,060 0 0
,, ...	6	Regravelling	I. N. Miller	1,641 8 4
,, ...	6	Gravel, resheeting and scarifying	,, ...	2,365 9 4
Blaxland S. ...	55	Prime and seal 135,274 sq. yds. between Lidsdale and Ben Bullen.	B.H.P. By-Products Pty. Ltd.	9,669 1 11
Byron S.	10	Earthworks, basecourse, etc., Approaches to subway south of Crabbes Creek.	B. Murray	2,330 9 2
Conargo S. ...	331	Bituminous surfacing 5 m. 3,472 ft. to 10 m. 3,472 ft. and 25 m. to 30 m.	Chesterfield & Jenkins (Qld.) Pty. Ltd.	2,060 0 0
Condobolin M. ...	57, 61	Construction of 6 R.C. box culverts and removal of three existing timber culverts.	,, ,, ...	1,950 14 0
Coolamon S. ...	243	Supply, delivery and spreading 10,216 cu. yds. gravel ...	Staines and Grundy ...	2,216 9 4

Council.	Road No.	Work.	Tenderer.	Amount. £ s. d.
Coonabarabran S.	...	Supply of 1,469 cu. yds. aggregate	B.H.P. By-Products Pty. Ltd.	1,986 10 3
,, ...	...	Supply of 96.4 tons of bitumen	Bitumen & Oil Refineries, Aust., Ltd.	1,711 2 0
Dumaresq S. ...	9	Flush seals, reseals and road mix reseals, excluding supply of materials.	Chesterfield & Jenkins (Qld.) Pty. Ltd.	1,854 9 4
Gundurimba S. ...	65, 146, 148	Surfacing	B.H.P. By-Products Pty. Ltd.	2,679 15 0
Hume S. and Albury C.	20	Surfacing 1.95 m.—8.51 m. west of Albury	Chesterfield & Jenkins (Qld.) Pty. Ltd.	2,193 16 0
Jemalong S. ...	56	Supply, delivery and spreading 5,264 cu. yds. maintenance gravel between Forbes and Grenfell.	J. R. Brown	1,135 1 4
Leeton S.... ...	80	Supply of aggregate	Murrumbidgee Sand & Gravel Co.	1,716 0 0
Lismore M. ...	306	Realignment and reconstruction 1 m. 35 ch.—2 m. 14 ch....	F. E. Bown	7,927 0 6
Lockhart S. ...	57, 59, 370	Winning and loading gravel	F. W. Hall	1,318 6 8
Lower Hunter S.	...	Construction of three span timber beam bridge and approaches.	Geo. Miller	3,822 5 6
Maitland C. ...	9	Resheeting with tar premix and bitumen flush reseal between Victoria Bridge and Long Bridge.	B.H.P. By-Products Pty. Ltd.	6,402 11 6
Marthaguy S. ...	202	Supply, delivery and spreading maintenance gravel at various locations.	G. G. Gillham	3,041 5 0
	203, 333		J. C. Beaumont ...	2,060 1 3
Patrick Plains S.	503, 220, 181	Surfacing on roads	B.H.P. By-Products Pty. Ltd.	1,424 1 3
Port Stephens S....	518	Supply and delivery 4,220 cu. yds. gravel	W. & M. Kennedy ...	2,532 0 0
,, ...	10	Supply and delivery 1,080 cu. yds. gravel	Beavis Bros.	1,080 0 0
,, ...	10	Supply and delivery 3,000 cu. yds. gravel	W. & M. Kennedy ...	1,262 10 0
Wade S.	80	Surfacing 8 m. 40 ch.—12 m. 24 ch. east of Griffith ...	B.H.P. By-Products Pty. Ltd.	1,957 10 2
Wallarobba S. ...	128, 301	Resurfacing with bitumen	,, ,, ...	1,774 16 4
Weddin S. ...	6	Supply, delivery and spreading 7,978 cu. yds. of maintenance gravel between 257 m. and 275.1 m.	McClellan & Death ...	3,708 9 3
Wingadee S. ...	18	Supply, delivery and spreading 15,200 cu. yds. of loam 17 m. 40 ch. to 18 m. and 23 m. to 32 m.	,, ...	2,090 0 0
Woodburn S. ...	145, 149, 153	Surfacing	B.H.P. By-Products Pty. Ltd.	1,530 1 8
Woollahra M. ...	173, 339	Supply and application of binder and application of aggregate.	W. B. Carr Constructions Pty. Ltd.	1,068 7 6
Yanko S. ...	243	Surfacing	B.H.P. By-Products Pty. Ltd.	1,415 11 3

Tenders accepted by Department on page 114.

Haulage of Cement on the Great Western Highway in the vicinity of Lett River.

Sydney: Alfred Henry Pettifer, Government Printer—1949.

MAIN ROADS STANDARDS.

NOTE: Numbers prefixed by "A" are drawings, the remainder are specifications unless otherwise noted.

Form No.

EARTHWORKS AND FORMATION.

70* Formation. (Revised, July, 1946.
A 1532* Standard Typical Cross-sections.
A 1149* Flat Country Cross-section, Type A. (Revised, 1930.)
A 1150* Flat Country Cross-section, Type B. (Revised, 1936.)
A 1151* Flat Country Cross-section, Type D1. (Revised, 1936.)
A 1152* Flat Country Cross-section Type D2. (Revised, 1930.)
A 1476 Flat Country Cross-section, Type E1. (Revised, 1937.)
A 1101 Typical Cross-section One-way Feeder Road. (1936.)
A 1102 Typical Cross-section Two-way Feeder Road. (1931.)
A 114 Rubble Retaining Wall. (1941.)

PAVEMENTS.

71* Gravel Pavement. (Revised, January, 1939.)
228* Reconstruction with Gravel of Existing Pavements. (Revised, January, 1939.)
254 Supply and Delivery of Gravel. (Revised, August, 1939.)
72* Broken Stone Base Course. (Reprinted with amendments, August, 1947.)
68* Reconstruction with Broken Stone of Existing Pavement to form a Base Course. (Revised, October, 1933.)
296 Tar. (Revised, March, 1939.)
337 Bitumen. (Revised, February, 1939.)
305 Bitumen Emulsion. (Revised, September, 1942.)
351 Supply and Delivery of Aggregate. (Revised July, 1941.)
65* Waterbound Macadam Surface Course. (July, 1939.)
301* Supply and Application of Tar and/or Bitumen. (Revised, December, 1948.)
122* Surfacing with Tar. (Revised, January, 1949.)
145* Surfacing with Bitumen. (Revised, January, 1949.)
93* Re-surfacing with Tar. (Revised, January, 1949.)
94* Re-surfacing with Bitumen. (Revised, January, 1949.)
230* Tar or Bitumen Penetration Macadam, Surface Course, 2 inches thick. (Revised, December, 1936.)
66* Tar or Bitumen Penetration Macadam, Surface Course, 3 inches thick. (Revised, September, 1936.)
125* Cement Concrete Pavement (April, 1939) and Plan and Cross-section A 1147 (March, 1932).
466 Bituminous Flush Seals and Reseals—Fluxing of Binders. (March, 1947.)

GENERAL.

342* Cover Sheet for Specifications, Council Contract. (Revised, April, 1939.)
24B* General Conditions of Contract, Council Contract. (Revised, August, 1948.)
64* Schedule of Quantities.
39* Bulk Sum Tender Form, Council Contract. (Revised, August, 1946.)
38* Bulk Sum Contract Form, Council Contract.
121* Provision for Traffic (Revised, June, 1947) with general arrangement, A 1323* and details A 1325* of temporary signs. (Revised, January, 1947.)
A 1342* Warning Signs, Details of Construction.
A 1346 Iron Trestles for Road Barriers.
A 1341 Timber Trestle and Barrier.
A 1824 Light Broom Drag. (1941.
A 1924 Pipe Frame Drag.
A 178 Mould for Concrete Test Cylinder.
A 1381–3, A 1452–5 Tree Guards, Types A, B, C, D, E, F, and G.
197* Hire of Council's Plant. (Revised, April, 1937.)
A 478* Specimen Drawings, Rural Road Design, with drawings A478A* and A 478B*.
A 478C* Specimen Drawing, Flat Country Road Design.
A 1113* Rural Road Plan and Longitudinal Section Form (tracing cloth).
A 1114* Rural Road Cross-section Form (tracing cloth).
A 1115* Urban Road Plan Forms (tracing cloth).
193 Duties of Superintending Officer (instructions). (Revised, July, 1938.)
314 Standard Regulations for Running of Ferries. (Revised, January, 1947.)
A 1645 Stadia Reduction Diagram. (1939.)
355* Instructions for Design of Two-lane Rural Highways (1937).
A 1487* Horizontal Curve Transitions (diagrams).
A 1488*, A 1488A*, A 1488B*, and A 1488C*.—Horizontal Curve Transitions (tables for speeds of 30, 40, 50, and 60 miles per hour).
A 1614 Widening of Shoulders on Crests.
369* Instructions for Design of Urban Roads (1939).
288 Instructions for Design of Intersections (Revised, January, 1948.)
402 Instructions for Design of Rural Intersections (acceleration and deceleration lanes). (1941.)

Form No.

KERBS, GUTTERS, AND GULLY PITS.

243 Integral Concrete Kerb and Gutter and Vehicle and Dish Crossings (Revised, July, 1939) and Drawing. (A134A.)
245 Gully Pit (Revised, May, 1939) and Drawings (*a*) with grating (A 1042); (*b*) Kerb inlet only (A 1043); (*c*) with grating and extended kerb inlet (A 1352); (*d*) extended kerb inlet (A 1353).
A 190 Gully Grating. (1933.)
A 1418 Concrete Converter. (1936.)

FENCING.

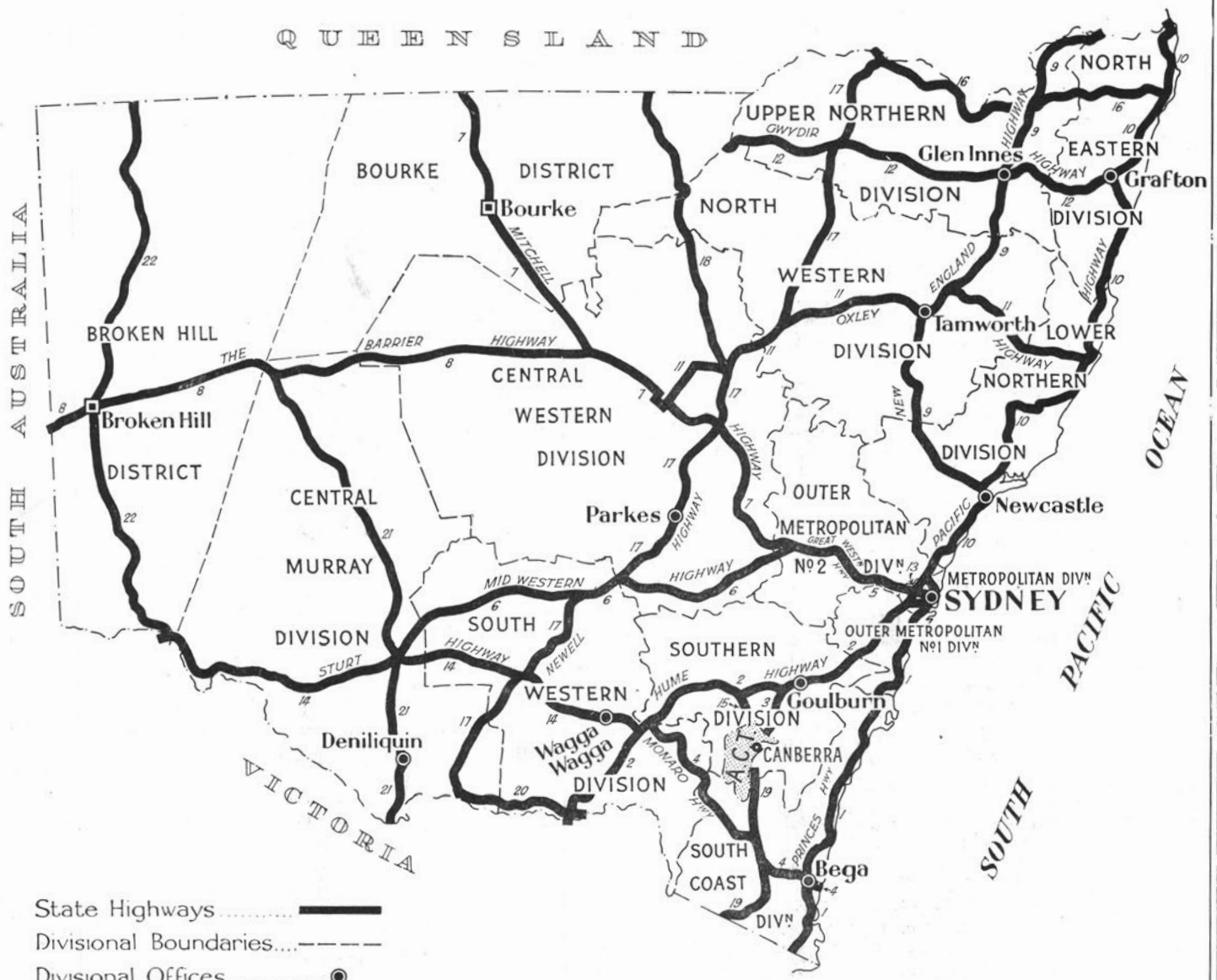
142 Split Post and Rail Fencing and Drawing (A 43).
141* Post and Wire Fencing (Revised, December, 1947) and Drawings (*a*) Plain (A 494); (*b*) Rabbit-proof (A 498); (*c*) Flood gate (A 316).
143 Ordnance Fencing (Revised, February 1934) and Drawing A 7 (Revised, November, 1939.)
144 Chain Wire Protection Fencing and Drawing (A 149).
246 Location of Protection Fencing (instruction) (Revised, May, 1940.)
A 1301 Motor Traffic By-pass 9 feet wide. (1936.)
A 1875 Motor Traffic By-pass 20 feet wide. (1942.)

BRIDGES AND CULVERTS.

A 4 Standard Bridge Loading (general instruction). (1948.)
A 4A Standard Bridge Loading (instruction for dead-end Developmental Roads.) (Revised, 1938.)
18* Data for Bridge Design. (Revised November, 1948.)
84* Data accompanying Bridge or Culvert Designs.
A 26 Waterway Diagram. (Revised, 1943.)
371 Waterway Calculations. (1939.)
A 421 Boring Gear. 2 inches. (1930.)
A 44 Boring Gear, 3½ inches. (1926.)
A 2847 Rod Sounding Apparatus. (1945.)
A 2995 Rod Sounding Apparatus, with tripod (1947).
25* Pipe Culverts and Headwalls (Revised, December, 1939) and drawings, Single Rows of Pipes, 15 in. to 21 in. dia. (A 143*), 2–3 ft. dia. (A 130*), 3 ft. 6 in. dia. (A 172*), 4 ft. dia. (A 173*), 4 ft. 6 in. dia. (A 174), 5 ft. dia. (A 175), 6 ft. dia. (A 177); Double Rows of Pipes, 15 in. to 21 in. dia. (A 211*) 2–3 ft. dia. (A 203*), 3 ft. 6 in. dia. (A 215), 4 ft. dia. (A 208), 4 ft. 6 in. dia. (A 207), 5 ft. dia. (A 206), 6 ft. dia. (A 213); Treble Rows of Pipes, 15 in. to 21 in. dia. (A 210), 2–3 ft. dia. (A 216), and Straight Headwalls for Pipe Culverts, 15–24 in. dia. (A 1153*).
A 1* Joint for Concrete Pipes. (Revised, August, 1933.)
A 142* Inlet Sump Pipe Culverts for 3 ft. dia. or less. (Revised, December, 1947.)
138* Pre-Cast Concrete Box Culvert (Revised, February, 1948) and drawings 9 in. high (A 485*), 12 in. (A 446*), 1 ft. 6 in. (A 447*), 2 ft. (A 448*), 2 ft. 6 in. (A 449).
A 311 Concrete Arch Culvert, 5 ft. high. (1931.)
A 314 Concrete Arch Culvert, 10 ft. high. (1931.)
206* Reinforced Concrete Culvert (Revised, February, 1948) and instruction sheets (A 305, A 359, A 306, A 304).
A 1832 Cast-in-Place Concrete Pipe Culverts. (1942.)
A 309* Concrete Culvert Posts. (Revised, June, 1937.)
300 Pile Drivers, specification for 25 ft., and drawings for 50 ft. (A 209) 40 ft. (A 253), and 25 ft. portable (A 1148).
A 1886 Arrangement of Bolting Planks for various widths of deck. (Revised, September, 1948.)
A 45 Timber Bridge, Standard Details. (Revised, October, 1947.)
A 1791 Timber Beam Skew Bridge Details. (1941.)
164 Timber Beam Bridge (Revised, April, 1947) and instruction sheets, 16 ft. (A71), 18 ft. (A 68), 20 ft. (A 70) and 22 ft. (A 1761). (Amended August, 1946.)
A 1226 and A 1165 Low Level Timber Bridges, instruction sheets for 16 feet, and 18ft. between kerbs. (1932.)
A 1222, A 1166, and A 1223 Single Span Timber Culverts, instruction sheets for 16 ft., 18 ft. and 20 ft. between kerbs. (1931.)
139* Timber Culvert and drawings, 1 ft. 6 in. high (A 427), 2 ft (A 428), 3 ft. (A 429), 4 ft. (A 430), 5 ft. to 8 ft. high, (A 431). (1928.)
326 Extermination of Termites in Timber Bridges. (Revised, October, 1940).
A 222* Pipe Handrailing Details. (Revised, July, 1947.)
350 Reinforced Concrete Bridge. (Revised, January, 1946.)
495 Design of Forms and Falsework for Concrete Bridge Construction (September, 1947.)

Standards marked * may be purchased from the Government Printer, Sydney.
Others may be purchased from the Head Office of the Department of Main Roads, 309 Castlereagh Street, Sydney, single copies being free to Councils.

State Highway System of the State of New South Wales



State Highways .....
Divisional Boundaries.....
Divisional Offices.....

SCALE
50 0 50 100 150 200

Area of New South Wales, 309,433 square miles.
Length of public roads within New South Wales, 126,058 miles.

MILEAGE OF ROADS CLASSIFIED UNDER THE MAIN ROADS ACT, AS AT 1st JULY, 1948.

State Highways	6,490
Trunk Roads	3,741
Main Roads	12,635
Secondary Roads (County of Cumberland only)	56
Developmental Roads	2,801
	25.723
UNCLASSIFIED ROADS, in Western part of State, coming within the provisions of the Main Roads Act	2,309
TOTAL ...	28,032